Environmental Building News™

The Leading Newsletter on Environmentally Responsible Design & Construction

A Publication of BuildingGreen, LLC www.BuildingGreen.com Volume 19, Number 6 · June 2010

Avoiding the Global Warming Impact of Insulation

Insulation is key to reducing carbon emissions from buildings. But the blowing agents in extruded polystyrene and spray polyurethane foam offset much of that benefit.

by Alex Wilson

TWO COMMON FOAM INSULATION materials are produced with hydrofluorocarbon (HFC) blowing agents that are potent greenhouse gases—extruded polystyrene (XPS) such as Dow Styrofoam of Owens Corning Foamular, and standard closed-cell spray polyurethane foam (SPF). While all insulation materials reduce greenhouse gas emissions (by saving energy), insulating with thick layers of either of these two particular foams results in very long "payback periods" for the global warming potential of the insulation, thwarting even the best attempts to create carbon-neutral buildings. The bottom line is that designers and builders aiming to minimize the global warming impacts of their buildings should choose fiber insulation (cellulose, fiberglass, or mineral wool) or non-HFC foam insulation.

"The more insulation the better" is a common refrain in the green building industry. *EBN* has long advocated very high levels of insulation, particularly in residential and small commercial buildings, which are skin-dominated. At the furthest end of the spectrum is the Passive House movement (see *EBN* Apr. 2010), where it is not uncommon to provide R-50 under a floor slab, R-60 in the walls, and as much as R-100 in the attic. High levels of insulation are seen as a key strategy for achieving net-zero-energy and carbon-neutral performance—the latter meaning that the building will have no net contribution to climate change.

How we achieve high levels of insulation is a very significant issue, however. We rarely pay attention to the fact that insulation materials themselves contribute to greenhouse gas emissions and global warming. This happens in two ways: through the embodied energy of the insulation (the energy use and greenhouse gas emissions that result from manufacturing

(continued on p. 9)

Photo: Bensonwood

Unaware of the recently reported GWP implications of certain foam insulation materials, builder Tedd Benson specified four inches of extruded polystyrene over 2x6 studs insulated with dense-pack cellulose in this net-zero-energy home.

In This Issue

***Feature Article* 1**
- *Avoiding the Global Warming Impact of Insulation*

***mail@BuildingGreen* .. 2**
- *Chemicals Article Lacked Balance*

***What's Happening*...... 3**
- *Cradle to Cradle Certification System Being Transferred to New Organization*
- *USGBC Launches LEED-ND*
- *Chinese Drywall Manufacturers Liable for Millions in Damages*
- *Energy Star Beefs Up Requirements and Enforcement*
- *EPA Proposes Disposal Rules for Coal Ash*
- *Newsbriefs*

***Product News & Reviews* 7**
- *CertainTeed Introduces a Formaldehyde-Free Batt Insulation*
- *Bamboo Dimensional Lumber? "Lumboo" Is Here*

***BackPage Primer* 16**
- *Power-Flushing with Pressure-Assist Toilets*

Quote of the month:

"Specifying a high-GWP insulation completely defeats the point of using it."

– Scott Shell, FAIA of EHDD Architecture commenting on new information on the global warming potential of insulation materials

(page 12)

ENVIRONMENTAL BUILDING NEWS (ISSN 1062-3957) is published monthly by BuildingGreen, LLC. *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.

Editorial & Subscription Office
122 Birge St., Suite 30, Brattleboro, VT 05301
802-257-7300 · 802-257-7304 (fax)
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Printed on New Leaf Opaque100: 100% post-consumer content. Chlorine-free process using Green-e certified renewable energy.

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Chemicals Article Lacked Balance

As a long-time reader of *Environmental Building News*, I have come to rely upon and respect your publication for its professionalism and unbiased reporting about new developments in the fields of sustainable design and construction. In fact, when asked by design professionals who are interested in increasing their "sustainability IQ" what publications I recommend, I always suggest *EBN* as the only publication that is indispensable.

As such, I was surprised to see the article "Chemistry for Designers: Understanding Hazards in Building Products" in the March 2010 issue. Unlike most of your publication's articles, this article lacked balance and presented the same unproven assertions about several widely used building materials, including PVC. While I recognize that some people have legitimate concerns about PVC and agree that it is important to have ongoing open dialogue, your article (and accompanying tables) presents only one side and lacks depth. I realize that you are attempting to distill complex information into more easily consumed segments, but this approach raises more questions than it answers.

For example, one table recommends replacing commercial carpets that contain PVC with carpets that meet the NSF-140 Platinum standard. The NSF-140 standard makes no reference to PVC in carpet. In fact, there are several types of carpet and hybrid resilient sheet flooring made with PVC that are certified to the NSF-140 Platinum standard.

Finally, while I appreciate the front-page acknowledgment of Tandus' C&A brand and our work with Kaiser Permanente in developing a new floor covering based on their preference to phase out the use of PVC, I do question the casual reference to the "proactive" manufacturers mentioned on page 11. While there's no doubt that some of these manufacturers have meaningful track records and are doing commendable work in reducing the environmental impacts of their products, wouldn't it be better to actually cite these? Exactly what have these companies done to develop and offer replacements? As presented in your article, the point is ambiguous, at best, and only contributes to the flood of greenwashing that *EBN* has been so effectively working to counter during the past several years.

Ross Leonard
Director of Marketing, Tandus

Editors' Response

We appreciate the substantive critique of "Chemistry for Designers." We too recognize the pitfalls in "attempting to distill complex information into more easily

Photo: Tandus

Tandus Ethos carpet-cushion backing is made from recycled film from auto glass.

consumed segments." However, given the widespread confusion in dealing with these issues, we decided that EBN *could best help our readers by providing perspective at an overview level—with many of the concerns described in this article having already been addressed at greater depth by previous* EBN *articles. We tried to describe the core complexity of the issues and the tradeoffs involved while also giving direction to designers on where to focus their efforts.*

The perspective on PVC presented here reflects EBN*'s position over the years—we have repeatedly expressed concerns about PVC, particularly about phthalates and other additives—while also making it clear that in some cases the feasible alternatives to PVC may be even less preferable. Similarly, our GreenSpec Directory sometimes includes PVC-based products that have other outstanding environmental attributes (e.g., weatherization assemblies), and excludes PVC-free alternatives that have been shown to have greater life-cycle impacts (e.g., cast-iron sewer pipe).*

Mr. Leonard is totally correct that NSF-140 does not specifically address PVC issues, nor some of the other concerns mentioned. It is our understanding that the NSF-140 Platinum standard may end up favoring PVC because of the recycled content requirement (it is easier to recycle PVC), but NSF-140 Platinum does require CA 01350 emissions testing and excludes PBDE flame retardants, which were also concerns grouped in the table. These were meant to be read as examples, as was the set of "proactive manufacturers" mentioned. While we feel this article provides needed guidance in a complex area, we certainly appreciate being taken to task by our readers when they feel the approach we've taken fails to reflect EBN*'s longstanding reputation.*

Correction

In our story on revolving doors (*EBN* May 2010), we left off at least one manufacturer from our list. Crane Revolving Doors, a subsidiary of DORMA group (www.dorma-usa.com), should have been included.

What's Happening

Major Changes With Cradle to Cradle Certification

McDonough Braungart Design Chemistry (MBDC) is in the process of transferring the Cradle to Cradle Certification system to the Green Products Innovation Institute (GPII), a recently formed, California-based nonprofit organization. In a high-profile news conference at the Google headquarters in Mountain View, California, on May 20, 2010, William McDonough was joined by Governor Arnold Schwarzenegger, Global Green executive director Matt Peterson, and leaders of Herman Miller, Shaw, and YouTube in announcing the formation of GPII, which is focused on "transforming the making and consumption of things into a regenerative force for the planet."

GPII will take over the review of Cradle to Cradle applications and issue certifications. Over the next few years, GPII will gradually assume management and further development of the Cradle to Cradle Certification protocols. To date, 100 companies have engaged in the Cradle to Cradle process, and 300 products currently carry the certification.

According the James Ewell, the director of consulting for MBDC, the transfer of the certification program to GPII was driven partly by confusion about the program and criticism that the party responsible for administration and maintenance of the program was not separate from the party that helps companies comply with the program requirements (see the feature article "Cradle to Cradle Certification: A Peek Inside the Black Box" in *EBN* Feb. 2007 and the editorial "Fixing the Perception Problem with Cradle to Cradle Certification" in *EBN* Mar. 2010). "We had a conflict of interest—at least it was perceived that way," Ewell told *EBN*. Under GPII, Cradle to Cradle Certification will be bestowed by an organization separate from MBDC.

In managing the Cradle to Cradle Certification system, GPII will train and certify assessors (called "Licensed Assessment Partners" or LAPs), who will assist manufacturers in complying with certification requirements as well as regulations of the California Department of Toxic Substances Control (DTSC). MBDC will help the Institute train LAPs until the Institute has the capacity to do so on its own. "In other words, we'll help create our own competition," quips Ken Alston, CEO of MBDC. In this process, MBDC will itself become an LAP and will continue to consult with the industry to apply the Cradle to Cradle framework to product and process design.

GPII also plans to develop an open, public database that "tracks product chemical data and also creates a list of 'positive' alternative chemicals, materials, and processes." Companies that participate in the GPII process will "voluntarily share information about the chemistry of their materials, along with manufacturing processes, to help transform the industry as a whole," according to the organization's website. To protect manufacturers' intellectual property, part of the database will be proprietary. The characteristics of specific chemicals used in these proprietary formulations will become part of the publicly available portion of the database and will be used in creating a list of chemicals, materials, and processes that are deemed to be safe.

During the transition period, MBDC will spend four to six months creating a Version 3 of the Cradle to Cradle certification system, which the institute will adopt and roll out.

When asked whether Version 3 of Cradle to Cradle will fix the terminology problem that *EBN* addressed in the above-referenced editorial (that at the lower levels of certification, Cradle to Cradle isn't really certification, but rather more of a review process), Alston told *EBN* that he thinks that concern will be resolved. "I'd say it is highly likely that there will be a "non-certified" lower level in the next generation of the certification program," he said.

– Alex Wilson

For more information:

Green Products Innovation Institute
San Francisco, California
www.gpinnovation.org

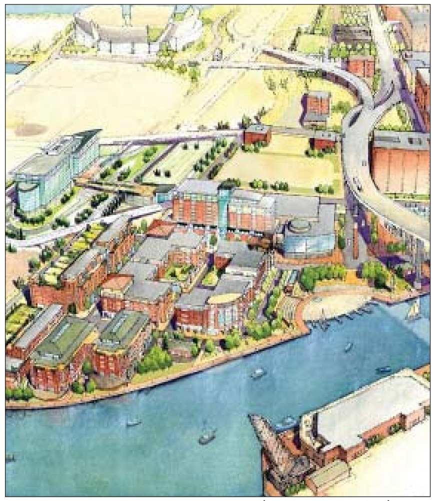
McDonough Braungart Design Chemistry
Charlottesville, Virginia
434-295-1111
www.mbdc.com

USGBC Launches LEED-ND

On April 29, 2010, the U.S. Green Building Council (USGBC) officially launched its LEED for Neighborhood Development (LEED-ND) rating system. A joint effort between USGBC, the Natural Resources Defense Council, and the Congress for the New Urbanism, LEED-ND incorporates principles of green building, smart growth, and new urbanism (see *EBN* Mar. 2009). All three organizations had to approve the final rating system before it was released.

Registration for LEED-ND is now open at LEEDOnline.com. Although not all of the credit forms are ready, one key form—for the Smart Location & Linkages prerequisite—is available because the prerequisite relates to site location, the earliest phase of a project. Submittal forms for the rest of the system will be available later in the year.

USGBC has also announced the costs for registration and certification through LEED-ND. Registration will cost $1,500 for all projects. Review of the Smart Location & Linkages prerequisite will cost $2,250. Certification fees will vary according to project size and are charged at each of the three stages of certification. Projects under 320 acres (130 ha) will be charged $18,000 plus $350 per acre over 20 acres (8 ha) for the first phase, and $10,000 plus $350 per acre over 20 acres for each subsequent phase. Projects with 320 or more acres will be charged flat fees of $123,000 for the first phase and $115,000 for each of the two subsequent phases.



Rendering: Forum Architects

The mixed-use Flats East District in Cleveland is pursuing LEED-ND certification.

– Allyson Wendt

For more information:

U.S. Green Building Council
www.usgbc.org/leed

Chinese Drywall Manufacturers Liable for Millions in Damages

Since 2008, Chinese-manufactured drywall has been blamed for severe corrosion and sulfur odors in homes, particularly in warm, humid, southern states. Now a federal judge, U.S. District Judge Eldon Fallon, has awarded seven Virginia families a total of $2.6 million in damages caused by drywall from one Chinese manufacturer. In another case, he awarded $164,000 to a single family to cover the costs of remediation. At the same time, remediation guidance issued by the U.S. Consumer Product Safety Commission (CPSC) for homes with Chinese drywall shows that these figures are not unreasonably high and may in fact match the costs faced by homeowners.

In his decision in the Virginia case, Judge Fallon wrote that Chinese-manufactured drywall contained a "significantly higher concentration of strontium and significantly more detectable levels of elemental sulfur" than that manufactured in the U.S. He also noted that the "level of corrosive sulfur gases emitted by Chinese drywall exceeded the safe level established by recognized standards."

The judge's findings are backed up by CPSC, which confirmed the link between the drywall and corrosion in 2009 (see *EBN* Jan. 2010). In both cases, Judge Fallon decided that drywall manufacturers were responsible not only for the costs of remediating the drywall damage but also the costs of relocating during the remediation process.

The remediation guidance issued by CPSC recommends that homeowners remove all problematic drywall and replace electrical components and wiring, gas service piping, sprinkler systems, and smoke and carbon monoxide alarms. This can be expensive: in one of Judge Fallon's cases, the family's remediation costs totaled over $113,000, not including relocation costs. According to David Jaffe, vice president of construction liability and legal research at the National Association of Homebuilders (NAHB), many builders are quoting costs of $100,000 and up for drywall remediation.

Jaffe told *EBN* that NAHB is working on its own remediation guidance document for members; he expects the guidance to be available before July 2010. He noted that CPSC is primarily concerned with consumer health and safety, so its guidance focuses on remediation of safetyrelated items in homes. "There are other aspects of remediation that don't affect health and safety," said Jaffe, such as salvaging expensive cabinetry while getting to the drywall behind it—a task that requires knowledge and time, both of which can raise costs.

– Allyson Wendt

For more information:

Consumer Product Safety Commission
www.cpsc.gov/info/drywall/index.html

Energy Star Beefs Up Requirements and Enforcement

The Energy Star program is overhauling its standards, certification process, and enforcement techniques—and its image—after the U.S. Government Accountability Office (GAO) reported that it was able to get bogus products approved.

In March 2010, GAO released a report about its experiences submitting 20 made-up products to Energy Star for certification, highlighting weaknesses in the program, which relies primarily on self-policing by manufacturers to maintain the label's integrity. These products ranged from the truly ridiculous—a gas-powered alarm clock—to those that seemed believable but included fake data that showed performance better than anything currently on the market. According to the report, "GAO found that for our bogus products, certification controls were ineffective primarily because Energy Star does not verify energy-savings data reported by manufacturers." The program did require confirmation of test results for two products, which were then rejected.

The agencies that oversee the Energy Star program—the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (EPA)—responded quickly to the findings, changing the program's policies and the way it approves products. By April 10, 2010, the agencies had stopped approvals of new products through Energy Star's self-certification and automated-qualification programs (which did not require staff member reviews). The Energy Star program now requires staff review of all products, as well as testing results backed up by reports from independent laboratories.

DOE and EPA began testing products that have already been certified, starting with the most common appliances such as refrigerators, washers, dishwashers, and water heaters. The agencies have also taken action against 35 manufacturers whose products carried the Energy Star label but did not meet Energy Star standards. Among these was LG Electronics, which had 21 refrigerators carrying the label—some sold under the Sears/Kenmore name—that failed to meet Energy Star standards. LG removed the Energy Star labels from those products and signed a memorandum of understanding with testing and certification firms Underwriters Laboratories, Intertek, and CSA International to have all of its products tested to ensure Energy Star compliance.

Energy Star is also strengthening the standards it uses for its homes label. New guidelines for the homes program, which go into effect in January 2011, will require that Energy Star homes exceed the 2009 International Energy Conservation Code by 20%. New requirements include enhanced air sealing and envelope insulation, higher-efficiency heating and cooling systems, and moisture control in the envelope.

– Allyson Wendt

Photo: Avanti

This refrigerator from Avanti is Energy Star certified. Some manufacturers had to remove Energy Star labels from products that did not meet the standards.

For more information:

Energy Star
www.energystar.gov

EPA Proposes Disposal Rules for Coal Ash

On May 4, 2010, the U.S. Environmental Protection Agency (EPA) issued a draft proposal for regulating the widely anticipated use and disposal of coal combustion residuals (CCRs), including coal fly ash, which is widely used in construction materials. The proposal comes in the wake of a large spill from a coal-ash holding pond in Kingston, Tennessee, in 2008 (see "Coal Ash in Spill Could Not Have Been Used in Concrete," BuildingGreen.com, Dec. 2008). Coal ash contains mercury, cadmium, arsenic, and other harmful substances. EPA has proposed two options for better regulating coal ash; after a 90-day public comment period, the agency will decide which option to pursue, modify the specifics based on input, and finalize its rule.

Both options proposed by EPA would regulate coal ash under the Resource Conservation and Recovery Act, the law that governs the use and disposal of solid waste. The first option would categorize coal ash as a "special waste" that could be disposed of only in permitted facilities built to specifications determined by EPA; these specifications would include special liners and other elements to prevent leakage. Facilities would be subject to federal and state regulation and enforcement. Under the second option, EPA would set performance standards for disposal facilities but would not have the authority to enforce them. Enforcement would come from lawsuits brought by citizens.

Although these specifications would be similar to those required for the disposal of hazardous waste, the proposed rule stops short of labeling coal ash as "hazardous." This pleases Tom Pounds, CEO of the fly ash-brick manufacturer CalStar (see *EBN* Jan. 2010), who worried that the hazardous waste label would impede the use of coal ash in building materials. One kind of coal ash, fly ash, is commonly used in concrete mixtures to replace portland cement, lowering the embodied energy and carbon footprint of the material. According to Pounds, "They [EPA] have done several things to address that concern." Both options proposed by EPA maintain what is called the Bevill exemption, which exempts coal ash used in products (like concrete) from the disposal requirements.

Questions have been raised about the exemption—some are concerned that toxins in the ash could escape from material when it is broken, drilled into, or demolished. Tom Lent of the Healthy Building Network asks, "Is storing it bound up in concrete in our walls better than in these landfills and slurry ponds? The science is ambiguous at best." But EPA notes, "We have no data showing that encapsulated uses pose a problem for human health or the environment." Bruce King, P.E., an expert on building with concrete, agreed. "Mixing fly ash into concrete is by far the most benign way of using it, or disposing of it, that I know of. Yes, there's some mercury, but evidence and testing to date doesn't make me worried about it."

The EPA rules will affect other CCRs, such as the flue-gas desulfurization gypsum (synthetic gypsum) used in a lot of drywall today, bottom ash, and boiler slag. According to EPA, however, the "beneficial uses" of these products will not be restricted.

The public comment period will end in August 2010; the public is invited to comment through EPA's website.

– Allyson Wendt

For more information:

U.S. Environmental Protection Agency
www. epa.gov/epawaste/nonhaz/industrial/special/fossil/ccr-rule/index.htm

Newsbriefs

Rebuilt Kansas Community Now Powered Completely by Wind—On May 4, 2007, Greensburg, Kansas, was hit by a tornado that destroyed 95% of the town. Three years later, the town of 1,400 has become a clean energy success story, complete with a new wind farm that powers the entire community (see *EBN* Feb. 2008). Developed by John Deere Renewables, the Greensburg Wind Farm began operating in March 2010 and generates more than enough energy to power all of the town's homes and businesses on an annual basis. The 12.5 MW farm includes ten turbines that are rated at 1.25 MW each. Surplus renewable energy credits are being purchased by NativeEnergy, a green energy retailer, and sold as carbon offsets. Greensburg was recently honored with an Edison Green Award, which recognizes communities that work to minimize their carbon footprint while creating green collar jobs and improving community health and self-sufficiency. For more information, see www.greensburggreentown.org.

NSF Develops Sustainability Standard for Resilient Flooring—Independent standards developer NSF International, in conjunction with the American National Standards Institute (ANSI), recently finalized American National Standard 332: Sustainability Assessment Standard for Resilient Floor Coverings. Operating on a point-based system, the standard uses four levels of certification—conformant, silver, gold, and platinum—and covers a range of products, including vinyl composition tile, vinyl and rubber sheet flooring, and linoleum sheet flooring and tile. Product evaluation, according to NSF, is based on informed design, intelligent manufacturing, long-term value, progressive corporate governance, and innovation. Standard 332 is founded on principles such as the ISO 14000 series standards on life-cycle assessment and was subject to public comment and voting for two years before its approval in the spring of 2010.

U.S. Greenhouse Gas Emissions Plummeted in 2009—Emissions of greenhouse gases (GHG) associated with energy use were down 7% in

Photo: Joah Bussert

These 1.25 MW wind turbines produce enough electricty to power the entire town of Greenburg, KS.

2009 compared to 2008, according to the U.S. Energy Information Administration (EIA). That's the largest single-year decline in emissions since the agency began keeping data on energy consumption (from which GHG data are derived) in 1949, more than 60 years ago. EIA attributes some of the fall in emissions to the economic downturn but also points to a decline in the energy intensity of the economy as well as the carbon intensity of the energy supply. Total energy consumption during 2009 fell across all sectors, most notably in the industrial sector, where consumption dropped by nearly 10%. Meanwhile, the carbon intensity of the energy supply decreased mainly in the electric sector, where the price of coal rose while the relative price (per Btu) of natural gas fell dramatically. For more information, visit www.eia.doe.gov/oiaf/environment/emissions/carbon/index.html.

GSA Pledges to Pursue Zero Environmental Footprint—At the U.S. Green Building Council's Federal Summit in Washington, D.C., on May 18, 2010, U.S. General Services Administration (GSA) administrator Martha Johnson announced a bold new goal for the agency responsible for all the facilities of the federal government: net-zero environmental footprint. Johnson stressed that the key word was "eliminate"—not "limit"—the impact of the federal government on the environment. GSA has long been a leader in the push for more sustainable building practices. Johnson proposed that GSA could achieve a zero footprint by using federal buildings to test new technologies, focus on occupants as well as building design, encourage smart-grid-capable design, purchase only green products, run the federal fleet on alternative fuels, and develop metrics and methods for tracking progress towards green goals.

Product News & Reviews

CertainTeed Introduces a Formaldehyde-Free Batt Insulation

CertainTeed has introduced Sustainable Insulation, a fiberglass batt insulation that uses a formaldehyde-free, bio-based binder to hold the fibers together. CertainTeed's Sustainable Insulation joins Johns Manville's batt insulation (acrylic binder) and Knauf's EcoBatt (bio-based binder) in the formaldehyde-free fiberglass insulation market.

Most fiberglass batt insulation is made with phenol formaldehyde or urea-extended phenol formaldehyde to bind the glass fibers together. And though formaldehyde exists naturally at low levels in the atmosphere, it is labeled a known carcinogen by the International Agency for Research on Cancer (IARC).

Formaldehyde emissions from fiberglass are often low enough to pass California 01350 emissions standards (all of CertainTeed's fiberglass batts are certified through GreenGuard Children & Schools and CA 01350), but in high enough concentrations formaldehyde can negatively impact indoor air quality, as shown by the FEMA trailers contaminated by particleboard held together with formaldehyde-based adhesives (see *EBN* Apr. 2008). Tom Lent of the Healthy Building Network advocates formaldehyde-free insulation materials, claiming the levels of formaldehyde emitted from some building assemblies that use fiberglass insulation are higher than CA 01350 testing indicates. Although the insulation industry may disagree with Lent's assertions, minimizing the use of formaldehyde-based products in today's airtight buildings is a reasonable precaution.

CertainTeed would not divulge the plant source or chemical composition of its bio-based binder, so assessing Sustainable Insulation's overall environmental impact is difficult. But Robert Brockman, the company's marketing manager for residential and commercial insulation products, told *EBN* that the binder's initial chemical composition is similar to that of sugar. A chemical reaction transforms the binder into the final product, which is no longer a food source and should be as durable as phenolic binders.

Sustainable Insulation has the same R-value as CertainTeed's standard insulation, around R-3.2 per inch, and contains the same amount of recycled content at around 35%, with approximately 4% from post-consumer sources such as glass bottles. The Canadian version uses a different glass source and contains 65%–70% recycled content, all of it post-consumer. According to Brockman,

Photo: CertainTeed Corporation

Free of dyes or pigments, Sustainable Insulation's mottled tan color is the result of the manufacturing process.

the Canadian product contains more post-consumer recycled content because there is more high-quality recycled glass available for use in the Alberta, Canada, plant than for the facility in California.

CertainTeed, an Energy Star Partner of the Year, should be commended for improving the environmental performance of its fiberglass, but the company is marketing Sustainable Insulation as having 50% rapidly renewable content, counting both the sand and the binder in that calculation. The company claims that erosion and geological forces are always producing sand, similar to statements found in a report by the North American Insulation Manufacturers Association (NAIMA) entitled "Using Recycled Materials is Just the First Step Toward Safeguarding the Environment." While sand, the primary ingredient of most fiberglass, is plentiful, it is not considered a rapidly renewable resource in most circles. LEED limits the term—and the points it awards—to materials that come from either animals or plants and those that "have a harvest cycle of ten years or less." Sustainable Insulation's plant-based binder is considered rapidly renewable, but the small amount in the product would likely not be enough to garner an MRc6 LEED point.

Sustainable Insulation is available unfaced or kraft-faced in the same thicknesses (2½–10¼ inches or 6.4–26.0 cm) and widths (11–48 inches or 28–122 cm) as CertainTeed's standard fiberglass batts. Because Sustainable Insulation contains no dyes or pigments, it is a mottled tan color, similar to Knauff's EcoBatt, setting it apart from CertainTeed's standard yellow fiberglass or Owens Corning's ubiquitous pink fiberglass.

CertainTeed is manufacturing Sustainable Insulation in its Chowchilla, California, and Redcliff, Alberta, plants and is currently distributing it in California and western Canada. In those areas, the cost should be comparable to that of the company's standard fiberglass insulation. *EBN* checked with California's Pacific Supply, which supplies building products to the construction industry, and was told that Sustainable Insulation was actually priced slightly lower than the standard product. Brockman said shipping costs would rise as one gets further from the manufacturing centers. CertainTeed plans to roll out the product from west to east as more factories begin producing it, but the company is not committing to replacing its standard formaldehyde-based products with its new bio-based binder at this time.

– Brent Ehrlich

For more information:

CertainTeed Corporation
Valley Forge, Pennsylvania
800-233-8990
www.certainteed.com

Bamboo Dimensional Lumber? "Lumboo" Is Here

Dimensional lumber has defined the "stick-built" home for decades, but bamboo stalks were used for centuries before 2x4s came along. Now a trendy green material, bamboo is angling in on its old turf.

Cali Bamboo, a maker of bamboo flooring and other products since 2004, launched Lumboo, a product line of dimensional bamboo lumber, in March 2010, four years after beginning development of the product. Like other bamboo wood products currently sold, Lumboo is manufactured by gluing strips of bamboo together into a block (see *EBN* Mar. 2006). According to Jeff Goldberg, Cali Bamboo CEO, the company has not firmly settled on a binder despite the fact that Lumboo is in production, but he said it will probably be phenol-formaldehyde-based and urea-formaldehyde-free.

This block of strips is mechanically compressed under hundreds of thousands of pounds of pressure in a process that makes the product denser. The blocks are milled into 1x4, 2x4, 2x6, and 4x4 products, although due to the strength of the product, the actual sizes are much smaller than their nominal sizes (see table). Lumboo is made in China and distributed from several points in the U.S. by Cali Bamboo.

Product	Actual Dimensions (in.)	Weight (lbs)	Cost (plus freight*)
1x4, 8 ft.	0.5 x 3	4.5	$5
2x4, 8 ft.	1 x 3	9	$8
2x6, 8 ft.	1 x 5	15	$14
4x4, 8 ft.	3 x 3	27	$25
4x4,10 ft.	3 x 3	34	$35

*The product ships from warehouses in Southern California, Pennsylvania, or Ontario. Source: Cali Bamboo

Lumboo has not undergone formal testing for code listing from the International Code Council (ICC) and is currently being sold by Cali Bamboo for fencing, said Goldberg. He told *EBN* that decking and even framing lumber in homes are on the horizon, especially if the company can bring the price down. Due to its density, Lumboo won't take nails and should be pre-drilled. It can be cut with a normal miter saw, but a sharp blade is recommended.

Cali Bamboo claims that Lumboo is termite-resistant, noting on its website: "The high silica content of bamboo cannot be digested by termites." Goldberg said that Cali Bamboo does not have testing data to support that claim (or any testing on overall decay resistance), noting that it is a well-known attribute of bamboo. The possible decay resistance of Lumboo is intriguing, and *EBN* looks forward to data from Cali Bamboo on both that and structural properties.

– Tristan Roberts

For more information:

Cali Bamboo
San Diego, California
858-200-9540
www.calibamboo.com

Avoiding the Global Warming Impact of Insulation *(from page 1)*

and transporting the material); and, with some foam insulation materials, through the leakage of blowing agents that are highly potent greenhouse gases.

Understanding Embodied Energy and GWP

Researcher Danny Harvey, Ph.D., of the University of Toronto, sounded the alarm about the climatic impacts of blowing agents used in certain foam insulation materials in a technical paper in the August 2007 issue of the journal *Building and Environment*. Daniel Bergey of Building Science Corporation presented a synopsis of Harvey's research at the Northeast Sustainable Energy Association (NESEA) Building Energy Conference in March 2010.

With the help of Bergey and John Straube, Ph.D., P.Eng., of Building Science Corporation, *EBN* reexamined the assumptions Harvey used, included new information about the blowing agents in use today (which differ from what Harvey assumed), and calculated the payback on the lifetime global warming potential (GWP) of insulation materials.

All insulation materials take energy to manufacture and transport—something we refer to as *embodied energy*. We consulted the Inventory of Carbon and Energy (ICE), developed by Geoff Hammond and Craig Jones of the Department of Mechanical Engineering at the University of Bath in the U.K., for values of embodied energy and embodied carbon for different insulation materials. Although its figures are based on European (rather than North American) data on the energy used to produce and transport building materials, ICE offers the most accessible, current information available on embodied energy. Using this data and information about insulation performance, we can calculate the *embodied GWP* of these insulation materials. Currently, ICE does not address blowing agents.

Blowing agents

When insulation materials are made with halocarbon blowing agents (compounds containing halogens, such as chlorine or fluorine), the GWP of those gases far outweighs the embodied GWP that results from the embodied energy of the insulation materials.

Blowing agents create tiny bubbles of low-conductivity gas in closed-cell foam insulation materials. Chlorofluorocarbons (CFCs) were originally used as blowing agents for polyisocyanurate (polyiso), extruded polystyrene (XPS), and closed-cell spray polyurethane foam (SPF). After it was discovered in the 1970s and '80s how damaging CFCs are to the Earth's protective ozone layer, they were replaced with "second-generation" hydrochlorofluorocarbon (HCFC) blowing agents, which had lower ozone depletion potential (ODP), as required by provisions of the *Montreal Protocol on Substances That Deplete the Ozone Layer*.

These second-generation HCFC blowing agents were required by the Montreal Protocol to be phased out at the beginning of 2010; some have been replaced with "third-generation" HFC blowing agents. While these HFCs have zero ozone depletion potential, they are quite potent greenhouse gases. Initially, there was little focus on this property of halocarbon blowing agents, but concern about GWP of foams is growing. Blowing agents

Table 1. ODP and GWP Values of Blowing Agents Used in Foam Insulation

Type of Insulation	Blowing Agent	Atmospheric lifetime (yr)	ODP[1]	GWP[2]
Polyisocyanurate				
Original	CFC-11	45	1	4,750
2nd Generation	HCFC-141b	9.3	0.11	725
3rd Generation	Pentane, cyclopentane	A few days	0	7[3]
Spray Polyurethane				
Original	CFC-11	45	1	4,750
2nd Generation	HCFC-141b	9.3	0.11	725
3rd Generation	HFC-245fa	7.2	0	1,030
3rd Generation	CO_2	variable	0	1
Extruded Polystyrene (XPS)				
Original	CFC-12	100	1	10,900
2nd Generation	HCFC-142b	17.9	0.065	2,310
3rd Generation	HFC-134a[4]	13.8	0	1,430

1. Ozone-depletion potential (ODP) values from U.S. EPA using Montreal Protocol sources. ODP values are relative to CFC-11, which is defined as having a value of 1.0.

2. Global warming potential (GWP) values from EPA using IPCC Fourth Assessment Report values; 100-year time horizon assumed. GWP values are relative to CO_2, which is defined as having a value of 1.0.

3. From L.D. Danny Harvey, "Net climatic impact of solid foam insulation produced with halocarbon and non-halocarbon blowing agents" in *Building and Environment*, August 2007 (Vol. 42, Issue 8).

4. Despite repeated inquiries, XPS manufacturers declined to say what their post-HCFC blowing agent is, and MSDS information has not been updated; the blowing agent is assumed here to be HFC-134a, though it may be a mix of HFC and hydrocarbon.

used in common foam insulation materials—both historically and today—are shown in Table 1 on previous page.

Lifetime GWP of insulation materials

By combining information about the GWP of the blowing agent in foam insulation (the quantity used in the foam and assumptions about how much leaks out over time) with the embodied GWP based on the embodied energy, we can calculate the *lifetime GWP* of an insulation material. Lifetime GWP is presented in Table 2 below. The data in this table has been normalized by square-foot R-value (far right column) to provide a common basis for comparison. Note that the values are highly dependent on assumptions; we chose conservative assumptions—key among them the assumption that 50% of the HFC blowing agent in foam will never leak out over the lifetime of the insulation. (Harvey assumed more rapid loss of blowing agents in his analysis.) In our analysis, we don't address the *rate* of loss, per se, only that 50% of the gas will leak out over its *lifetime*—which could be 50 years or 500 years; what happens to the foam during disposal has a significant effect on whether the blowing agent is released into the atmosphere. There is currently very little information on the lifetime of blowing agents in foam insulation; we hope that the U.S. Environmental Protection Agency or manufacturers will conduct research on this issue, which has tremendous bearing on the lifetime GWP of insulation materials.

Calculating GWP payback

The next step is calculating the "payback" of the lifetime GWP in insulation materials. By reducing heat loss and unwanted heat gain, any insulation material reduces the use of fossil fuels or electricity required for heating and cooling buildings. In so doing, these insulation materials reduce emissions of carbon dioxide (CO_2), a greenhouse gas that contributes to global climate change. We want to know how many years of energy savings it will take to *pay back* the lifetime GWP of the insulation to figure out whether it's a good idea to use that insulation material in our low-energy buildings. Another way to think about this is how many years of energy savings will be required to "break even" on the GWP of the insulation.

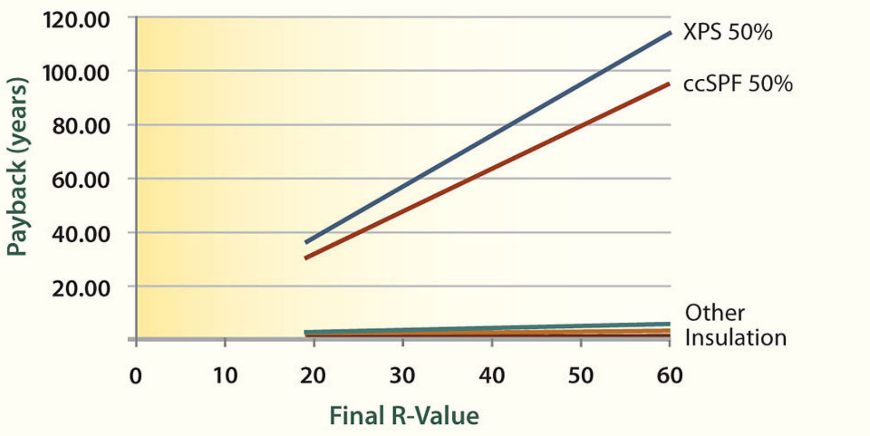
In the graphs on page 11, we have plotted this GWP payback of various insulation materials. These calculations are climate-specific and based on computer modeling. The graphs show the payback of the lifetime GWP of different insulation materials plotted as a function of final R-value in the moderately cold climate of Boston. We assume that

Table 2. Embodied GWP of Common Insulation Materials

Insulation Material	R-value R/inch	Density lb/ft^3	Emb. E MJ/kg	Emb. Carbon $kgCO_2/kg$	Emb. Carbon $kgCO_2/ft^2 \cdot R$	Blowing Agent (GWP)	Bl. Agent kg/kg foam	Blowing Agent GWP/ bd-ft	Lifetime GWP/ $ft^2 \cdot R$
Cellulose (dense-pack)	3.7	3.0	2.1	0.106	0.0033	None	0	N/A	0.0033
Fiberglass batt	3.3	1.0	28	1.44	0.0165	None	0	N/A	0.0165
Rigid mineral wool	4.0	4.0	17	1.2	0.0455	None	0	N/A	0.0455
Polyisocyanurate	6.0	1.5	72	3.0	0.0284	Pentane (GWP=7)	0.05	0.02	0.0317
Spray polyurethane foam (SPF) – closed-cell (HFC-blown)	6.0	2.0	72	3.0	0.0379	HFC-245fa (GWP=1,030)	0.11	8.68	1.48
SPF – closed-cell (water-blown)	5.0	2.0	72	3.0	0.0455	Water (CO_2) (GWP=1)	0	0	0.0455
SPF – open-cell (water-blown)	3.7	0.5	72	3.0	0.0154	Water (CO_2) (GWP=1)	0	0	0.0154
Expanded polystyrene (EPS)	3.9	1.0	89	2.5	0.0307	Pentane (GWP=7)	0.06	0.02	0.036
Extruded polystyrene (XPS)	5.0	2.0	89	2.5	0.0379	HFC-134a[1] (GWP=1,430)	0.08	8.67	1.77

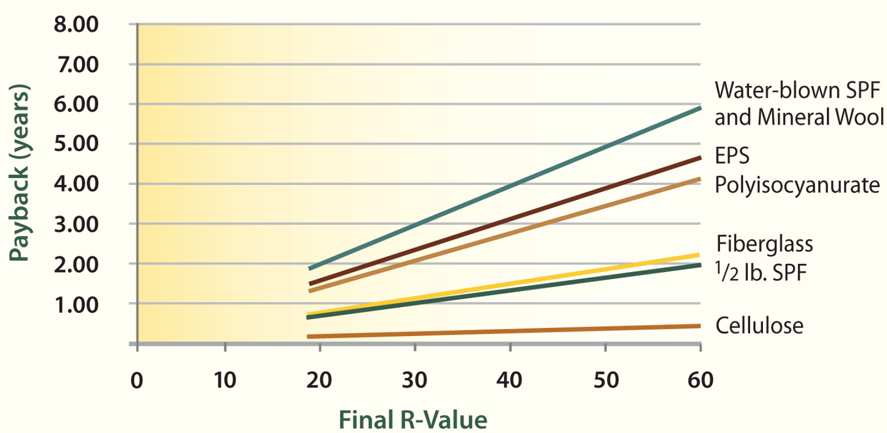
1. XPS manufacturers have not divulged their post-HCFC blowing agent, and MSDS data have not been updated. The blowing agent is assumed here to be HFC-134a.

Figure 1. Lifetime GWP Payback XPS & SPF



The lifetime GWP payback of extruded polystyrene (XPS) and standard closed-cell spray polyurethane foam (SPF), both of which are produced with HFC blowing agents, compared with other insulation materials. The analysis assumes that 50% of the blowing agent is lost over the life of the material.

Figure 2. Lifetime GWP Payback – Other Insulation



The lifetime GWP payback of various non-HFC insulation materials shown at a scale allowing comparison. In this analysis, closed-cell, water-blown SPF and rigid mineral wool are nearly identical, so those graphs cannot be distinguished.

Assessment of the *Incremental* GWP Payback from Added Insulation

In his original journal article in *Building and Environment*, Harvey examined not only the global warming payback of insulation materials on a *total* basis (examining the payback from the lifetime GWP of the entire amount of insulation in the system) but also the *incremental* GWP payback from adding insulation. In the latter analysis, he models the energy savings for lifetime GWP of the last increment of insulation—and the results are far more dramatic: paybacks in the hundreds of years for high-R-value increments. Building science experts John Straube and Terry Brennan argued that this is a flawed approach. "You need to look at the overall package, not the marginal," Brennan told *EBN*. Life-cycle assessment (LCA) expert Greg Norris agreed that the focus on total insulation was more appropriate than on marginal additions of insulation. For this reason, we are presenting only results that show the payback on the total insulation.

heat is provided by a 90%-efficient gas furnace, and we do not account for any change to airtightness as a result of adding insulation. To provide a consistent basis of comparison, we assume that the insulation in question is added to a 2x6 wall insulated with fiberglass insulation (whole-wall R-value of R-14). This is a common application for foam insulation materials, though not for fiber insulation materials, such as fiberglass and cellulose.

The results show, first of all, that the GWP payback is very rapid for all insulation materials that are produced without HFC blowing agents. In adding R-25 of polyiso (about 4 inches) to an insulated 2x6 wall, for example, the payback of the lifetime GWP of the polyiso is about 2.7 years; going all the way to R-60 with 7.5 inches of polyiso would increase that GWP payback to only slightly over 4 years. With cellulose, the GWP payback is always less than one year, even at R-60.

With XPS and standard closed-cell SPF (produced with HFC-245fa), the GWP payback is much longer. With one added inch of XPS (R-5) the GWP payback is about 36 years; with two inches, the payback is 46 years; and with four inches the payback jumps to 65 years. Adding the same R-value increments of standard closed-cell SPF yields GWP paybacks of 30, 38, and 54 years respectively. (Because the R-value per inch of this SPF is somewhat higher than R-5/inch, those GWP paybacks result from somewhat thinner layers.)

Assumptions are key in this analysis. In a climate colder than Boston's, the energy savings from the insulation will be greater, so the time required to pay back the lifetime GWP of the insulation will be shorter. In a warmer climate, the payback will be longer. If we were to assume that 100% of the HFC blowing agent leaks out over the life of the insulation, the payback periods of XPS and standard SPF would nearly double.

What This Means for the Way We Build

EBN spoke with several environmentally concerned designers and builders about the issue of GWP payback of insulation materials. Even though it's a complex and confusing issue, we found that interest is strong (at least among this subset of the building industry), and the information could significantly change building practices.

According to Scott Shell, FAIA, a principal at EHDD Architecture in San Francisco, "combating global warming is the most critical issue, and specifying a high-GWP insulation completely defeats the point of using it." Shell told *EBN* that he had become aware of this issue and his company is "moving aggressively to eliminate these [HFC-blown foams] on all of our projects."

"This information will influence our product selection profoundly," says David Foley, of Holland and Foley Architecture in Northport, Maine. "We do what we do for many reasons, but anthropogenic climate change is among the most important," he told *EBN*. "Talk about an inconvenient truth!"

Larry Strain, FAIA, of Siegel & Strain Architects in Emeryville, California, told *EBN* that this information "will definitely influence our product selection." His company has already started eliminating foam insulation from its projects because of concerns about halogenated flame retardants. "If it takes up to 60 years to recover the GWP from manufacturing the foams," he said, "it gives us another, even stronger, reason to find alternatives."

Nico Kienzl, of the environmental design consulting and lighting design firm Atelier Ten in New York City, told *EBN* that his firm has looked qualitatively at embodied energy and GWP in the past, and that has influenced what the company recommends ("our preferred choice being mineral wool"). "More quantitative information will be valuable in informing a discussion that often seems to be too single-mindedly focused on more insulation being always better," Kienzl said.

Shell says that "there are reasonable replacements in the vast majority of cases: polyiso for roof insulation, dense-pack cellulose or low-density spray foam (such as Icynene) instead of high-density, and rigid mineral fiber for walls above and below grade." There remain some challenges, according to Shell. "We still need to look into finding suitable products for plaza deck insulation, where paver pedestals need good structural bearing capacity; and similar for below slabs-on-grade."

EHDD just vetoed closed-cell spray foam for a Passive House the company is designing. "We're using Icynene in the framed floor over a crawl space, and dense-pack cellulose in walls and ceilings," said Shell. Rather than relying on SPF for air sealing on walls, Shell is sealing the joints of exterior sheathing with a self-adhered flashing, such as Vycor (from Grace Construction Products). "This is a better and cheaper approach than trying to use spray foam as an all-in-one solution," he said.

EHDD also recently eliminated XPS from the Packard Foundation net-zero-energy office building the company is designing," due to high GWP and toxics." In its place, the company is specifying Roxul mineral wool (see *EBN* Oct. 2009) both above and below grade.

On its Yosemite Institute project, Siegel & Strain Architects has eliminated almost all foam, except under slab and slab edge. "We may take another look at that now as well," says Strain.

Tedd Benson, president of Bensonwood in Walpole, New Hampshire, and a well-known leader in the timber-frame construction field, has been refining insulation systems for decades. "We have been trying to make our production more efficient and simultaneously improve the performance and environmental characteristics of our wall and roof systems," Benson told *EBN*. The company's current wall system—the OBPlus Wall—is the latest in

Photo: John Straube

John Straube used a tongue-and-groove EPS instead of XPS for insulating beneath the concrete slab in a deep-energy retrofit of his home.

that evolutionary process, relying entirely on cellulose insulation between wood I-studs. "We didn't have the benefit of your research when we developed the OBPlus Wall," says Benson, "but I was happy to see that we look even wiser now than we thought we were." The company's foam insulation decisions are focused on the use of SIPs on some of its roof assemblies and below-grade requirements. "Your article will definitely guide us toward better decisions in these areas."

Paul Eldrenkamp, of the residential remodeling company Byggmeister, in Newton, Massachusetts, and a Passive House consultant, had already been moving away from SPF when he heard Daniel Bergey's presentation at the NESEA Building Energy conference. He had done this for three reasons:

> First, spray foam (open-cell certainly, but also closed-cell) is much harder to install well than most people realize. We only began to understand this after we started testing every insulation job with a blower door. Second, installers do not protect themselves anywhere near well enough from the side effects of frequent exposure to the material before it's fully cured. And third, the high fossil fuel content probably means the price of spray foam will track the price of petroleum, whereas cellulose, for instance, will likely always be a fraction of the cost of spray foam for a given R-value—so we shouldn't forget how to insulate with cellulose.

Eldrenkamp notes that his company still does use a small amount of closed-cell SPF for strategic air sealing. "We believe that CCSF [closed-cell SPF] is uniquely effective and appropriate in old basements," he told *EBN*. "We have done one deep-energy retrofit in which we sprayed CCSF on the exterior cladding before adding new cladding; we've decided that, going forward, we'll strip the cladding and apply rigid PIR [polyiso] instead."

Avoiding High-GWP Insulation Materials

APPLICATION	ALTERNATIVE
Alternatives to extruded polystyrene (XPS)	
Wall sheathing	Polyisocyanurate installed on exterior or interior
	Expanded polystyrene (EPS) – higher-density recommended for greater compressive strength
	Avoid insulative sheathing; use cavity-fill insulation with control of thermal bridging (offset studs, etc.) and a separate air barrier
Below-grade foundation walls	High-density EPS on exterior
	High-density rigid mineral wool or rigid fiberglass on exterior
	Interior insulation (polyiso, rigid mineral wool, other fiber insulation)
Below-grade sub-slab	Rigid mineral wool if compressive strength is adequate (confirm with structural engineer)
	Foamglas (significant cost increase)
	EPS – some suggest a minimum 1.5 lb/ft^3 density for compressive strength and moisture resistance (may be difficult to find)
Roof sheathing (below membrane)	Polyisocyanurate
Roof – inverted membrane	Foamglas (significant cost increase)
Alternatives to spray polyurethane foam (SPF) made with HFC-245fa blowing agent	
Wall and roof cavity	Open-cell SPF (increased thickness to achieve comparable R-value)
	Cavity-fill fiber insulation (increased thickness to achieve comparable R-value)
Envelope air-sealing layer	Water-blown open-cell SPF or thin layer of closed-cell SPF with cavity-fill insulation
	Provide air barrier with separate layer, such as exterior panel sheathing with self-adhered flashing or tape over joints
Interior insulation over rough foundation wall	Water-blown closed-cell SPF (installation problems have been reported with water-blown formulations; obtain performance guarantee and inspect carefully for shrinkage or adherence problems).

Other Concerns With XPS and SPF

Along with the global warming potential of the HFC blowing agents in XPS and standard closed-cell SPF, there is also the issue of flame retardants. All foam insulation materials today are made with halogenated (chlorine- or bromine-based) flame retardants, and there is increasing concern about the health and environmental impacts of these compounds (see "Polystyrene Insulation: Does it Belong in a Green Building?" in *EBN* Aug. 2009 and "Flame Retardants Under Fire" in *EBN* June 2004).

If we replace HFC-blown foam insulation materials with fiber insulation alternatives, such as dense-pack cellulose installed in double-wall or Larsen-truss (curtain-truss) wall system, we can avoid the use of halogenated flame retardants. We can also continue pushing for foam insulation manufacturing to shift to safer, phosphorous-based flame retardants and composite manufacturing with layers that are fire-proof. While the foam insulation industry is transitioning to blowing agents that do not contribute significantly to global warming, it should also focus on addressing this other concern.

Other issues with SPF are quality control during installation and potential performance problems, particularly with the relatively new water-blown alternatives to HFC-blown SPF. With SPF insulation, the installer is essentially *manufacturing* the insulation in place. The process involves precisely mixing two components at the right temperatures and allowing the material to expand and cure (a process that uses water vapor from the air). Because curing SPF is an exothermic (heat-generating) reaction, manufacturers recommend installing no more than two inches (50 mm) at one time—and this is very hard to control, particularly in a cavity between framing members that are close together. If the foam builds up significantly thicker than two inches, there is potential for problems, such as offgassing of harmful chemicals or improper adherence or shrinkage. In short, proper installation of SPF requires a highly skilled installer and, even then, there are risks of performance and offgassing problems that are not well understood.

The Future of Foam Insulation

Manufacturers are working to develop and deploy *fourth-generation* blowing agents that have zero or very low GWP while still providing the various performance and safety properties that are required. Such developments would alter the conclusions of this article. Both Dupont and Honeywell are working on hydrofluoroalefin (HFO) blowing agents. At the 2010 NESEA Building Energy Conference, Gary Loh of DuPont described a zero-ODP, low-GWP (less than 10), nonflammable, low-conductivity blowing agent, for SPF, FEA-1100, that is currently undergoing toxicity testing and should be introduced (if toxicity testing continues to demonstrate safety) sometime between 2013 and 2015. Honeywell already has a similar product on the market in Europe for one-component polyurethane foams (HFO-1234ze) and expects to broaden its family of HFO blowing agents.

When these new products replace the HFC-blown insulations in the coming years, the argument for avoiding SPF and XPS on the basis of lifetime GWP should largely disappear. By then, manufacturers may also have replaced the halogenated flame retardants with safer compounds. Until that time, however, there are good reasons to limit use of XPS and closed-cell SPF.

Final Thoughts

If our goal is to create buildings that have little or no net contribution to global warming, then the lifetime GWP of insulation materials is a key consideration. When designing highly insulated buildings or carrying out deep-energy retrofits (a top priority of green building and renovating), we should avoid insulation materials with high GWP—extruded polystyrene and spray polyurethane foam that is made with HFC-245fa—so that we aren't sacrificing the very environmental benefits we're trying to achieve. The table on page 13 lists some of these options.

Furthermore, the GWP of foam insulation materials is high enough (especially earlier-generation materials made with CFCs and HCFCs) that it may even make sense to consider the *capture and thermal degradation* of these blowing agents during building demolition. In the early 1990s, Northeast Utilities in Connecticut had a program to recover and thermally destroy the CFC blowing agents in the polyurethane insulation recovered from refrigerators that were turned in through an appliance rebate program. That program was implemented to prevent ozone depletion, but such a program could apply as well to greenhouse gas emissions. Most of the XPS, SPF, and even polyiso currently in place was produced with CFC or HCFC blowing agents with significantly higher GWP values than today's blowing agents, so there are considerable quantities of high-GWP foam "banked" in existing buildings, even accounting for leakage over the years.

As we consider alternatives to XPS and standard SPF, we should try to avoid options that reduce overall insulation levels. Achieving very high R-values in our building envelopes should remain a top priority of green design. In most applications, high R-values can be achieved without using high-GWP foams through thoughtful product specification or changes to construction details with little or no increase in construction cost. There remain challenging applications, however, such as sub-slab insulation, where affordable alternatives to XPS simply may not exist or where building officials balk at the alternatives.

In making these product substitutions or altering our construction details to avoid XPS or SPF, we should also pay careful attention to long-term durability. XPS and SPF have some very attractive properties relative to permeability and air barrier performance. In some cases, adding more complex framing systems, such as double-stud framing in residential construction, can create durability problems. If unsure about proper moisture management with new wall systems, seek advice from a knowledgeable building science expert.

For more information:

"Net climatic impact of solid foam insulation produced with halocarbon and non-halocarbon blowing agents" by L.D. Danny Harvey in *Building and Environment*, August 2007 (Vol. 42, Issue 8)

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From the Library

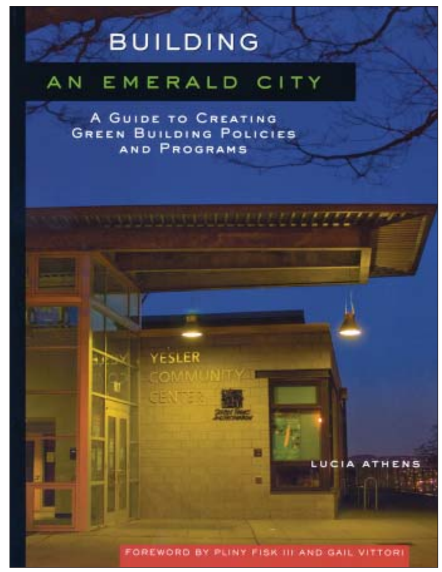
Retrofitting Suburbia: Urban Design Solutions for Redesigning Suburbs (Ellen Dunham-Jones, AIA, and June Williamson; Wiley, 2009; 272 pages, $75)—The U.S. is a land of suburbs. Dunham-Jones and Williamson seek to shift the conversation from urban redevelopment, which is well studied and common, to suburban redevelopment, which can be significantly trickier. How does one turn car-dominated design into a pedestrian-friendly area? Through case studies and analysis, the authors look at several types of redevelopment, including that of malls and shopping centers, big-box stores, residential subdivisions, and commercial strip complexes. These projects increase public space, add mixed-use spaces, and apply smart growth principles in unlikely places.

Resilient Cities: Responding to Peak Oil and Climate Change (Peter Newman, Timothy Beatley, and Heather Boyer; Island Press, 2009; 166 pages, $30)—Beginning with the twin threats of climate change and peak oil, the authors of *Resilient Cities* outline a vision for cities that can survive radical changes in lifestyle and resource availability. Their vision includes bike- and pedestrian-friendly streets connecting neighborhoods where residents live, work, and shop. The book lays out seven shifts needed to make this vision possible: everything from an increase in renewable energy and sustainable transport to a renewed sense of local places and resources. There is nothing terribly new in this volume, but it does offer a succinct introduction to the challenges facing urban areas and suggests some common-sense solutions.

Sustainable Facilities: Green Design, Construction, and Operations (Keith Moskow, AIA; McGraw-Hill, 2008; 208 pages, $70)—Twenty buildings for environmental organizations provide the material for Moskow's look at green building. Nicely illustrated with photographs and drawings, each case study lists specific sustainable features of the building and considers its design, construction, and use phases. Moskow discusses how site and the clients' aims helped to shape each project, and pays particular attention to the lessons learned. Appended to the case studies are short articles focused on topics illustrated by the buildings, from daylighting and wastewater reuse to working within a tight budget. Not extremely technical, but specific enough to show the reader what strategies are at work in each structure, the book is a nice balance of inspiration and explication.

Materials for Sustainable Sites: A Complete Guide to the Evaluation, Selection, and Use of Sustainable Construction Materials (Meg Calkins; Wiley, 2008; 464 pages, $80)—In this detailed resource for designers and specifiers, Calkins explores the environmental impact of a wide range of building materials, from concrete and steel to wood and other bio-based materials. In each chapter, she includes charts of essential information on each material; for example, in the concrete chapter, she includes not only the constituent parts of portland cement but also the energy requirements of the manufacturing process and the environmental and architectural effects of various additives. Also included are the relevant standards for each material type. Calkins also includes a chapter on using salvaged materials.

Building An Emerald City: A Guide to Creating Green Building Policies and Programs (Lucia Athens; Island Press, 2010; 224 pages, $30)—As the former manager of the City of Seattle Green Building Program, Lucia Athens is well equipped to offer advice on planning for urban sustainability. This practical guide combines case studies with Athens' personal experience to provide creative pathways for establishing green building programs in cities across the country. With a focus on policy initiatives, funding and mandates for green building, and building codes and certifications, this book directly addresses climate change while challenging readers to rethink conventional planning strategies and transform our urban landscapes.



Greening Our Built World: Costs, Benefits, and Strategies (Greg Kats; Island Press, 2010; 280 pages, $35)—Environmentally minded communities recognize the importance of green building and development, but despite the urgent call to take action on climate change, green trends have been relatively slow to catch on. *Greening Our Built World* seeks to shift clean-energy, low-carbon ideas into the mainstream. Complete with case studies and user-friendly appendices, this book serves as an excellent reference for cost-conscious professionals wishing to examine the financial, spiritual, and environmental advantages of introducing green design into their communities.

Environmental Building News
122 Birge St., Suite 30 · Brattleboro, VT 05301
A publication of BuildingGreen, LLC · www.BuildingGreen.com

BackPage Primer

Power-Flushing with Pressure-Assist Toilets

Many of today's best-performing low-flow toilets enhance their flush with air pressure to force water into the bowl at high speed.

In a standard (non-pressurized) gravity-flush toilet, water fills a tank behind and above the toilet bowl. When the toilet is flushed, a valve at the bottom of the tank opens and water flows from the tank into the bowl, producing the siphon-action flush.

With a pressure-assist toilet, instead of an open tank behind the toilet bowl there's a sealed plastic vessel hidden inside the porcelain tank. After the toilet is flushed, the pressure vessel fills from the bottom using standard water pressure. As water (1.6 gallons or less, depending on the model) flows into the vessel, air in the tank is compressed above the water, "charging" the tank. No special pump or compressor is involved; water pressure creates the compressed air.

When the user flushes the toilet, this compressed air forces the flush water into the bowl at a higher velocity—and shorter duration—than with a standard gravity-flush toilet. This burst of water does an excellent job at removing waste. According to Sloan, its Flushmate pressure-assist mechanism will deliver a peak flow of flush water at about 70 gallons per minute, which is twice the velocity of gravity-flush toilets.

Some pressure-assist toilets use as little as 1.0 gallon (4 liters) per flush to remove 1,000 grams of test media (based on the MaP testing protocol—see *EBN* Jan. 2004). Two manufacturers make pressure-assist flush systems: Sloan Valve Company and WDI International. These mechanisms are used in dozens of toilets made by leading manufacturers. The 1.0 gallon-per-flush (gpf) Sloan Flushmate IV mechanism (see image) is widely touted for its effectiveness and water savings.

Image: Sloan Valve Co.

An added benefit to pressure-assist toilets is that the porcelain tank will not sweat—a common problem with gravity-flush toilets in humid areas when cold water fills the tank. With pressure-assist toilets, the tank-within-a-tank construction provides an insulating air space.

A significant downside to pressure-assist toilets—and the likely reason they have not achieved a larger market share—is the flush noise. Pressure-assist toilets make a characteristic "whoosh" sound when flushed, and this can be fairly startling, particularly with older, 1.6 gpf pressure-flush mechanisms. The latest Flushmate IV model is much quieter than the 1.6 gpf Flushmate III, though still noisier than standard gravity-flush.