Environmental Building News™
The Leading Newsletter on Environmentally Responsible Design & Construction
A Publication of BuildingGreen, Inc. www.BuildingGreen.com Volume 16, Number 10 · October 2007

Prefabricating Green:
Building Environmentally Friendly Houses Off Site

IN AUGUST 2007, A HOME APPEARED in Walpole, New Hampshire, over the course of eight days. Sponsored by Habitat for Humanity, the house was designed by design-build company Bensonwood, also of Walpole, and constructed by volunteer labor. This house was different from most Habitat houses, however, which are typically built on site using conventional wood-framing methods. For the Walpole home, Habitat chose to build a prefabricated home with precision-cut timbers and panels constructed at the Bensonwood factory by volunteers; the panels were later assembled on site, also with volunteer labor.

The resulting house produced less waste material than a site-built house, thanks to cutting equipment programmed to maximize the use of each piece of wood. It was also built faster than a site-built house, including the time spent assembling panels at the factory, and it featured a well-insulated building envelope with strong attention to construction details. The house included Bensonwood's unique measures designed to "disentangle" the electrical, plumbing, and mechanical systems from the structure, making them easier to install and modify.

Not all prefabricated homes incorporate as many advanced features as the one in Walpole, but Bensonwood is not alone in exploring ways to bring environmental sensitivity and smart design to prefabricated housing. On paper, prefabricated housing has the potential to offer significant environmental benefits: stronger, better-insulated structures; less waste from construction; reduced transportation impacts; and, in some cases, easier disassembly for reuse. Prefabricated construction also has the potential, given the efficiency of factory production, to deliver these benefits at a lower cost than site-built housing.

The prefabricated housing industry has been slow to accept high-performance building practices, however, failing to

(continued on p. 10)

Photo: Jody Forcier

On the right, volunteers put the finishing touches on the Bensonwood Habitat house. On the left, workers install ceiling trim above a wall system that allows easy modification and installation of wiring. (see p. 15)

In This Issue

Quote of the month:

"Once you change the specs and go outside a manufacturer's comfort zone, costs go up."

John Abrams, South Mountain Company, on greening prefabricated housing.

(page 13)

ENVIRONMENTAL BUILDING NEWS (ISSN 1062-3957) is published monthly by BuildingGreen, Inc. *EBN* does not accept advertising. Subscriptions are $99/year. Outside North America add $30. Periodicals postage paid at Brattleboro, Vt. and at additional mailing offices. POSTMASTER: Send address changes to *Environmental Building News,* 122 Birge St., Ste 30, Brattleboro, VT 05301.

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122 Birge St., Suite 30, Brattleboro, VT 05301
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Printed on Rolland Enviro100 Print, 100% post-consumer, certified Ecologo, processed chlorine free, FSC recycled and manufactured using biogas energy.

From the Editors

When It's Greener To Build

Whether with lightbulbs or buildings, many of us in the green building world are in love with conservation and efficiency. Of course, if the goal is reducing our footprint on the planet, better than doing something efficiently is to not do it at all—whether it's turning on a light or making a building. The mindset of efficiency in the green building movement contains, at its logical extreme, a latent distaste for buildings themselves.

This tension cuts to the core of our mindset as green builders. To get a glimpse of this, let's examine a contrary question: "Is it ever greener to build than to not build?" Purists who believe in leaving the land untouched might reply, "No." But surely this position is too extreme—should we only use existing infrastructure? Should we not have a built environment?

Our architecture, no matter how efficient, will always exact some environmental costs. But concern about resource consumption should be a lens through which we examine buildings, not the definition of green itself. We should also consider our fundamental ethics of building: Why do we build? In what ways is the *act* of building green?

When there is a need for a building, and the design and construction team remains loyal to the expression of that need, we see ecological and humane buildings rise from the earth. They provide homes that keep our families safe and warm. They contain schools for our children to learn, centers where we can heal, and places to work.


Photo: Sarah Lavigne

We each have our favorite human-made or wild examples of architecture that affirm the reasons why we work in a creative industry, why we design and build. At the heart of the building process is a crafting of materials, energy, and motion that can render us awestruck and in love, as artisans and as occupants. In this way buildings have the power to evoke not only the highest emotions that we are capable of, but they forge a connection between those emotions and the most mundane aspects of life, a connection that nurtures the entire community of life.

Resource efficiency and other green measures express one aspect of that connection, but they are not the whole. We see this in buildings that do everything right according to conventional green measures but that fail to inspire or nurture, often because they honor only one-dimensional values, such as profit, convenience, or efficiency. Perhaps the same buildings would be "greener" if their designers did not undervalue the human need for harmony with both the natural and constructed environments.

When we build with awe for life at the forefront of our process, we inherently build in a way that supports life. Therefore let's adopt a mindset not of being green by doing the least harm, but of being green by honoring our bond with the earth at every step of the building process.

– Tristan Korthals Altes

To our readers: Please note the change of our managing editor Tristan Roberts' surname to Korthals Altes (pronounced *Kor-thulls All-tiss*). Tristan Korthals Altes, or simply Tristan Altes, and his new wife chose the name from his Dutch ancestry. Please also join us in welcoming our new art director, Amie Walter, and in wishing *buon viaggio* to Julia Jandrisits, who is leaving BuildingGreen after two years to attend the Florence Academy of Art in Italy.

mail@BuildingGreen

Poor Insulation Work Adds to Home Retrofit Challenges

As a remodeling contractor, I read your recent article "The Challenge of Existing Homes" [see *EBN* Vol. 16, No. 7] with great interest. I think, however, that the challenge posed by existing homes is even broader than the article acknowledges.

Most homeowners who have their homes insulated have no idea if the job was good or not. For that matter, most insulation crews have no idea if they did a good job. For the past few years I have been doing quality-control audits on utility-rebated insulation work done on older homes in Newton, Massachusetts. Almost invariably the insulation work consists of blowing cellulose into the exterior walls at too-low pressure and with no attention to air-sealing. The net result is insulation coverage often as low as 60% of the area of the exterior walls and leakage rates well above 5,000 cubic feet per minute at 50 pascals (the result is extrapolated, because often we can't reach a 50-pascal pressure difference—even after the insulation work has been done). These homeowners have no idea they could get much, much better. Sadder still, the insulation crews have no idea they could do much, much better. And we're stuck with these bad insulation jobs for decades.

How can we create a steady demand for quality weatherization work? I think the first step is to establish a metric that can be readily understood by the general public. Your case studies point to part of the problem: the energy load of one house is measured in million Btus annual total consumption, another is measured in Btus per hour of peak load, and the third is measured in million Btus annual consumption, but split between heating and cooling.

When I give insulation workshops, I ask participants how large their houses are and how much they pay for electricity, gas, and oil. Nine out of ten have only a vague idea. So much for calculating and comparing Btus per square foot per year with such a group. The measurement system needs to be much simpler and more intuitive than the numbers you used in the case studies.

We should encourage more widespread use of HERS [Home Energy Rating System] numbers. HERS ratings are far from perfect (in particular when applied to older homes), but they will only get better with more widespread application. If real estate agents were required to provide HERS numbers with property listings and if remodelers were required to reduce the HERS ratings of existing homes by a certain percentage to get a final inspection signoff, an essential feedback loop would be closed and a new level of demand for quality weatherization work would be created.

My remodeling company has started to calculate before-and-after HERS ratings for our projects. It has not been easy, but it will get easier. My crew and most of our clients have been receptive to the idea. I am confident it will soon be one of the most important numbers we calculate. Using HERS ratings backed up by actual performance data over time, both we and our clients will know when we get our energy improvements right and when we get them wrong—and as a result we will get them right much, much more often.

Paul Eldrenkamp, Owner
Byggmeister, Inc.
Newton, Massachusetts

What's Happening

California Fire Codes Regulate Plastic Decking Concerns

A highly publicized series of wildfires has struck California in the last decade, putting a focus on homes in wildfire-prone areas and the flammable materials they are constructed from—including roofing, siding, and decking. Taking effect on January 1, 2008, the Wildland-Urban Interface Building Codes, developed by the California Office of the State Fire Marshal (SFM), aim to protect homes and the safety of occupants and firefighters. Among other provisions, the codes restrict relatively flammable decking, including wood-plastic composites.

The new codes affect "Fire Hazard Severity Zones," identified by topography (fire spreads faster on slopes), vegetation that fuels fires, weather patterns, history of past wildfires, and likelihood of fire spreading from neighboring areas. Those zones affect a significant portion of the state, mostly in rural areas, but they also frequently intersect with populated areas. According to Kevin Reinertson at SFM, the standards have been projected to affect 8%–11% of new construction in California.

Landscaping provisions require homeowners to clear flammable materials for 30 feet (9 m) around a building and manage fuel loads for 100 feet (30 m) around a building to create a "defensible space" for fire-

Source: U.S. Navy

A fire propagation test by the U.S. Navy evaluating plastic lumber in 2001. After 29 minutes, a fire that was started at the top of the experiment apparatus on a deck assembly is being extinguished due to dripping, flaming debris that is burning test material below the assembly.

fighters. The standards cover vents, walls, windows, and decking—roofs should be ignition-resistant, and cornice vents that could admit flames are prohibited, for example. Decking has also been a key focus of the regulations. Many homes feature wide expanses of decking, which is usually flammable; laid horizontally with air gaps between boards, the decking can easily catch burning embers and ignite.

In support of the code development, the California Forest Products Laboratory tested flammability of a variety of wood, plastic, and wood-plastic composite decking materials in 2002 (see *EBN* Vol. 11, No. 11). The tests found that solid products, like redwood decking, and some composites, such as Trex, performed much better than hollow or channeled products. Several plastic and composite products performed very poorly, suffering from runaway combustion and dripping, flaming debris.

Fears of runaway combustion, structural failure, and flaming debris helped shape the new codes, which offer decking materials multiple compliance paths. Acceptable materials may, like heavy timber or masonry, be recognized as noncombustible or ignition resistant. Flame retardant treated wood, which by definition meets the Class A, or highest, flame-spread rating in ASTM E-84, is specifically allowed. Other materials may be allowed by passing SFM performance requirements for ignition resistance and heat-release rate while exposed to flames. While not equivalent to ASTM E-84, these tests may allow the use of decking boards achieving only a Class B rating in ASTM E-84, opening the field to a variety of wood and plastic products.

According to Bill Towson, codes representative for Arch Wood Protection, which offers Dricon, a flame retardant treated wood, the wood-plastic composite industry lobbied the SFM to allow Class B materials, despite the potential for reduced fire safety. "Everybody had their opportunity for input when we were promulgating the regulations," said SFM's Reinertson, but he denied that the wood-plastic composite industry had unduly influenced the results. Steve Quarles, an advisor on wood performance issues for the University of California Cooperative Extension who helped run the 2002 tests, told *EBN*, "There were a number of factors on the table, including cost to the consumer" of various alternatives.

Quarles welcomed the regulations, noting, "It's a lot better than where we were before." He noted that the regulations address key components of the building envelope and are encouraging development of new standards. In particular, an ASTM task group is considering developing a standard based on the SFM standards, and other states are looking at adopting some version of them. The standards have also encouraged ASTM to develop a standard demonstrating resistance of vents to flames and embers—something that some products can currently claim, but not conclusively demonstrate.

– Tristan Korthals Altes

For more information:

California Office of the State
Fire Marshal
Sacramento, California
916-445-8200
http://osfm.fire.ca.gov

New Organization Supports Green Mechanical Subcontractors

Hydronics engineer Tom Meyer has enough experience to know that what gets built is never exactly what is on the plans. He has also observed that most of the people who actually build green buildings are not well served by the education and training opportunities in today's green building world. Those insights led him to create the Green Mechanical Council—GreenMech for short—to provide basic training for mechanical contractors and to seek more respect for their work within the broader green building world. "Installers and service technicians are the cutting edge of the whole industry. The rest of us have to start supporting them instead of sitting on them," Meyer says.

Founded in August 2006, GreenMech has grown rapidly to more than 100 member organizations. These members include several major mechanical contractor trade associations, a large share of contracting firms, and some equipment manufacturers, among others. "Everybody is coming together for one thing," Meyer says: "To improve mechanical systems in buildings."

As a practical example of the challenge that installers face in green buildings, Meyer points to the multiple water-supply piping systems that these buildings sometimes have, for potable water, rainwater, and graywater, for example, in place of the single system in conventional buildings. While the plans may distinguish multiple systems by color, Meyer notes, in the field there is a real risk of cross-connecting them, with possibly disastrous results. "How do we keep this from happening?" he asks, adding that GreenMech aims to be the forum for that type of conversation.

GreenMech seeks to partner with the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) and to become an educational program provider for the U.S. Green Building Council (USGBC). "We will become the mechanical educators at other than the engineering level," Meyer claims, adding, "We're the conduit to the guy who puts his butt in the truck in the morning." GreenMech recently pilot-tested its initial course, titled the Green Awareness Certification Program, and got a positive response, according to Meyer. This course, tailored for mechanical systems technicians, introduces students to the basic technologies and concepts of the green design world.

– Nadav Malin

For more information:

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New Green Training Program for Real Estate Community

EcoBroker has provided green real estate training over the last four years to more than 1,700 licensed realtors in 42 states, Canada, and the Caribbean. Now this leader in green real estate education has some friendly competition. Earth Advantage, an established third-party certifier of green homes, recently unveiled its own program—Sustainability Training for Accredited Real Estate Professionals (STAR). Its stated purpose is to educate the real estate community to communicate knowledgeably and effectively about the green features and benefits of new and existing homes.

Both EcoBroker and STAR provide realtors with continuing education credits, certification upon the successful completion of an exam at the end of the courses, and ongoing support after they've received their certification. But rather than competing, the two programs may complement each other, so much so that John Stovall, EcoBroker's vice president for business, said he would like to think of them as "associates … rather than competitors."

Realtor Don McCoy of Exit Realty Group–Southern Oregon, agrees. McCoy, who has successfully completed the two programs, explained that differences in the teaching approaches may be reason enough for realtors to experience both. EcoBroker classes can be taken online over the course of a year, and are "fundamentally important for acquiring the language of green," explained McCoy, who said he took his time with the material and "soaked it up like a sponge." STAR, on the other hand, is taught in 18 hours over a two-day period, a format that may make it feel more advanced. "Agents are just going to forget (the information) if they don't already know the language," said McCoy. His advice to fellow realtors who are new to the green building aspect of their industry is to do EcoBroker first so that "then, when you do the Earth Advantage afterwards, it will make sense."

Members of the real estate industry are readying themselves for what they believe will be one of the next big drivers in their business. At the annual Northeast Real Estate Conference & Expo, for example, in September 2007, the theme was "green." At an introductory seminar by Stovall on green real estate given to over 200 realtors, one told *EBN*, "We're so ready to learn this stuff. And it's finally being offered to us in a language we can understand." Earth Advantage executive director Sean Penrith noted that "the response [to STAR] has been phenomenal. We told ourselves that if we could fill six classes in the first year we'd be happy, but we've tripled that. We've had entire firms come to us wanting all their brokers to be certified."

STAR classes are located throughout Oregon and southwest Washington, but Earth Advantage intends to make the program available nationally and is in the process of licensing

EcoBroker's John Stovall speaks to a packed "green real estate" class at a September 2007 conference in Burlington, Vermont. Photo: Rachel Navaro

STAR to green building organizations in seven other states beginning in 2008.

–Rachel Navaro

For more information:

Earth Advantage Inc.
www.earthadvantage.org

EcoBroker
www.ecobroker.com

Newsbriefs

New York's First Lady Pushes for Green Home Grants—Fresh on the heels of "greening" the Governor's Mansion following the January 1, 2007, inauguration of her husband, New York Governor Eliot Spitzer, First Lady Silda Wall Spitzer is now working to help other New York residents do the same. The First Lady has proposed legislation to grant up to $10,000 for new or renovated homes that meet "green building criteria." New York's Deputy Secretary for the Environment, Judith Enck, said the grants would encourage "typical middle-class homeowners to embrace LEED standards in their homes." Spitzer said that part of the intention is to defray the costs of improving energy efficiency. Grants would be awarded at a rate of $5/ft^2 ($50/m^2) for up to $10,000 per home, a formula modeled after the state's incentive for greening commercial buildings.

Mixed-Use Chicago Building Uses Renewables—After over a year of renovation supervised by Wilkinson Blender Architecture, a 120-year-old building in Chicago is ready to house both living quarters for its owners and a recording studio for their record label. The two-story building has registered for LEED for Homes certification and features several renewable-energy systems that will provide around 10,000 kilowatts of electricity a year—enough to provide half of the building's energy needs. A large photovoltaic array joins three wind turbines on the roof, which also contains a garden and patio. The project uses 15 wells in conjunction with a ground-source heat pump; the wells were drilled from within the basement using a small, portable drilling rig, since the urban lot prevented the use of any large machinery.

Workers install one of three wind turbines on the roof of a renovated mixed-use building in Chicago. Photo: Brian Peters

Illinois Legislates for Green Neighborhoods, Cities—Perhaps gearing up for the 2007 Chicago-hosted Greenbuild convention, Illinois recently passed two innovative green building laws. The first bill enacts a "smart cities" grant program to fund urban preservation, redevelopment, and green technology at the municipal level; it also creates a "green cities" grant program for municipalities whose buildings conform with "nationally recognized and accepted green buildings guidelines, standards, or systems." The "green cities" grants may be used for new construction, existing buildings, commercial interiors, core and shell development, homes, schools, or neighborhood development. In a separate piece of legislation, the Green Neighborhood Grant Act provides funds of up to 1.5% of the total cost of up to three private developments that achieve certification under the LEED for Neighborhood Development rating system, currently being piloted by the U.S. Green Building Council. More information is available at www.ilga.gov/legislation; search for HB3394 and SB135.

Indoor Air Quality Study Supports Replacing Older Woodstoves—Air-quality test results confirm that it's possible to reduce the concentration of fine particulate matter, which is harmful indoors even at extremely low concentrations, by using cleaner-burning woodstoves certified by the U.S. Environmental Protection Agency (EPA). University of Montana researchers saw a 72% reduction of residential indoor particulate matter of 2.5 microns and smaller during the 2006–2007 winter, after the replacement of 20 older woodstoves in Libby, Montana. While the new stoves reduced both acute and chronic exposure to woodsmoke, the study did not confirm whether EPA-certified woodstoves reduced exposure to volatile organic compounds. Information on the study is available at www.umt.edu/cehs/ibshe_presentations/Ward%20IBSHE.pdf; more information on woodstoves can be found at www.epa.gov/woodstoves/.

NARI Offers Certification for Green Remodelers—The National Association of the Remodeling Industry (NARI), working with GreenHome Guide, has developed a certification program for remodeling professionals using green building techniques. Applicants must have five years of remodeling experience, have been focused on green remodeling techniques for at least three years, and have 16 hours of continuing education related to green building. They must also pass a test, drawn in part from the Green Building Guidelines developed by the National Association of Home Builders, that covers building science principles, indoor air quality, energy efficiency, and deconstruction techniques, among other topics. NARI organizes study groups for all of its certification programs through its local chapters; more information is available at www.nari.org/certify/.

Timeline and Reports on Forest Certification in LEED Released—The U.S. Green Building Council (USGBC) has announced the next phase of its initiative to review how forest certification programs are addressed in the LEED Rating System (see *EBN* Vol. 15, No. 6). The Yale University-based consultant team hired to support the effort has posted its research reports for expert review, and LEED's Materials and Resources Technical Advisory Group (chaired by *EBN* editor Nadav Malin) is slated to meet on October 1–2, 2007, and release any proposed changes to the certified wood and rapidly renewable materials credits for public comment on November 3. The Yale team's reports are posted at www.yale.edu/forestcertification/usgbc.htm; comments on the reports are requested by October 1.

Awards & Competitions

Lifecycle Building Challenge Winners Announced

The U.S Environmental Protection Agency, The American Institute of Architects, the Building Materials Reuse Association, and West Coast Green have announced the winners of the Lifecycle Building Challenge (see *EBN* Vol. 16, No. 3). Created to recognize innovations in building disassembly and materials reuse, the competition invited both built and unbuilt entries in three categories: buildings, components, and services. Judges, including *EBN* executive editor Alex Wilson, chose nine winners and thirteen honorable mentions. One winner from each category is featured below; more on the winners can be found at www.lifecyclebuilding.org.

- The **Pavilion in the Park**, designed by Erin Silva of the Miller|Hull Partnership in Seattle, consists of four modules, each supported by two four-sided steel frames and set on concrete piers. Currently housing an exhibit on the history of Seattle's South Lake Union region, the building will move over time through several neighborhoods and was designed to be flexible enough to house many different exhibitions. All interior and exterior finishes have temporary joints between modules, making disassembly and relocation easier; adjustable ramps to the entrances will allow the building to adjust to varying topography.
- A drywall attachment system, **Green-Zip-Tape** was among the winners in the component category. Designed to ease the removal of drywall for repairs, the self-adhesive, fiberglass-mesh drywall tape is applied in much the same way as standard tape, but a tail is left exposed at the bottom of the wall and hidden under molding. When deconstruction is needed, this tab can be pulled, exposing the drywall seam and screws below. Among its other benefits, the product, from Tax Advantage Design in Houston, may help taxpayers depreciate drywall on a faster schedule.
- In the service category, a new profession of **deconstruction engineering** was among the winners. Students at California Polytechnic State University proposed that a deconstruction engineer work with a design team at the beginning of the building process to ensure that a building would be easy to disassemble at the end of its life. The profession would also overseeing deconstruction.

– Allyson Wendt

The Pavilion in the Park, located in Seattle, is an exhibition space designed to come apart in modules and move throughout the region as needed. Photo: Miller|Hull Partnership

Product News & Reviews

Alpen Fiberglass Windows—Leading the High-Performance Race

Alpen Energy Group, of Boulder, Colorado, has been a leading window technology innovator dating to the company's founding in 1981. Since getting into pultruded fiberglass frames in 2005, the company has established a reputation as manufacturer of the world's highest-performing windows. Among the company's high-profile installations is a fall 2007 project to replace windows at the Rocky Mountain Institute (RMI) headquarters and home of Amory Lovins and his wife Judy Lovins in Snowmass, Colorado. Most of the RMI windows will have center-of-glass insulation values of about R-12 (U-factor 0.08), and a few of the north-facing widows will achieve center-of-glass R-values of 20 (U-factor 0.05). See table below for details on the energy and transmission properties of these windows and others from Alpen.

Achieving the R-20 center-of-glass performance is made possible with inner and outer panes of PPG Starphire low-iron glass, three suspended polyester films, each with low-emissivity (low-e) coatings on both sides (Heat Mirror TC88 from Southwall, Inc.), low-conductivity xenon gas fill in the ¼" (6 mm) spacing between these glazings, and 1⅜" (35 mm) pultruded fiberglass frames filled with highly insulating vacuum packets of silica aerogel from NanoPore, Inc. Despite the exceptional energy performance, these windows transmit roughly 43% of visible light, according to Alpen president Robert Clarke.

Greg Franta installed Alpen windows, shown here in the kitchen, in his house in Boulder, Colorado. Photo: Greg Franta, FAIA

Alpen's business is split about evenly between residential and commercial window products. Most of Alpen's windows aren't quite as phenomenal as those on the north face of RMI, but they are still impressive. Increasingly, the company is combining suspended low-e Heat Mirror films with low-e *coated* glass. For applications where heat avoidance is a priority (such as west-facing windows), the company uses Cardinal's new 366 Low-E³ glass (see *EBN* Vol. 16, No. 1) as the outer pane, a suspended Heat Mirror 88 film (with a single low-e coating), and another layer of glass on the interior. This configuration provides a solar heat-gain coefficient (SHGC) of 0.24 and light transmittance of 56%.

Clarke estimates that the company has provided high-performance fiberglass windows for about 45 projects (averaging 20 to 25 windows per project) in more than 30 states during the last two years. Alpen's fiberglass pultrusions are made by InLine Fiberglass of Toronto, Ontario, and fabricated for Alpen by Duxton Windows & Doors of Winnipeg, Manitoba. In addition to offering fiberglass frames, the company provides some wood-framed windows, working with Eagle Windows of Dubuque, Iowa. Alpen also produces vinyl (PVC) windows, as they have for 12 years, but Clarke expects the fiberglass frames to gradually replace the vinyl ones. He estimates that Alpen's fiberglass windows currently cost 25% to 30% more than vinyl but expects those prices to converge in three to five years. "Alpen's primary focus is centered around making the highest performance window in the world at an affordable price," said Alpen's CEO Brad Begin. Adding suspended coated film to a window currently adds \$3 to \$4/ft² (\$30/m² to \$40/m²), but Clarke expects that to drop over time as well. "Two dollars to \$2.50 per square foot (\$20/m² to \$25/m²) is a reasonable near-term goal," Clarke told *EBN*. "We're increasingly automating the process of suspending the films," he said, and the company hopes to install state-of-the-art European equipment to improve manufacturing efficiency and reduce costs.

Greg Franta, FAIA, principal architect of RMI's Built Environment Team, recently reglazed his own home outside Boulder. Franta replaced wood windows with Alpen fiberglass windows using three glazing configurations, each optimized, or "tuned," for best performance in its orientation. "Forty to fifty percent of our projects have some elements of tuning," notes Clarke. On the south walls Franta installed windows with the highest SHGC to provide for passive solar heating; on the east and west he used windows with the lowest SHGC; and on the north he installed windows with the lowest U-factor (best insulation value). On the north, for example, he used Alpen quadruple-glazed windows with two layers of low-e coated glass and two suspended films of Heat Mirror TC-88—providing six low-e coatings on each window. With the optimized gas mix of krypton and argon, these windows provide a center-of-glass insulation value of about R-15.

Franta has specified Alpen windows on a number of other projects as well, including the recently completed—and LEED Platinum—LSR Reserve

Alpen Glass & Alpen Window Performance

Center Of Glass & Window Unit Values for Inline/Duxton Fiberglass Series 325 Fixed & Casement

Application	General Use	Cold Climate, south facing–favoring passive solar gain	Cold climate, east- or west-facing–favoring solar protection	North-facing and extreme climates–maximum insulation
CONFIGURATION				
Outer Lite	1/8″ Cardinal LoE² 272	1/8″ Low Iron	1/8″ Cardinal LoE² 272	1/8″ Low Iron
Interspaces And Thickness	1 @ 1/2″	2 @ 9/16″	3 @ 3/8″	4 @ 1/4″
Suspended Coated Film(s)	None	1 HM88	2 HM-TC88	3 HM TC88
Gas Fill	Argon	Argon	Krypton	Xenon
Inner Lite	1/8″ Clear	1/8″ Low Iron	1/8″ Cardinal LoE² 272	1/8″ Low Iron
Overall Thickness	3/4″	1 3/8″	1 3/8″	1 3/8″
PERFORMANCE				
Center-of-Glass R-value	4.1	5.1	14.7	20.0
Casement Unit R-value[1]	3.3	3.6	5.9	7.4
Fixed Unit R-value[2]	3.6	3.8	7.7	10.4
Center-of-glass U-factor	0.24	0.20	0.07	0.05
Casement Unit U-factor[1]	0.30	0.25	0.17	0.14
Fixed Unit U-factor[2]	0.28	0.23	0.13	0.10
Solar Heat Gain Coefficient (SHGC)	0.41	0.63	0.29	0.37
Visible Transmittance (Tvis)	71%	75%	40%	43%
"Winter" Inner Glass Temp (°F)[3]	56	58	66	67
UltraViolet Blockage	84.6%	98.7%	99.0%	99.5%
STC Acoustic Rating (estimated—glass only)	29	34	35	37

1. Assumes Inline/Duxton Fiberglass Series 325 Casement
2. Assumes Inline/Duxton Fiberglass Series 325 Fixed Window
3. Assumes 70°F indoors; 0°F outdoors, 15 mph wind

Imperial U-value to Metric U-value Conversion: I-P U-value x 5.678 = W/m^2.C

Performance data provided by Alpen and Inline Fiberglass, using Window 5.2 and Therm 5.2.14 computer modeling tools from Lawrence Berkeley National Lab, based on standard procedure according to the National Fenestration Rating Council (NFRC).

visitor center in Jackson, Wyoming. "They've been nothing but fantastic for me," Franta said of Alpen. "We don't hesitate recommending them." He said that the lead time to get the windows is occasionally longer than he would like, but he's been able to plan around that. When problems or issues have come up, Alpen has been "great about reworking things or correcting things."

Among Alpen's other projects is providing 39 windows for the Davis Research Center in Antarctica, which is owned by the Australian government. Most of these windows—being referred to by Alpen as "Penguin Pane"—will be quadruple-glazed with two Heat Mirror TC88 films suspended between a 5⁄16″ (8 mm) laminated, low-iron glass outer lite and a 1⁄8″ (3 mm) low-iron glass inner lite, with xenon gas-fill, a low-conductivity spacer, and fiberglass window frames made by InLine Fiberglass and with NanoPore vacuum insulation packets units. The performance of NanoPore "gets better and better as it gets colder," according to Clarke. These windows will have a center-of-glass R-value of 14.1, SHGC of 0.43, and visible light transmittance of 54%. With the NanoPore-insulated frames, the goal is to achieve a true *unit* insulating value of R-10 (unit U-factor of 0.10).

– Alex Wilson

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Product Brief

Fusiotherm Polypropylene Pipe Has New North American Distributor—Polypropylene pipe, a niche product known for its environmental and performance benefits (see *EBN* Vol. 13, No. 9), has a new North American distributor. In May 2007, Aquatherm, Inc., of Provo, Utah, became the exclusive distributor of Fusiotherm potable water pipe and Climatherm heating pipe in the U.S., while a sister company will continue to distribute in Canada. Aquatherm Piping Systems of Romeo, Michigan, relinquished its rights to the products. Parr Young, media director for the new distributor, said that the company hopes to reach across the country to all building markets. More information is at www.aquathermpipe.com.

Prefabricating Green *(from page 1)*

realize the full environmental potential of prefabrication. Changes to assembly-line procedures to add high-performance features—superinsulation of the house, for example—can be prohibitively expensive, making prefabrication less attractive for environmentally friendly building projects. If the changes are adopted throughout the industry, however, the costs of changing procedures would be spread among thousands of houses, making green design affordable.

This article examines both mainstream and more advanced green prefabricated housing, looking at the potential environmental benefits of this form of building and the potential for making green housing more affordable.

Is It Green?

From material waste savings and more durable houses to reduced transportation impacts during construction, prefabricated housing could offer many environmental benefits. This section examines the most common environmental claims for prefabricated housing.

More durable houses

Darrell Hoss, a high-end homebuilder in Stamford, Connecticut, represents a new breed of modular builder; his houses start at 5,000 ft^2 (460 m^2) and he attracts clients who are looking for high-quality homes with customized details. Hoss chose to build modular houses because, he said, "the basic quality is better—they're built in a controlled environment." Materials are stored and assembled indoors, where they are less likely to be damaged, and quality-control measures are easier and more common in a factory setting than on a building site. In many factories, materials are checked for quality, and supervisors routinely check modules to ensure that construction procedures, such as proper framing or air-sealing techniques, are being followed. Factories also tend to employ longer-term labor, leading to higher levels of training and thus better construction.

Modular houses, in particular, must be built strong enough to withstand the stresses of transport by truck and placement on a foundation by a crane. To achieve this strength, modules are often built using more material than comparable site-built houses. For example, many modules have both floor and ceiling assemblies even if they are part of a two-story house, creating a redundant assembly between the first and second floors. Similarly, the "marriage walls" between modules are twice as thick as a standard supporting wall. Some factories are adopting advanced framing techniques or looking for other ways to save material. Customized Structures, in Claremont, New Hampshire, uses open-web trusses to support the floors of its homes and uses two-stud corner framing and single-top plate framing for non-load-bearing walls.

Although much of the added strength of modular houses is needed to withstand the stresses of transport, it may not make the house more durable on site. One company, however, is using the need for added strength to create housing that meets stringent hurricane codes. Stalwart Built Homes, in Panama City, Florida, constructs LEED-certified modular homes designed to withstand 200-mile-per-hour (320 km/h) winds. "Building in the factory gives us more control of the product," said company president Julius Poston, arguing that quality-control measures in the factory ensure that the correct size and number of fasteners are used to make the house strong enough to survive a hurricane.

Not all prefabricated homes are overbuilt—panelized homes are not subject to the same transportation stresses as modular homes, since they are packed differently, and are therefore built in ways more akin to site-built homes. Connor Building Company, located in Middlebury, Vermont, builds historic reproduction homes with panelized components. Michael Connor, the company's president, argues that panelized construction allows him to control quality, and he refers to his company's process as "off-site manufacturing of a stick-built house," reinforcing the argu-

At the beginning of the assembly line at Customized Structures in Claremont, New Hampshire, walls are built and squared on special tables. They are then put on floor assemblies to create modules, shown at the rear on the left. Photo: Alex Wilson ment that panelized houses are not subject to the same overbuilding as modular houses.

Workers in the Connor Homes factory build structural and partition walls and cut rafters to size; all of the pieces are then shipped to the site, where crews assemble them. Floor studs and rafters are cut to size in the factory but assembled on site, meaning that the company does not have to double floor and ceiling assemblies. To control both quality and historical accuracy, architectural trim and details are also prefabricated or cut to size in the factory and installed on site.

Less waste

One of the benefits of prefabrication is that waste materials from one house can be stored for later use, limiting the amount of material that ends up in the landfill. Although statistics on waste are lacking, Rebecca Woelke, director of media relations for Michelle Kaufmann Designs (MKD) in Oakland, California, told *EBN* the company's modular homes yield up to 70% less waste than typical site-built homes. Such waste savings may be exceptional, given MKD's green focus, but even mainstream housing manufacturers are moving towards waste reductions, driven by a focus on "lean production" techniques that save materials, time, and money.

Lean production techniques were perfected in Japan, where Toyota successfully used them to streamline its manufacturing process. The prefabricated housing industry has followed Toyota's example, adopting techniques such as organizing materials and tools and bringing them closer to the worker, making a given task easier and more efficient. Lean production can also involve rearranging the order in which tasks are performed on a house, redesigning the house to make it more efficient to build and controlling the stock of needed materials so there is neither too much nor too little. Although some of these techniques could be used by production builders on site, they work best in the stability of a factory setting, where they can be fine-tuned over time.

In 2005, the Manufactured Housing Research Alliance (MHRA) prepared a report on lean production principles for the U.S. Department of Housing and Urban Development (HUD); MHRA compared survey data on efficiency and product quality from 141 manufactured and modular housing factories, then chose one factory to examine more closely. Among the lean production techniques recommended for that factory was ordering materials in sizes that would minimize or eliminate waste. For example, an exterior drywall product was being ordered in 8-foot sheets when 12-foot sheets would have been more appropriate. Changing to 12-foot sheets would not only save the factory money by lowering the labor costs of cutting drywall to size but also provide an environmental benefit, since properly sized sheets would minimize waste from trimming.

Newer factories that focus on environmentally friendly homes are also among those most devoted to greening their operations. Xtreme Homes, a modular home manufacturer in Oroville, California, reuses most cardboard shipping boxes before recycling them and sends any drywall that can't be used to a recycler that turns it into a soil amendment, according to Tim Schmidt, the company's president and CEO. Xtreme Homes also reuses pallets several times for shipping items to the site along with the house. At Customized Systems, the management decided to follow local tradition to get rid of materials it couldn't use or recycle: a large sign marked "free" directs passersby to materials piled in the parking lot. Like most free piles, Gillen said, this one disappears quickly.

While many of these measures are not unique to the factory setting—onsite builders also have waste-management programs—the factory

A Prefabricated House by Any Other Name …

Much of the terminology used by the prefabricated housing industry is not standardized. The entire industry is sometimes referred to as constructing "factory-built" or "systems-built" housing. Below are definitions of key terms as they are used in this article.

Prefabricated Housing: Prefabricated housing refers to any housing for which construction occurs primarily off site. It includes manufactured, modular, kit, and panelized housing.

Manufactured Housing: Also called mobile homes or trailers, manufactured houses typically consist of a single module, almost entirely finished in the factory, placed on either a permanent or a temporary foundation. These homes are usually built to the standards of a national code maintained by the U.S. Department of Housing and Urban Development (HUD), which may be less stringent than state or local codes for site-built housing.

Modular Housing: Modular homes are built from two or more modules, which are constructed in a factory with most finish materials in place, transported by truck to the building site, and set on a permanent foundation with a crane. "Buttoning up" on site includes some interior finishing as well as connecting modules to each other and to the foundation. Modular housing is built to state and local codes, like site-built homes, and can use metal or wood structural framing.

Kit Housing: Made especially popular in the early 20th century by Sears, Roebuck and Company, kit homes arrive on site in bundles of precut parts, fasteners, and sometimes finish materials. Some companies provide just the framing material, and others provide finish materials as well.

Panelized Housing: In this type of house, panels are constructed in a factory, trucked to the site, placed on a permanent foundation with a crane, and assembled by crews. The panels may be constructed of individual studs and plates like walls built on site, or they may use some other technology such as foam-core structural insulated panels (SIPs). Panels can arrive on site either unfinished (as just the framing) or finished (including framing, insulation, sheathing, and drywall).

Site-Built Housing: Also called stick-built housing for the conventional framing method, site-built housing is built entirely on the house site, where all materials are delivered. Many site-built houses use at least some prefabricated components, from pre-hung doors to trusses.

makes it easier to store materials for future uses, and tracking waste is simpler on the assembly line. At Connor Homes, for example, workers save any piece of lumber over six inches (15 cm) long for future use, a practice made possible by long-term storage space in the plant.

Better energy efficiency

According to Andrew Gianino, owner of modular house distributor The Home Store, in Whately, Massachusetts, building in a factory has another advantage: houses are built from the inside out, making insulating and air-sealing easier. A typical module is first framed and wired, then drywall is added, allowing insulation to go in behind the drywall before sheathing is added to the exterior. This allows workers to apply foam sealant behind outlets and other breaks in the wall more easily than if they were working from the inside. Houses are also built lower to the ground, making tough-to-reach corners more accessible for insulating and sealing.

The air-sealing of the whole house is only as good as the sealing performed between modules on site, however. A 1993 study, part of the Energy Efficient Industrialized Housing project sponsored by the U.S. Department of Energy, tested 11 houses for airtightness—four modular houses, four panelized houses, and three houses built with SIPs—and compared them with air-leakage numbers for average site-built houses. The study found that, while the panelized and SIPs-built houses performed better in the leakage tests than an average site-built house, the modular houses did not achieve the "full potential of greater energy efficiency possible with factory construction." Among the major sources of leakage in the modular houses, found with infrared imaging, were gaps between the "marriage walls" that connect modules, which had not been effectively sealed.

The modular housing industry responded to these problems, and many manufacturers now offer Energy Star-certified homes, which are inspected in the factory by third-party raters and often inspected on site for air infiltration and duct leakage. It remains vital, however, that the general contractor performing the onsite work be familiar with modular construction and the procedure for ensuring a good seal between modules.

The move toward Energy Star, though, has not resulted in many more energy-efficient homes, according to Thayer Long, executive director of the National Modular Housing Council, which represents the industry in Washington, D.C. Energy efficiency has been difficult to sell to homeowners because "it's difficult for a buyer to understand that a $2,000 investment up front is equal to greater savings down the road." Andrew Gianino at The Home Store agreed, noting that he has sold few Energy Star homes due to their higher upfront costs.

Lower transportation impacts

A site-built house requires designers, contractors, and laborers to travel frequently to and from the site. Materials must also be delivered to the site, often in multiple small batches of less than a truckload. Although more commonly used in prefabricated construction, a crane may be needed on site if the project calls for prefabricated roof trusses, increasingly common in site-built houses.

Prefabricated housing involves centralized production: workers come to a factory each day to work on one or more houses, each of which is then shipped to its site. Materials are also shipped in bulk to the factory, often in full trucks. A site may be all the way across the country, but most sites are fairly close to the factory, since the industry is generally regional. Connor Homes, for example, serves mostly Northeast states from its factory in Vermont, but ships one or two homes to Mid-Atlantic states every year and recently shipped one home to British Columbia.

Transportation efficiency varies depending on the manufacturer, housing type, and site location. A two-story modular house might use four tractor trailers, each carrying one module, several support vehicles traveling with the modules, and one or more trucks containing fixtures, flooring, or other parts to be installed on site. A crane must also travel to the site along with any other machinery used to prepare the site and the foundation. Several workers must travel to the site to button up the house.

By contrast, a panelized house might be shipped in fewer trucks, since the detached panels take up

2005 Construction Method of Single-Family Homes by Region

Region	Site-Built		Modular		Panelized and Pre-Cut		Total
	Units (thousands)	% of total	Units (thousands)	% of total	Units (thousands)	% of total	
Northeast	112	85%	15	11%	5	4%	132
Midwest	288	94%	13	4%	6	2%	307
South	734	96%	14	2%	14	2%	762
West	432	99%	2	0.5%	2	0.5%	436
National	1566	96%	44	3%	27	1%	1637

Source: *Buildings Energy Data Book, 2006,* U.S. Department of Energy, September 2006

Prefabricated housing operates regionally, largely because of transportation costs. Both modular and panelized construction have a larger market share in the Northeast than in any other region.

less space than fully built modules. More components—kitchen cabinets, for example—must travel to the site individually, but they pack more tightly when not attached in a module. Technology is making transportation of panelized components more efficient: Bensonwood optimizes its transportation with the same three-dimensional computer-aided design (3D CAD) software used to design its homes. The software looks at the panels, timber frames, and other materials needed for the house and packs them into virtual trucks, maximizing the use of space so fewer trips are needed.

One way to control the transportation impacts of prefabricated construction is to discuss property and site selection as well as house orientation with potential clients. This discussion (if it happens at all) is often limited to house orientation on a predetermined site. Although some companies will work with clients to locate and purchase land, many, such as MKD, require that clients already own land before entering the design process. Encouraging prefabricated house designers, manufacturers, and distributors to expand their services to property and site selection would lessen the transportation impacts not only of construction but also of daily commutes to and from the home after construction is complete.

A small module, designed and built by EcoMOD students, is lowered onto its foundation in Charlottesville, Virginia. A module added to the historic house in the rear, along with the module in motion, added affordable housing units to the market. Photo: EcoMOD

Making It Affordable

Prefabricated housing has long been touted as a cost-saving building process, particularly in areas with high labor costs; modular and panelized houses take less time to build, thus lowering the amount of time one must pay for labor. This cost savings makes prefabricated housing a good choice for affordable housing, but green options such as increased insulation or environmentally friendly finish materials can currently raise costs, since the assembly line must be changed for a single house.

John Abrams, of the design-build firm South Mountain Company on Martha's Vineyard, Massachusetts, has looked at using both panelized and modular construction for affordable housing projects on the island. The specifications for the most recent project, a group of ten homes called Jenney Way, were demanding, meeting LEED for Homes Platinum standards: walls with an insulation value of R-31, R-50 ceilings, triple-glazed windows on all but the south-facing side of the house (where double-glazed windows were used), and air-sealing, as well as environmentally friendly finishes and components free of added urea formaldehyde throughout.

South Mountain approached two onsite framing subcontractors, two panelized-home manufacturers, one SIP manufacturer, and two modular-home manufacturers and asked for bids meeting the specifications of the project. One modular company could not meet the specifications and declined to bid. After adjusting for the level of finish provided by each company, all of the bids from prefabricated-housing manufacturers came in higher than the site-built option—some significantly higher.

Abrams attributes this finding to the prefabricated-housing industry's lack of experience with high-performance buildings. "Once you change the specs and go outside a manufacturer's comfort zone, costs go up," he said. Abrams noted that another firm built affordable housing on the island using modular homes, because, when building to code, the costs were equivalent. Other aspects of the project, including its location on an island, made modular construction less attractive environmentally, requiring more ferry space and trucks to transport modules. Despite the results of his inquiries, Abrams is hopeful about the future of prefabricated housing: "There's tremendous potential to do better with modular," he said.

John Quale, an assistant professor at the University of Virginia School of Architecture, runs EcoMOD, an educational curriculum designed around prototypes of environmentally friendly and affordable modular housing built using SIPs. Architecture, engineering, and landscape architecture students, very few of whom have construction experience, build all of the houses in a school-owned warehouse. "If you're trying to do sustainability," Quale said of affordable housing, "you're going to be using materials that are the same as, if not better than, those used in a market-rate home, so you need other strategies."

Those other strategies are surprisingly simple: smaller is better, simpler is better, and SIPs offer a balance of performance and affordability that works with unskilled labor—necessary for affordable housing organizations, which often rely on volunteers to build homes. The first strategy is straightforward: smaller houses have a lower environmental impact and are less expensive to build, even if per-square-foot costs are higher. The second, simplicity, is an opportunity to cut labor costs and increase the reliance on volunteer labor. Complications in the roof design or room layout often require specialists for finishing and air-sealing; simpler designs require less specialized labor, saving money.

Finally, the unique combination of SIPs and modular construction offers both ease of assembly and energy-efficient performance. The use of panels also offers flexibility. When EcoMOD builds a house for the local area, the students construct modules out of SIPs and ship them to the site on a truck. When they were working with Habitat for Humanity on a house in the Gulf Coast, however, they shipped the steel framing and panels separately because, Quale said, "it doesn't make sense to ship air." Although using SIPs with steel framing ultimately makes construction faster and easier for EcoMOD, Quale admits that they carry a learning curve, and the labor force would have to learn new skills to work with the system.

Tedd Benson of Bensonwood agrees that panelized construction can work well with volunteer labor. Although many of the features of his houses

Checklist for Environmental Prefabricated Housing

SITE	
Location	Locate the house on a previously developed site to encourage density and reduce ecological disruption. Both panelized and modular construction siting have access requirements that may limit the choice of site, including wide access roads for modules, height requirements for a crane, and bridges strong enough to support heavy vehicles.
Environmental Impacts	Stay away from fragile or sensitive areas and preserve as much of the existing ecology as possible. Limit access by construction vehicles to specific parts of the site.
Orientation	Position the building to take advantage of southern exposure for passive solar heating in the winter. Also consider solar gain in the summer and incorporate shading into the house design.
HOUSE DESIGN	
Small	Keep the house small to minimize material use and operating costs. Small houses can be transported in fewer modules or panels, lessening the transportation energy needed for construction.
Simple	Simplify layouts and roof lines to make construction easier—and to make it easier to seal from air and moisture infiltration. Keeping design simple also lowers labor costs.
Standardized	Customization often eliminates the efficiencies of factory-line production and raises costs. If many customizations are needed, consider panelized housing, which arrives on site less finished than does modular housing.
Energy Efficient	Look for a manufacturer who can offer a high-performance house with R-30 walls, R-50 ceilings, and triple-glazed low-e windows. These specifications may raise cost, especially with modular housing.
CONSTRUCTION	
Building Techniques and Materials	Look for a manufacturer using best practices for air-sealing, insulation, and material-saving advanced-framing practices. Ask about environmentally friendly materials such as certified wood, low-emitting finishes and materials, and cabinets with low levels of urea formaldehyde.
Factory Practices	Ask about waste management and recycling rates. Manufacturers realize the most savings on materials when they order in bulk; this practice also limits the number of shipments to the factory, lessening the amount of fuel used to transport materials.
Transportation	Choose a manufacturer with a factory close to the building site. The transportation of the house should take as few trucks as possible. Note that while panelized construction may be the answer for houses built far from a factory, it often requires contractors to make more trips to the site.
Buttoning Up	Use a general contractor accustomed to working with prefabricated housing. Ensure that proper air-sealing occurs between panels or modules and along the foundation. Onsite contractors should use the same specifications for finish work as the factory, including low-VOC paints and sealants.

are advanced, working with Habitat volunteers on the home in Walpole was simple: "Since our building and finish systems require very few fasteners anyway, the simple tools [the volunteers used] turned out to be appropriate and efficient," he said.

Bensonwood homes are typically built with a timber frame that is cut with computerized tools in the factory and assembled on site. The wall panels are designed with pop-out panels to make electrical wiring simpler to install and change (see *EBN* Vol. 12, No. 2). Benson is currently working with a German company on an electrical connector that will enable the company to prewire each panel at the factory and connect the wires between panels simply and easily on site. These methods, among others, save on labor costs and make the house more affordable to live in, since changes to major systems require less time and therefore less money.

Final Thoughts

Prefabricated housing has come a long way from the metal-skinned trailer of the past, in design, construction, and energy efficiency. Some companies are using the efficiencies of prefabrication to bring green design and materials to more affordable homes, but the industry as a whole has a long way to go to address environmental building concerns.

The strength of prefabrication—assembly-line efficiency—is also its weakness. Changing the specifications of a prefabricated home to add extra insulation or environmentally friendly materials requires a change in assembly-line procedure, which can be prohibitively expensive for a single house or a small group of houses. Thus, to realize the environmental potential for prefabrication, large segments of the industry should embrace better insulated, more energy-efficient houses with greener materials. In addition, the industry should begin to think about not only how it makes its houses but also where those houses are going, and discuss siting and transportation concerns with clients.

Moving the industry in this direction won't be easy, but it is possible. "If the demand is there," said Gianino, "I promise you the manufacturers are going to be there to meet it."

– Allyson Wendt

For more information:

National Modular Housing Council
Arlington, Virginia
www.modularcouncil.org

Bensonwood
Walpole, New Hampshire
www.bensonwood.com

Customized Structures, Inc.
Claremont, New Hampshire
www.customizedstructures.com

EcoMOD, University of Virginia
Charlottesville, Virginia
www.ecomod.virginia.edu

South Mountain Company
West Tisbury, Massachusetts
www.somoco.com

Xtreme Homes, LLC
Oroville, California
www.xhllc.com

From the Library

Websites Explain Energy Tax Incentives

The existence of the Energy Policy Act of 2005 (EPAct) is well known; the fact that it was extended through 2008 might also sound familiar; the financial and environmental opportunities that the Act, and other policies, create for builders, homeowners, and commercial building owners, however, are less understood. The following websites offer a variety of information.

The Tax Incentives Assistance Project categorizes federal and state tax incentives according to whom they benefit—consumers, businesses, and builders or manufacturers—and then further categorizes information on the incentives according to context, such as commercial buildings. ▪ www.energytaxincentives.org

The Database of State Incentives for Renewables & Efficiency (DSIRE) offers a list of incentives and clear, detailed information for renewables and efficiency incentives by state. ▪ www.dsireusa.org

The U.S. Department of Energy website explains what EPAct means for individuals and businesses, breaking it down according to product category, product type, and the relative tax credit. ▪ www.energy.gov/taxbreaks.htm

The Energy Star website includes a comprehensive chart of EPAct, specifying its relative tax credits according to product category and product type. It includes links to the proper tax forms as well as to information from product manufacturers. ▪ www.energystar.gov/index.cfm?c=products.pr_tax_credits

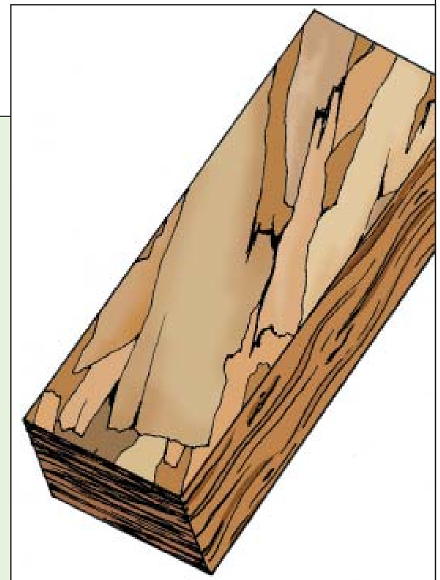
The IRS offers a website for homebuilders who can qualify for the Energy Efficient Home Credit through the end of 2008. ▪ www.irs.gov/newsroom/article/0,,id=154657,00.html

An IRS website for commercial property owners and leaseholders discusses who can qualify for energy efficiency tax deductions through the end of 2008. ▪ www.irs.gov/businesses/small/industries/article/0,,id=160505,00.html

An IRS website for homeowners addresses energy credits for energy-conscious purchases made through 2007. ▪ www.irs.gov/newsroom/article/0,,id=154658,00.html

– Rachel Navaro

BackPage Primer



Binders in Manufactured Wood Products:

Beyond Formaldehyde

Manufactured wood products—including plywood, oriented-strand board (OSB), laminated-strand lumber, particleboard, and medium-density fiberboard (MDF)—have the environmental advantage of being made from small-diameter or other low-quality trees or waste from wood-processing operations, conserving higher-quality timber. With these products, the wood is peeled into thin veneers, chipped into small strands or flakes, or ground into wood flour; in each case, the pieces are then glued to produce a durable and stable panel or lumber product.

Two glues, or binders as they are called in the industry, dominate the manufactured wood products industry: urea formaldehyde (UF) and phenol formaldehyde (PF). For interior-grade products, including particleboard, MDF, and hardwood plywood, UF binders have long been more popular because of their low cost and light color compared with PF binders. For exterior-grade applications PF binders are favored because of their better moisture resistance.

While UF binders are significantly less expensive than PF binders, they give off a lot more formaldehyde—a volatile compound that is classified as a known human carcinogen. Formaldehyde's other health impacts include respiratory problems; eye, nose, and throat irritation; allergic reactions; and depression. Its emissions can be recognized by the telltale sweet smell in most new kitchen and bath cabinets.

Partly due to concerns about formaldehyde emissions and in response to new California regulations that will restrict formaldehyde emissions (see *EBN* Vol. 15, No. 7), the industry has introduced other binders. SierraPine has long used methyl diisocyanate (MDI), a polyurethane binder, in its Medex and Medite II MDF, and since 2006 in its Arreis particleboard. MDI contributes to a better indoor environment for building occupants—once cured, it is extremely stable with virtually no offgassing—but it is extremely toxic in the factory.

Some OSB manufacturers have also used MDI, as does TrusJoist with its TimberStrand laminated-strand lumber. MDI is even more moisture-resistant than PF, making Medex appropriate for outdoor signage. Particleboard made from straw uses MDI instead of UF or PF binders—mostly because the MDI adheres better to the straw fiber. Several particleboard products, including Roseburg SkyBlend and SierraPine Encore, also use PF rather than UF binders (see *EBN* Vol. 14, No. 9 and Vol. 16, No. 8).

Given the concerns about formaldehyde, a lot of R&D is going into formaldehyde-free binders for manufactured wood products. Researchers at Oregon State University, inspired in part by the ability of mussels to form an extremely durable adhesion underwater, developed a formaldehyde-free, soy-based binder, now produced by Hercules and used in Columbia Forest Products' PureBond hardwood plywood (see *EBN* Vol. 14, No. 6).

Because most binders are more expensive than UF, we can expect manufactured wood product prices to increase to some extent as UF is eliminated.

Environmental Building News
122 Birge St., Suite 30 · Brattleboro, VT 05301

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A publication of BuildingGreen, Inc. · www.BuildingGreen.com