BuildingGreen

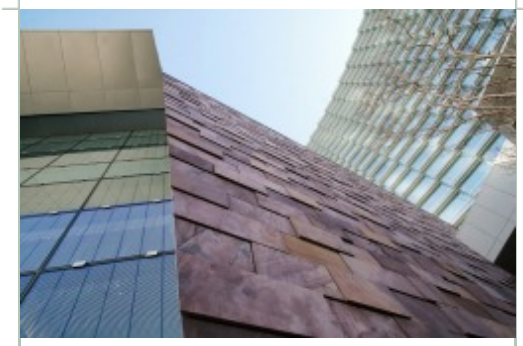
Stone, The Original Green Building Material

CEUs available

By Brent Ehrlich

Stone is natural and durable, emits no VOCs, requires almost no maintenance, and provides a connection to the earth and our history.

Stone was one of our first building materials. It has been used to construct everything from humble dwellings to our most iconic structures. As a building material, stone requires virtually no manufacturing and is so durable that stone structures built thousands of years ago are still used today—characteristics few contemporary "green" products can equal. Yet stone has been largely overlooked by the green building movement, while ephemeral products made of recycled plastic often carry green labels. Granted, stone has some significant environmental impacts, but they may not be as big as you think, and the stone industry has undertaken noteworthy sustainability efforts. This ancient building material may be more relevant than ever in today's green building industry.



Las Vegas Rock's "meta-quartzite," a locally quarried stone, is used as cladding on the LEED Gold Aria hotel in Las Vegas.

Dimension stone—stone that has been tooled, as opposed to crushed stone or aggregate—can be used as flooring, exterior cladding, solid surfaces, and walls as well as for landscaping and many other applications. Of the estimated 1.88 million tons (1.71 million metric tons) of dimension stone produced in the U.S. in 2011, 808,400 tons (735,000 metric tons) were used by the building industry, according the U.S. Geological Survey (for comparison, 95.6 millions tons of raw steel were produced in 2011, with 19.1 millions tons used in construction). Imports from Brazil, China, India, Italy, and other countries provide roughly half of the total U.S. supply, according to industry sources.

The data on stone are just *estimates*, however, mostly based on voluntary feedback from the industry or pulled from U.S. Occupational Safety and Health Administration records and other sources.

The truth is, the stone industry does not track data well, mostly because stone is surprisingly hard to track. Other manufactured building products have their chemical makeup and their production and sales data monitored and aggregated by manufacturers and trade associations and then used to get

them certified "green" as a way of marketing to the green building community. Many stone quarries, on the other hand, are old-school mom-and-pop operations that have been quarrying for decades with almost no marketing and little trade-group representation. And tracking some stones' path to market can be nearly impossible since both imported and domestic stone are often sent across the globe like a commodity to be cut and processed elsewhere. With a lack of baseline data, the stone industry has not been able to provide clear metrics and third-party documentation that are the basis for standards and green certifications used by competing industries.

Perceptions of Stone

Stone has all the attributes of a green product. It requires almost no chemicals to produce or maintain, it emits no VOCs or hazardous airborne pollutants, and it is water-resistant and durable. It is also an attractive material that will outlive most structures built today, and it can be salvaged from one building to be reused or repurposed in another. Stone cladding is used on new buildings to match original historic structures, and in the right application or climate—such as in areas with large temperature fluctuations—stone can be used as thermal mass for space heating and cooling. Some stone even has good solar reflectance. So why do so few people think about it as a sustainable material?

Stone vs. engineered products

"I think we have done a disservice to stone," says Jason F. McLennan, CEO of the International Living Future Institute. Stone is as elemental a building material as we have, McLennan says. In its simplest form, stone is cut from the Earth, tooled, and installed. That's it. "There is no 'perfect' material, but stone is as close to perfect as we can get," he said. Many new green materials or products, on the other hand, are manufactured, often using petrochemicals and components transported around the globe. "There are a whole host of issues with these products, and we sometimes overlook products like stone that are staring us in the face," continues McLennan. "Recycled content has become this banner for sustainability, but recycled plastic petroleum? That's not green," he argues.

The Center for Advancement of Public Action at Bennington College in Vermont is clad in marble salvaged from local abandoned quarries.

Performance and biophilia

McLennan contends that we have a universal attraction to buildings made from natural materials like stone, wood, and straw (see "Biophilia in Practice: Buildings that Connect People with Nature"). "There is a part of us that understands that these are the building blocks of nature. This is how we build. This is how we have always built," he exclaimed.

This connection between aesthetics and durability is important to high-performance buildings as well, whose lifespans are often intended to be 50 to 75 years or more. Stephanie Vierra, president of Vierra Design & Education Services, is a sustainability consultant to the Natural

Stone Council (NSC) and is also the technical editor of the National Institute of Building Science's Whole Building Design Guide. The Italians, she says—whose famed stone quarries have been producing materials for regional structures for thousands of years—understand that buildings are intended to last forever and should be flexible and beautiful. "If you are working on a building with a 50-, 70-, or 100-year life cycle and are going to try and install a new product that claims it is green but hasn't even been tested in the marketplace for five years, how are you going to guarantee you are going to meet that life cycle?" she asks. "I try to help people understand that stone is part of a broader set of systems so that everything is performing to the same level."

Stone Types and Uses

The primary types of dimension stone sold today are granite, limestone, marble, slate, and sandstone—but there are many others, including basalt, soapstone, and quartzite.

Granite

Granite is an igneous rock formed when liquid magma cools slowly under pressure deep below the earth's crust. True granite contains quartz, alkali feldspar, plagioclase feldspar, mica, and other minerals, but other igneous rock and some metamorphic rock (those transformed by heat and pressure), such as gneiss, are also sold as granite. True granite has densely packed mineral grains (hence the name granite) that give it a mottled, but uniform, appearance.

Granite is used for interior surfaces, such as countertops and walls, as well as exterior cladding, flooring, landscaping, and pavers. Because of the varying amounts of quartz and other minerals, granite may have a different density, porosity, strength, and hardness, depending on the stone. True granite has a light-gray-to-pink color, but commercial granite can be found in nearly any color, ranging from somewhat uniform grays and blacks to mottled brown, black, and white combinations. All granite is very hard, with a rating of 6 or 7 on the *Mohs scale*, but in general, those with more quartz are a lighter color and more porous, and those that are darker are more dense. It is also very strong, with compressive strength of 19,000 pounds per square inch (psi).

Limestone

Limestone is a sedimentary rock created primarily by the decay of ancient organisms that accumulated on seabeds and lakebeds and were compacted under pressure (or "lithified") over time. Limestone is 50% calcium carbonate ($CaCO_3$), with other forms of calcium, magnesium, silica (which gives limestone much of its hardness), and other minerals making up the remainder. Travertine, another type of limestone, is formed aboveground when $CaCO_3$ precipitates out of mineral springs, particularly near hot springs.

Limestone is used for interior surfaces, exterior cladding, flooring, landscaping, and pavers. Limestone has a uniform, non-crystalline structure but is vulnerable to acids, so when exposed to acid rain, the edges of limestone details can get rounded over time. There are three grades of limestone, Type 1 (low density), Type II (medium

Slideshow: School of Rock

Granite

density), and Type III (high density). These typically come in white, beige, gray, pink, and other colors, based on mineral content. At 3 or 4 on the Mohs hardness scale, limestone is generally too soft to be polished, and its compressive strength is less than granite's at only 8,000 psi.

Marble

Marble is a metamorphic rock formed when limestone, dolomite, and similar sedimentary rocks are exposed to heat and pressure over time. Unlike limestone, marble has veins caused by minerals crystalized during its formation and contains small fissures.

Similar to limestone, marble is used for interior surfaces, exterior cladding, flooring, and landscaping. It typically comes in white, pink, red, and gold and is a soft stone, similar to limestone, at about 3 or 4 on the Mohs scale; compressive strength is also similar, at 7,500 psi. And marble is also vulnerable to acids, so common kitchen spills can easily damage and stain the surface unless sealed.

Sandstone

Sandstone is a sedimentary rock created when sand, primarily grains of quartz and feldspar, is compacted under pressure. Calcium carbonate, silica, and iron oxide between the grains bond them together like cement. Sandstones that undergo additional heat and pressure become quartzitic sandstone and over time become the metamorphic rock quartzite.

It is used for interior surfaces, exterior cladding, paving, and landscaping. As with other stone, mineral content dictates the color of sandstone, but most are beige, brown, gray, light pink, or red. Sandstone is very hard, at 6 or 7 on the Mohs scale (depending on mineral composition), and has compressive strengths ranging from a low of 4,000 psi for common sandstone to 20,000 psi for quartzite.

Slate

Slate is a metamorphic rock formed from layers of clays or volcanic ash transformed by years of heat and pressure. Made up of quartz, aluminum, chlorite magnetite, and other minerals, slate has a dense, layered nature that allows it to break along planes to create thin, durable slabs.

Slate is commonly used for countertops and other interior surfaces as well as for exterior cladding, flooring, landscaping, roofing, and pavers. Slate can be combinations and shades of gray, black, red, purple, or green, and both performance and aesthetics can vary greatly between products. Slate is hard, at about 6 on the Mohs scale, and is naturally resistant to chemicals and stains.

Stone, from Quarry to Site

Each type of stone is extracted differently depending on the local stone characteristics and quarry type, but there are some similarities between operations.

Quarrying

Most quarries are open-pit, but there are also underground quarries and shelf quarries that access stone through a hillside or ledge. According to the Natural Stone Council, to access stone in open-pit quarries, the upper layers of earth and vegetation are removed, along with poor-quality stone. This "overburden" is stored onsite for use in later reclamation. The stone is then carefully assessed and removed in "benches," or large rectangular blocks extending 20 feet or more and 8 to 12 feet per side. The stone is drilled along the outer dimensions of the benches; diamond wire saws, hydraulic splitters, or small explosive charges are used to loosen the stone before removal by heavy equipment. (In slate quarries, large sections are broken off to make best use of the layers of stone.)

The stone is then inspected and stored onsite before being transported for further processing. Scrap stone can be crushed for aggregate, landscaping, and other uses, or can be stored for later quarry reclamation. In general, slate quarrying produces more waste than other stone types.

Processing

After removal, the stone blocks are often treated like commodities. They can be processed locally near the quarry or shipped as far away as Italy or China. Shaping the stone requires two or more steps: in the primary processing, the blocks are cut into thinner slabs using a variety of saw types, some of which require water to protect the blades or wires from overheating and the stone from damage. For products that require a rougher surface, this first cut may be all that is required, but most products undergo a second processing that involves finishing to a desired look (anything from polishing to antiquing or "distressing") and cutting to specific dimensions.

Some products, particularly travertine and marble used indoors, may have an acrylic filler applied during this step, and some granite manufacturers use epoxy to fill small pores and cracks to reduce the possibility of staining and improve strength. Thermal treatments that apply flame to granite surfaces are also used in applications where a rough, slip-resistant finish is desired.

Transportation to site

Stones from different quarries have unique looks, so for designers and architects searching for a specific stone color or type, purchasing locally can be very difficult. The route stone takes from processing to site can vary from a few miles—if purchased from a local quarry that has processing facilities—to thousands of miles, if the stone is imported from Brazil or another country and sent to Italy or China for processing before being sent to the U.S. Even stone quarried in the U.S. is regularly sent oversees for processing and then sent back to the U.S., an obviously wasteful practice dictated by lower overseas labor costs.

Potential Environmental Concerns

Education is the key to convincing people that stone is sustainable, but some myths about the industry persist: namely, that quarrying equals mining, all granite poses a radioactive health risk, and transportation energy required to get the heavy stone to the jobsite is a deal-breaker.

Quarrying is not mining

Many people don't distinguish between quarrying and mining. Jack Geibig—former director at the Center for Clean Products at the University of Tennessee and current president of Ecoform, a company that specializes in life-cycle analysis (LCA) and other environmental metrics—shared that perception, but after visiting more than 20 quarries throughout the U.S. during a study sponsored by the Natural Stone Council (NSC), he came away convinced the impacts are very different.

"In mining," says Geibig, "you are taking elements from deep in the earth and concentrating them at the surface." A lot more material is taken out of mines than out of quarries (it takes about 143 pounds of rock to produce one pound of copper, at current rates) there is much more waste, the process is more energy-intensive, and tailings and runoff frequently contain toxic byproducts that contaminate air and local ground water.

Located in the Permian Basin in Texas, site of an ancient sea, TexaStone Quarries' limestone sits on the surface; its quarrying requires almost no removal of topsoil or vegetation.

With most quarries, the rock is at the surface in large concentrations, and the main environmental problems come from noise, occasional runoff of solids, and scrap piles at the surface. These issues are manageable, however, with good practices, and at the end of a quarry's production (which could be hundreds of years), most can be repurposed, filled in using waste from production to create useable land or, in some cases, made into lakes. As a consultant, Jason F. McLennan toured several quarries run by Cold Spring Granite and concluded, "If you compare them to an even modest forestry operation, the habitat impacts are a fraction of what they are with logging and milling wood." He acknowledged that there are poorly run facilities in every industry, but he claims the amount of site disturbance and soil and habitat loss from forestry operations far exceeds that of quarrying.

Is that countertop radioactive?

In 2008, *The New York Times* ran an article, "What's Lurking in Your Countertop?" that reported on granite countertops emitting radon—a colorless, odorless, carcinogenic radioactive gas—into suburban homes. While the article reported that the vast majority of granite countertops are safe, the scare gained traction on the Internet, and granite's link to radon was cemented. Peer-reviewed, independent studies conclude that radon does not pose a significant risk in the vast majority of granite or slate countertops, but granite is a natural material, and just as your home may sit atop a radon hotspot or your concrete could potentially contain radioactive aggregate, it is possible that a select product may emit radon as well. Even then, however, a "hot" countertop is very unlikely to pose a risk based on normal household ventilation rates, according to other studies.

Still, no level of a carcinogen is safe, so finding a way to put this issue to rest is in the industry's best interest.

The Rock of Ages quarry in Barre, Vermont, has been quarrying granite for 128 years and is now nearly 600 feet deep.

Some companies, such as Cold Spring Granite and Las Vegas Rock, are doing their own testing now—but it would be nearly impossible to test all granite due to costs and the difficulties of tracking today's stone through the market.

Hauling stone

Transporting stone from quarry to jobsite does have a negative environmental impact. Heavy equipment and trucks are usually required to move the massive blocks, which can weigh 20 tons or more, from the quarry all the way through processing. A study of embodied carbon and natural stone done by the Scottish Institute of Sustainable Technology (SISTech) along with Heriot-Watt University in Edinburgh shows that transportation is a significant contributor of embodied carbon in stone and confirms that the further the stone travels, the greater the impact.

With any material, impacts of extraction can be averaged out over the service life. Here, stone has an advantage: its durability means that those transportation impacts may not be quite as significant if considered over a 100-plus-year lifespan. On the other hand, if stone is treated like just another disposable product, with that granite countertop winding up in the dumpster when the kitchen is next remodeled, the extraction impacts loom larger. In any case, minimizing the distance the stone takes from quarry to jobsite will improve its carbon footprint: buy regionally if possible.

Impact of sealants

Cracks and voids in marble or travertine are sometimes filled with acrylics, and those in granites are sometimes filled with epoxies. This is done to improve the appearance, reduce places where dirt and mold can accumulate, or give the stone additional strength, which can reduce breakage and allow for thinner, lighter products. Acrylics are considered safe, and even epoxy resins are approved for food contact by the U.S. Food and Drug Administration. Most of the resins are removed during processing but, with epoxies, workers could be exposed to the endocrine disruptor bisphenol-A (BPA).

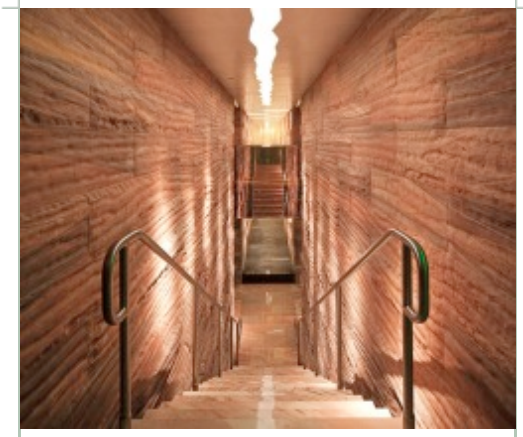
Stone used on exteriors is rarely treated, but those used for countertops and other interior applications are often sealed to prevent staining. These sealants often contain a number of problematic chemicals, including volatile solvents, which penetrate the small pores better than waterborne products, and perfluorochemicals (PFCs), which are used to repel water and stains and have become a staple of the stone industry. PFCs are extremely hydrophobic, but they also remain in the environment indefinitely and have unknown long-term impacts on organisms and the environment. When possible, opt to leave your stone untreated. A little patina never hurt anyone.

Industry Initiatives

The stone industry in the U.S. has not done a good job explaining stone's environmental footprint or

dispelling myths about the industry. Part of the reason for this was that no umbrella group existed to promote the sustainability of the different types of dimension stone prior to 2003 and the formation of the Natural Stone Council. Instead, numerous smaller groups—like the Marble Institute of America, Indiana Limestone Institute of America, and the National Slate Association, to name few—competed with each other to best represent their members, and sustainability marketing was not high on most agendas.

According to Brenda Edwards, owner and general manager of TexaStone Quarries, when the group first met, it was the first time all of the competing stone organizations had been in the same room. The industry realized it needed to better communicate its sustainability message; it reached out to the Center for Clean Products at the University of Tennessee and its team, then headed by Geibig. The stone industry "hadn't thought much about sustainability because the product was natural," said Geibig. But with no data on stone's impact on the environment, the industry decided to commission life-cycle inventories (LCI) of granite, limestone, marble, sandstone, and slate. Some of this data was published in 2008 and can be downloaded from NSC's website.



The Las Vegas Rock stone incorporated into the Sahra Spa at The Cosmopolitan hotel in Las Vegas looks like sandstone and remains slip-resistant even after polishing.

The LCI data has limitations. It is focused primarily on quarrying and processing and uses a small sample of self-reported data from surveys. The LCI was not intended to compare different stones against each other, but subsequently it has been used to create a life-cycle assessment (LCA) that compared granite and limestone claddings with other cladding types, including brick and mortar, precast concrete, and aluminum. The building modeled in the LCA was steel-framed with an interior wall, structural wall, exterior sheathing, insulation, drainage plane, an air cavity, and the cladding. The appropriate anchoring system for each cladding was included in the LCA, but the installation was not. The results indicate that granite cladding had the least detrimental environmental profile, followed by limestone and brick (a virtual tie), and then aluminum.

The SISTech study published in 2010 used an "LCA-based approach" to measure and compare the embodied carbon of sandstone, granite, slate, and marble with a host of other building materials. Using its own data and those pulled from the University of Bath's Inventory of Carbon and Energy (ICE), it showed sandstone, granite, and marble to have lower embodied carbon than brick, timber, and steel, but slate fared slightly worse than other stones (due to waste from quarrying and processing), with more embodied carbon than concrete or brick but less than steel.

Despite the attraction to comparing and contrasting different building materials, it may not be a good idea to jump to conclusions from a small batch of studies. The results of these two studies are based on relatively small and incomplete sample sizes, and the methodologies do not follow ISO 14040/14044 LCA protocols. One can see trends in the data that can be useful, however, such as confirmation of slate's use of additional processing energy.

The life-cycle inventory generated by NSC is valuable since it continues to establish baseline data that can be used to track and improve stone's environmental footprint. And perhaps more importantly, the work has led to the development of best practices for the industry, which also laid the groundwork for a third-party green certification system for quarries and processors.

Improving the footprint of stone

The stone industry is employing new quarrying and production methods that improve the efficiency of stone production and lower its environmental impact. In the quarry, cutting with diamond wire saws reduces waste and minimizes dust; in the shop, CNC (computer numerical control) machining maximizes production and minimizes waste; and on buildings, thinner, lighter products are being used that replace larger, less resource-efficient slabs.

There is still a lot of work to do, of course, since not all stone quarries and processors are using the latest technologies or methods. To help the industry understand and implement sustainability objectives the NSC developed "best practices" for the industry, which can be particularly useful for those with minimal knowledge of green building. Each section provides detailed recommendations, but some of the highlights are listed below.

Water Consumption, Treatment, & Reuse : Reseed the quarry site with native grasses to help prevent erosion, reduce airborne dust, and provide wildlife habitat; treat and reuse wastewater onsite.

Site Maintenance & Quarry Closure : Reduce fuel consumption by minimizing idling of heavy equipment; conserve as much local vegetation as possible to reduce erosion; and plan for quarry closure, including use of creative end-of-life options such as creation of parks.

Solid Waste Management: upgrade to newer equipment that minimizes dust and waste; sell the scrap or reuse it for onsite landscaping; recycle oil and other waste produced by the operation.

Transportation: Use rail instead of trucks when possible; minimize the distance the stone travels for processing.

Pending standards… Coming soon

These best-practice recommendations help provide a framework for the industry's developing standard, currently titled NSC 373: Sustainability Assessment for Natural Dimension Stone. Still in draft form, the standard when released will establish a rating system for quarries and stone processors using third-party-verified metrics for:

- water
- transportation
- site management
- land reclamation
- adaptive reuse
- corporate governance
- energy
- waste and byproducts management

- safer chemical and materials management
- human health and safety

NSC 373 is similar to other multi-attribute NSF standards that exist for carpeting and resilient flooring and will have Silver, Gold, and Platinum certification levels. "Once the standard is in the marketplace, it has the potential to really transform the industry," says Vierra.

One of the most challenging sections of the new standard is—no surprise— transportation. "Stone is very difficult to track," says Geibig, "so we are working to develop a chain-of-custody arrangement much like wood has." The sustainability standard applies to both domestic and imported stone and will certify operations along the supply chain, such as quarries and processors. Anyone who buys or sells stone without changing its characteristics, such as distributors, would have to maintain chain-of-custody documentation that shows where it came from and where it got shipped to, Geibig explains. "We want to make sure the stone is handled in the most environmentally responsible method possible, and we want whoever is making the purchasing decisions to be informed about the stones they are purchasing."

Water used during processing of stone is now filtered and recycled by many fabricators. Shown here is limestone being processed at TexaStone facilitates.

The standard's chain-of-custody requirement would eventually help reduce transportation energy and its associated environmental costs—and would differentiate products in a crowded market—but it could also help guarantee that workers are treated fairly. Currently, stone is sent overseas for processing because it is often less expensive to ship a 20-ton chunk of granite overseas and back than it is to have it processed in the U.S. 200 miles away, and labor costs are the main reason for this. Cheap labor often means poor working conditions; stone processing can put workers at risk, going against the principles of sustainability.

Adoption of a standard like this could also help the industry keep pace with LEED requirements. LEED version 4 (LEED v4), currently under development by the U.S. Green Building Council (USGBC), recognizes building materials that use "leadership extraction practices," such as Forest Stewardship Council certification for forest products. Subject to USGBC approval, stone products certified under a credible sustainability standard could contribute to a LEED credit. The draft standard would also for the first time allow untreated natural products like stone to count automatically toward indoor-air-quality credits without independent lab testing. These steps are likely to open up more conversations about stone's place in green buildings.

Edwards is piloting the standard at her TexaStone Quarries, a limestone quarry that fabricates and ships stone internationally and throughout the U.S. "The standard is still in process," she says. "There are quite a few comments, and it is back in revision, so it will probably be the first part of the summer before it comes back for a vote again." She agrees that the transportation section needs to be revised, and there are sections open for interpretation that still need editing, but she feels having so much consensus on the standard at this stage is a huge step forward for the industry.

Some quarries are already innovating

Some quarries are looking forward to the new standard but are moving ahead now with their own green initiatives. Cold Spring Granite, an industry leader in sustainability with a variety of stone quarries and processing facilities across the U.S., recycles all of its industrial water, quarries stone on demand, uses diamond saws instead of explosives to minimize waste, and is updating to more energy-efficient equipment. The company also participates in Declare, the International Living Future Institute's platform for ingredient disclosure.

Las Vegas Rock didn't wait for an industry standard to have its stone certified Silver under Cradle to Cradle. Las Vegas Rock quarries meta-quartzite, a unique stone comprised of pure, glass-grade silica bonded by quartz. "Our stone has the aesthetics of a sandstone but the hardness of a quartz," according to Justin Lindblad, the company's vice president of business development. Lindblad said the company uses no resins during finishing and creates zero waste from production. Fines are collected and sold to concrete companies or glass manufacturers; larger pieces are crushed and sold for landscaping; and all water is filtered and recycled back through its facilities. The company's quarry operations also minimize impact on the land. "If the quarry has native vegetation, we have a company called Native Resources come and relocate the plants," he says, "but we really don't disrupt a lot of area."

Getting Closer to Perfect?

The stone industry is slowly accepting its need to engage with the green building community, but there is still a lot of work to do. Old habits are hard to break, but Edwards is encouraged by the changes she has seen in the industry in just the last year. Colleagues and competitors who were skeptical of the new standard and green building in general and were reluctant to participate have now seen the draft and are actively engaged with the process. This engagement should continue to improve stone's environmental footprint. There is no perfect building material, as McLennan says, but stone is getting closer.

For more information:

Natural Stone Council

Continuing Education

Receive continuing education credit for reading this article. The Green Building Certification Institute (GBCI) has approved this course for 1 CE hour towards the LEED Credential Maintenance Program.

Learning Objectives

Upon completing this course, participants will be able to:

1. Explain how stone is natural and durable, emits no VOCs, requires almost no maintenance, and provides a connection to the earth and our history.
2. Differentiate between various stone types and uses, particularly for the primary types of dimension stone: granite, marble, limestone, sandstone, and slate.
3. Explain the environmental impacts of stone from quarry to site to installation and dispel two myths about stone.
4. Recognize both the benefits of, and the limits to, the industry's life-cycle inventory; discuss how some quarries are innovating.

To earn continuing education credit, make sure you are logged into your personal BuildingGreen account, then read this article and pass **this quiz**.

Discussion Questions

Use the following questions to inform class discussions or homework assignments.

1. Explore the industry's best practice guidance documents for implementing environmentally preferable operations, located on NSC's website. What are some of their ways to manage the main environmental problems coming from noise, occasional runoff of solids, and scrap piles at the surface?
2. What are some of the transportation challenges that are unique to stone? How might those challenges inform a chain of custody certification for stone suppliers that have adopted best practices? How might such a tracking policy inform the distance that stone travels, particularly for processing?
3. Just because you can average out stone's extraction and transportation impacts over its service life, should you? The tactic may help put stone on the sustainability map but does it require too many assumptions about end-use to be practical? How does the claim relate to the fact that stone is both a raw and finished material?
4. Consider the connection between aesthetics and durability in high-performance buildings with long lifespans. What do you think is beautiful about stone? What color(s) exemplifies the stone available in your region? What are its complementary colors? How does it patina? What does it look like wet? How about at night—does it glow or disappear in moonlight? How might you convey your appreciation for stone to a client?

Sidebar: Salvaging Stone at Bennington College

The Center for Advancement of Public Action at Bennington College in Vermont was designed to be an environmentally sustainable building by Tod Williams Billie Tsien Architects. The building incorporates marble salvaged from discards at abandoned quarries within 50 miles of the college. The sills of the windows and most of the horizontal surfaces are black granite quarried farther north, near Lake Champlain. All of the buildings are clad in marble, and, according to the project architect and manager, Susan Son, “We used a random pattern so we could use as many pieces as possible.” The stone was salvaged from the quarries and fabricated into 2"-thick cladding pieces of varying lengths.

"We also had large accent pieces of panels where you see drills and marks created during quarrying," she said. The building's cladding creates a tie to the past yet is durable enough to last another 100 years or more. Some of the pieces were pushed in slightly, and the marble's varying sizes and five different tones, ranging from white to blue-green, reflect the light and surroundings so the stone creates a mood that changes with the seasons and weather. Son says that the building disappears in winter, but when it is wet it becomes very soft, like a watercolor. The material embodies sustainability and the local surroundings and community.

March 29, 2013

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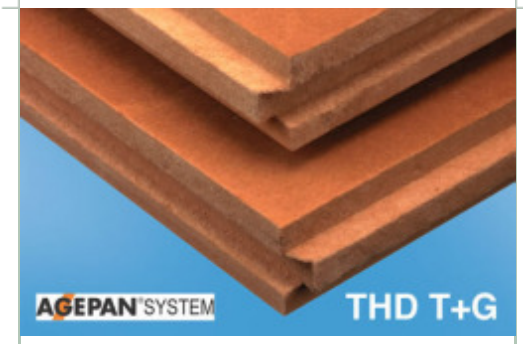
BuildingGreen

Agepan: A Vapor-Permeable, Wood-Based Insulation Board

Builders are turning to an insulating sheathing imported from Europe to make walls that won't rot.

By Erin Weaver

Agepan (pronounced "AH-ge-pahn") Functional Wood is a line of vapor-permeable, insulating, wood-fiber wall, roof, and floor panels. Manufactured in Germany since 1996 by Glunz AG and imported to the U.S. by several dealers specializing in products for Passive House construction, the fiberboard panels have been catching on in light-frame construction. To understand why, it helps to contrast them with common building practices.



Agepan THD T+G 230 is a permeable, wood-fiber thermal insulation board for use in walls and roofs.

Advantages over polystyrene

High-performing wall assemblies are increasingly incorporating continuous insulation outside of the structural assembly to reduce thermal bridging and provide continuous air and water barriers. Wrapping the exterior in rigid polystyrene foam is common, but polystyrene poses problems of its own—from use of a non-renewable resource to toxic flame retardant content to global warming potential. The relatively low vapor-permeability of polystyrene (along with many structural sheathing products) can be a benefit, though, such as in installations where sunshine can drive water vapor from masonry cladding inward through an exterior assembly.

However, in most applications using polystyrene, its low vapor-permeability is not necessarily beneficial. As long as such an assembly allows drying to the interior, it's fine, and prominent building scientists have lauded this overall approach—but some designers and builders argue that we should open the exterior to vapor movement to maximize drying potential, especially in colder climates where interior water vapor can condense inside a wall and cause rot.

"Reversing the wall assembly"

Albert Rooks imports Agepan through his Small Planet Workshop; Rooks told *EBN* that builders "on the hunt for a really high-R wall" happened upon the European concept of "essentially reversing the wall assembly" by moving the plywood sheathing—or Agepan's semi-permeable oriented-strand board (OSB)—to the interior. More permeable to the exterior than to the interior, this wall can dry in both directions, creating what the manufacturer calls a "breathing wall system."

Products Available from Agepan Functional Wood

Product	Application	Density	Permeability	R-Value
THD: Trockenverfahren hergestellte Holzfaser-Dämmplatte, dry-processed wood fiber thermal insulation board for walls and roofs				
THD STD 60mm	Interior	230 kg/m³ (14.4 lb/ft³)	18 perms	R-3/in.
THD T+G 52mm	Exterior	230 kg/m³ (14.4 lb/ft³)	21 perms	R-3/in.
DWD: Diffusionsoffene Wand Dachplatte, permeable wall and roof panel				
16mm	Exterior	565 kg/m³ (35.3 lb/ft³)	18 perms	R-1.6/in.
TEP: Trockenestrichplatte, floor underlayment panel				
40, 60, 80mm	Interior	230 kg/m³ (14.4 lb/ft³)	n/a	R-3/in.
UDP: Unterdeckplatte, lighter-duty roof panel				
22, 25, 32mm	Exterior	270 kg/m³ (16.9 lb/ft³)	n/a	n/a
OSB: Oriented strand board made with Agepan fiber-coating technology				
6–30mm	Interior	600–660 kg/m³ (37.5–41.2 lb/ft³)	0.7 perms	n/a

Sample drawings provided by the company recommend walls consisting of exterior cladding and a rainscreen over DWD, thick cavity insulation, and OSB and THD STD on the interior; flooring over TEP or OSB; and roofing installed over THD T+G 230, thick insulation, and interior OSB.

Agepan also differs from many other products that perform just one function; it can provide a thermal break, an integrated weather-resistive barrier (including air barrier), and a base for installation of a rainscreen and cladding all in one. The exterior panels are more stout than fiberboard panels made in North America; according to Rooks, "they don't bow out under dense-pack cellulose." Agepan achieves an R-value of R-3.1 per inch (U-0.33) while remaining vapor-permeable: 52mm (2") Agepan THD T+G 230, available through Rooks' Small Planet Workshop, provides R-5.74 insulation and is rated at 21 perms.

Making wood chips water-resistant

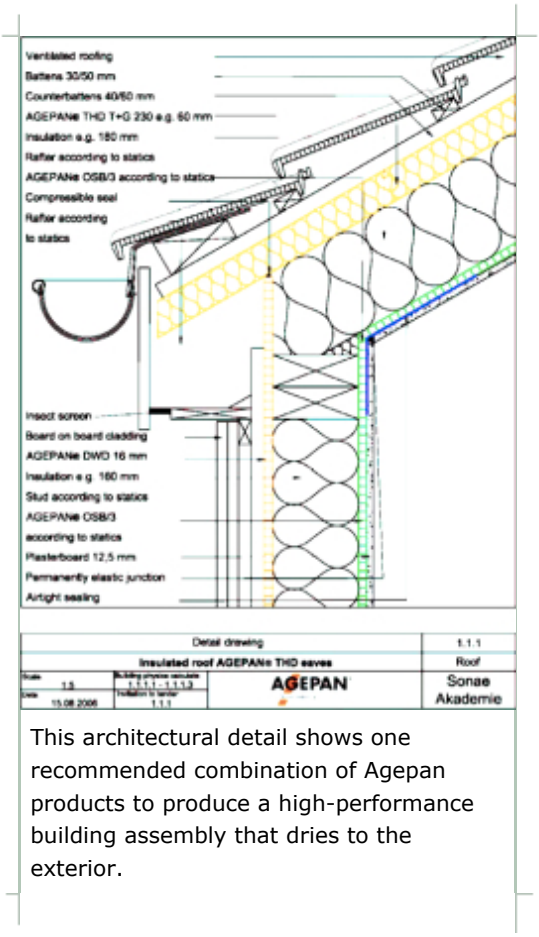
At the Agepan plant in Meppen, Germany, pine from regional forests is combined with sawmill scraps. The wood is chipped, boiled, and then dried to 2%–3% residual moisture; mixed with paraffin wax and a PMDI binder (a polyurethane-type binder); then pressed to achieve the densities that differentiate the various Agepan panels. Mixing the materials prior to pressing distinguishes Agepan's water-resistance from that of standard OSB, which is coated after pressing and is highly vulnerable to moisture absorption through the many exposed end-grains throughout the board; Agepan is water-resistant throughout, meaning that with the use of a rainscreen, no additional water-resistant barrier is needed on the exterior, according to the manufacturer. The faces of the boards are denser than the interior, with the cavities between internal wood fibers providing Agepan's insulating properties.

Installing Agepan

Agepan can be installed with staples and screws, and penetrations or cut edges can be taped if needed. In colder climates, the plywood, OSB, or THD STD serving as an air barrier on the interior should be taped to keep warm interior air from infiltrating the insulation cavity and potentially condensing, but Rooks says the tongue-and-groove exterior is tight enough to prevent wind-washing. It can also be taped to function as a primary or secondary air barrier, depending on the climate and the design of the assembly. Agepan is not UL-listed, but is rated Class E under EN 13501-1—not suitable in applications requiring resistance to flame spread.

Nathan Young, owner of Nathan D. Young Construction in Portland, Oregon, says his company was hesitant at first when working with Agepan but found it easy to work with, noting that it's most important to make sure everyone understands which side of the board is which: the higher-density face goes on the exterior to provide a sturdy surface for attaching a rainscreen. Young told *EBN*, "You've just got to make sure everybody's paying attention."

Cory Eckert of Laupen Homes in Olympia, Washington, agrees that the Agepan DWD he worked with was easy to install, and he adds that one person could install the lightweight boards alone. A recent project used strips of plywood attached to the DWD as a rainscreen, and the DWD joints were only taped in places where the panels had been cut, losing the tongue-and-groove edge. "Time will tell on the performance," Eckert said, "but with all the years of use in Europe, I am sure this won't be a problem."



This architectural detail shows one recommended combination of Agepan products to produce a high-performance building assembly that dries to the exterior.

Evaluating costs

Young speculated that domestic manufacturing could cut the price of Agepan in half, since much of the cost is in shipping from Germany. It currently retails in the U.S. at more than $17 for a 25" x 89-3/4" sheet of 5/8" DWD, or $1.10/ft^2, and nearly $32 for a 23-5/8" x 74-1/2" sheet of 2" THD T+G ($2.62/ft^2).

Young says that although the cost is "not negligible," we also "don't have anything to compare it to that achieves the same characteristics" because of Agepan's performance and permeability. Rooks agrees, noting that his company imports Agepan because "a thick, diffusion-open wall that will last 100, even 200, years is something we need to be able to do."

For more information:

Small Planet Workshop
http://www.smallplanetworkshop.com/

March 29, 2013

IMAGE CREDITS:

1. Photo: Sonae Industria
2. Source: Glunz AG
3. Image: Sonae Industria

BuildingGreen

Self-Cleaning Buildings, Brought to You by Smog-Eating Technology

New architectural panels and roof tiles break down smog, but the real reason to install them is that they stay clean.

By Paula Melton

A new breed of building products is getting attention for its purported ability to remove smog-forming chemicals from surrounding air. Reynobond with EcoClean architectural panels from Alcoa Architectural Products and BoralPure concrete roofing tiles from Boral are some of the market leaders in this emerging field of smog-eaters, along with pioneer TX Active concrete from Essroc, which *EBN* has previously covered.

It turns out there is solid science behind these products, but their benefits don't really have much to do with smog and outdoor air quality. Many building owners will find the self-cleaning properties of these products are what make them worth the modest extra investment.

How they eat smog

The potential of smog-eating building products is to oxidize nitrogen oxide and nitric oxide (collectively called NO_x) before they get oxidized in the air and contribute to smog and acid rain. To accomplish this, both Reynobond with EcoClean panels and BoralPure tiles have a coating that contains tiny (nano-scale) particles of titanium dioxide (TiO_2). The TiO_2 is a *photocatalyst*: in combination with UV light, it breaks down organic chemicals without getting depleted. This reaction takes NO_x from the air and deposits it on the surface as nitrate (NO_3) or nitric acid (HNO_3), which rain washes away.

How they self-clean

Because TiO_2 can also kill bacteria, fungi, and other small organisms through the same oxidation process, it can prevent surfaces from growing mildew, algae, or other

nuisance microbes. It's also "superhydrophilic": water droplets penetrate beneath any particles that have collected on the surface and spread out dramatically instead of beading; even small amounts of water sheet off, taking dirt, soot, dead organisms, and nitrates with them.

Although TiO_2 provides an alternative to other coatings typically used for "self-cleaning" products —perfluorochemicals, which persist and bioaccumulate in the environment—it is far from harmless. TiO_2 can wreak havoc in aquatic ecosystems, so it's a substance to use with caution.

This RTKL-designed United Technologies building in Jupiter, Florida, incorporates Alcoa's Reynobond with Ecoclean panels.

Reynobond with Ecoclean

Alcoa's Reynobond architectural panels consist of a lightweight plastic core sandwiched between two metal sheets. EcoClean is a licensed version of the Hydrotect TiO_2 coating developed by plumbing-product manufacturer Toto. Alcoa is offering only its painted aluminum Reynobond panels with the EcoClean coating right now.

"Titanium dioxide products have been around for several years," says George Rosado, commercial director at Alcoa Architectural Products. "However, because of the processes involved, the color offerings tend to be limited, and the products can be costly." Alcoa has gotten past that cost barrier, he said. Due to a streamlined *coil-coating* process—which can uncoil, coat, cure, and re-coil a metal sheet in a matter of minutes—the company is able to offer its panels in more than 30 colors at a fairly low (3%–5%) cost premium, he told *EBN*. Other than the EcoClean coating, Rosado added, the product is exactly the same as regular Reynobond.

Because of the superhydrophilic surface, EcoClean could also reduce maintenance costs as well as some of the environmental impacts of cleaning building exteriors. Compared with regular Reynobond, detergents or solvents to remove oil-based deposits are less likely to be needed. Like regular aluminum-clad Reynobond, though, the EcoClean-coated panels should not be pressure-washed.

Alcoa warns that the EcoClean coating is thinner and softer than the resin beneath it, so abrasion may damage it. It's unclear how durable the coating is during regular use. The makers of Prosolve 370e coated tiles, for example (see sidebar), state that their products should be recoated every five to ten years. It's also uncertain whether TiO_2 might be released into groundwater as these coatings break down—potentially a significant concern as the technology sees wider adoption.

BoralPure

The TiO_2 in BoralPure roofing tiles, by contrast, is part of a cementitious coating applied to the

concrete, explains John Renowden, vice president of technology at Boral Roofing. "It is actually an additional layer of fine concrete on the top, and the active ingredient is in the mix." He claimed that the tiles would probably never need to be recoated: "Our durability testing doesn't wear them out."

The tiles are available in four shapes and six colors—a more limited palette than Boral's regular tiles. Although Boral Roofing touts the product's ability to fend off mold and algae, Renowden readily admits that feature is more compelling in Florida, say, than in Arizona. The self-cleaning isn't just about organisms, though, he adds: "A lot of homeowners' associations require residents to wash the roof regularly. What we find is that the BoralPure tiles stay a lot cleaner than the regular products." The tiles can clean themselves even in the relatively dry climates where roofing tiles tend to be very popular, he asserted. "Actually, you don't need a lot of rainfall," he said. "You quite often get condensation on the roof, which is sufficient."

Renowden says that builders tend to charge $400 to $1,000 extra for the BoralPure tiles, depending on the size of the home.

KB Home's ZeroHouse 2.0 features BoralPure roofing tiles.

From the lab to the real world

Boral claims that 2,000 ft^2 of its tile can offset the nitric oxide (NO_2) emissions from a car driven 10,800 miles; this is based on experiments done in independent labs measuring performance according to the ISO 22197-1:2007 test method for photocatalytic materials. Alcoa asserts that 10,000 ft^2 of its product can offset the smog-forming potential of "four cars every day"—which it compares with planting 80 trees. Putting aside all other reasons to plant trees and avoid driving, do actual installations back up these numbers?

Renowden points to a study that measured NO_x levels in road tunnels in Italy before and after a photocatalytic paint and UV lights were installed; the study found NO_x abatement of 50%–65%.

Real-world data remain elusive. Sasaki Associates specified a TiO_2 coating for a sound-barrier wall between the Los Angeles port in Wilmington, California, and a new 30-acre park. Although the port authority chose not to paint all 2,000 linear feet of the wall, it agreed to paint a 300-foot section as a test area—and also to plant 600–700 trees. "The park opened about a year-and-a-half ago," notes Steve Hamwey, P.E., of Sasaki, "but the Port hasn't sent their people out to do an analysis." Although a handful of European pilot studies (PDF) have found very localized outdoor air-quality differences —sometimes significant ones—it will be difficult for architects to argue the case for a product's smog-eating or even self-cleaning properties without more evidence to back up the claims.

You don't need direct sunlight for the TiO_2 to work, but shade and cloudy days reduce the rate of oxidation. Airflow can also affect performance, as could the presence of black carbon or dust, notes Michael Bergin, Ph.D., an earth and atmospheric scientist at the Georgia Institute of Technology. "I think the real application is for indoor air quality," said Bergin, who has studied a number of smog-eating materials, and who coauthored a 2009 report (PDF) for Toto about Hydrotect, the TiO_2

coating licensed to Alcoa as EcoClean. "In buildings, the air is in the room long enough to have more time to react with the surfaces."

The rate of NOx abatement in outdoor air, in fact, can't keep up with that of NO_x production in the most smog-prone areas, Bergin claims. Even if you covered the entire surface area of the Atlanta metro region with Hydrotect and assumed ideal conditions for oxidation, the coating would neutralize only 460 tons of NO_x per year—"more than a hundred times less than the emissions rate," Bergin says. "This stuff cannot even put a little dent in the atmospheric levels of NO_2."

When it might make sense

William Strang, president of operations at Toto Americas, doesn't view these metrics as a deal-breaker: he sees multiple indoor uses for the technology—for example, in bathrooms and commercial kitchens "to decrease the use of aggressive and harmful chemistries that you would normally use"—and he isn't at all fazed by the relatively low NO_x abatement rates for exterior applications, in part because of the solvent-free and detergent-free self-cleaning features.

Sure, we need "better catalytic converters, more electric cars, more bike paths, less diesel soot, and more public transportation," he says. But he still believes Hydrotect has a place in helping reduce smog formation. "This gives us the opportunity to incrementally add to that whole package of solutions. For me, there is no silver bullet—but there is silver buckshot."

Megan Koehler, associate at KMD Architects, feels less sure. Tasked with researching TiO_2 technology for possible use on a San Francisco medical office building adjacent to a freeway, Koehler wonders whether the potential benefits outweigh the unknowns. "We're trying to focus on healthy products, and I'm getting a little bit leery" due to the potential occupational hazard of a spray-applied TiO_2 product, she told *EBN*.

"It would be great to mitigate the need for cleaning the building," she added. "But from what I'm seeing, it reduces that need, but it doesn't eliminate it—so you're still needing to bulk up your structure for window-washing equipment, for example." Smog-eating is still on the slate of possibilities, however, in part because it is a simple benefit to communicate about. With many green building strategies, "it's hard to demonstrate measurable benefit to neighbors," so if air-quality benefits are real, they might not only clean the air but also help clear the air between building owners and the community.

Sidebar: Other Self-Cleaning Products

When choosing products, keep in mind that no one is sure how much TiO_2 might end up in groundwater as non-durable coatings break down. Before you spec, ask manufacturers how long the coating really lasts.

Brise soleil—Prosolve 370e from Elegant Embellishments is a decorative, modular-tile exterior shading system coated with a fine layer of TiO_2. The complexity of the pattern maximizes the surface area exposed to the air, potentially allowing a higher rate of NO_x abatement. The system must be re-coated every five to ten years.

Coatings—PURETi offers coatings for opaque exterior and interior surfaces as well as for glass. The company claims its coatings reduce maintenance costs by 50% but recommends reapplication every three years on interior surfaces and every five years on outdoor surfaces.

Paving stones—Germany's FCN offers Airclean pavers, but they may not be available in the U.S. TX Active concrete from Essroc can be an option for some pavers manufactured in the U.S., such as Ecological Paver systems from Advanced Pavement Technology. However, self-cleaning technology may not translate well to a horizontal surface because of minimal airflow and reduced ability for water to sheet off.

Roofing membranes—Siplast offers a modified-bitumen roofing membrane surfaced with granules that contain TiO2—a technology the company dubs "Noxite." Siplast claims the TiO_2 remains active throughout the life of the membrane. However, bitumen (asphalt) comes with its own hazards, and a horizontal surface is probably not an ideal application for the technology.

Self-cleaning windows—A number of glass manufacturers offer self-cleaning and self-defogging as an option: Pilkington makes a line called Pilkington activ, while PPG offers Sunclean, and Saint Gobain has introduced Bioclean. These companies do not make claims about smog-eating, and durability is uncertain. Abrasions and scratches damage the coating.

March 29, 2013

IMAGE CREDITS:

1. Photo: Perzel Photography Group
2. Photo: KB Home

BuildingGreen

Schools Cite Health as a Top Reason for Going Green

A study shows health drives the school construction market—but many buildings lag far behind, another report laments.

By Paula Melton

The connection between sustainable school buildings and student performance can be difficult to quantify—but the idea that children learn more readily when they can see, hear, and breathe clearly isn't exactly controversial. This year, a full 89% of K–12 school respondents in a recent market survey conducted by McGraw-Hill Construction listed enhanced health and well-being among the most important reasons to build, retrofit, and operate greener schools. That number is up from 61% in 2007 and puts health nearly on par with operational cost savings among primary- and secondary-school officials.

"Financial compensation has always been an important driver," notes Michele Russo, director of green content and research communications at McGraw-Hill Construction (MHC), but the nearly equal focus on "positive environmental health impacts" surprised her, she said. "This is different from what drives the other sectors." Russo added, "I think we're going to see more of that playing out within other sectors" and pointed to healthcare, hospitality, and retail construction as areas where health and financial considerations could easily dovetail.

More data would help

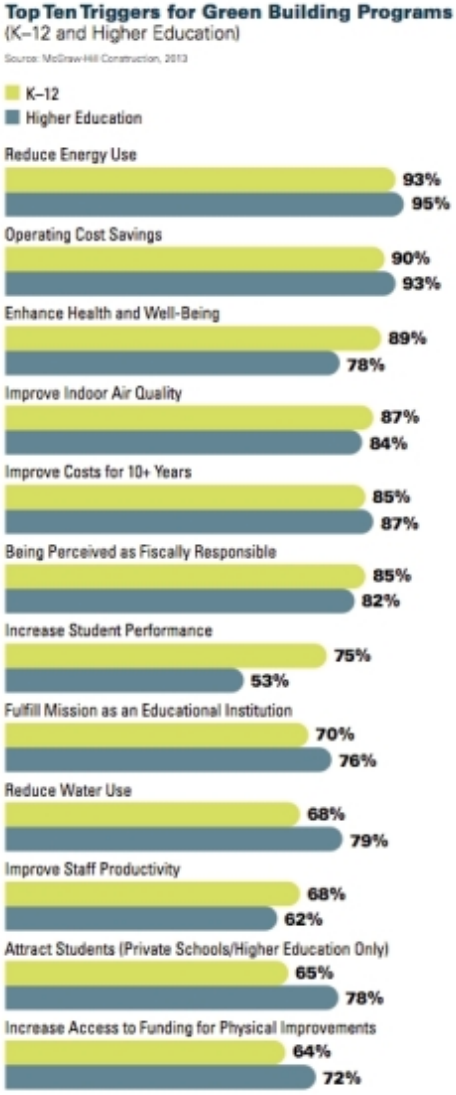
Russo laments the lack of school-level data on student performance, however, pointing out that submetering for

energy or water performance is relatively simple compared with measuring learning. "What's interesting is how many people don't know" when you ask about correlations between green building and academic performance, she said. "The industry *really* needs to know how to benchmark and measure these things" in order to build support for implementing changes.

Educators, she notes, are understandably reluctant to "measure the success of the lighting program by test scores," but there are few good alternatives. Asking teachers to consistently track metrics like student attentiveness would be difficult because "teachers are already extended in a lot of different ways." Russo said she finds the "don't know" answers helpful in their own way, however: "I always keep my eye on that. It indicates a need in the marketplace."

Are our schools crumbling?

The Center for Green Schools points out a much more fundamental lack of data in its 2013 "State of Our Schools" report: U.S. school buildings suffer from decades of deferred maintenance and desperately need modernization, small-scale studies suggest, but it's been 18 years since the federal government did a comprehensive survey of school facilities. Estimates suggest that one-quarter of students go to schools with inadequate facilities and that the country is facing $271 billion just for deferred maintenance costs; an additional $542 billion would be required to bring U.S. schools up to modern standards.



The top three reasons for schools' green building and operations are saving energy, saving money, and—in a very close third—enhancing health and well-being.

The study also notes social inequities, pointing to "significant disparity in educational spaces available in schools with the highest poverty concentration compared to schools with the lowest poverty concentration." In conjunction with the report, Architecture for Humanity has partnered with the Center for Green Schools to urge the federal government to take action. A comprehensive survey, the organizations note, would be a first step toward finding the most cost-effective ways to begin repairing and upgrading school infrastructure nationwide.

The two groups are also collaborating on a free online resource called the *Healthy Schools Investment Guide*, which aims to help school districts invest wisely in green retrofits and operations. The guide will be available in April 2013.

March 18, 2013

IMAGE CREDITS:

1. Source: New and Retrofit Green Schools SmartMarket Report, 2013, McGraw-Hill Construction

BuildingGreen

If You Build It, They Will Walk

By Erin Weaver

The results of a decade-long study bear out the common-sense idea that walkable, mixed-use neighborhoods with recreational destinations encourage residents to walk more.

A study tracked the walking habits of people moving into new developments in Perth, Western Australia, and confirmed that access to walkable destinations increased people's physical activity.

The study, beginning in 2003, surveyed more than 1,400 people who planned to move into new developments in Perth, Western Australia. Respondents self-reported their weekly walking habits in surveys filled out both before moving and approximately one year later; the authors tallied walkable destinations in the respondents' previous neighborhoods and in the new developments, such as shops, parks, and mass transit stops.

Some developments provided fewer such amenities, causing a decline in residents' walking. For those with increased access to walkable destinations, every additional local shop meant residents walked an extra 5–6 minutes per week, and every additional recreational facility correlated with an extra 20 minutes of physical activity per week. The authors suggest policies are needed that encourage the inclusion of recreational and transport-related destinations in housing developments to utilize "the potential of local infrastructure to support health-enhancing behaviors."

April 3, 2013

IMAGE CREDITS:

1. Stuart Sevastos

BuildingGreen

NYC Can Slash Emissions by Midcentury, Says Report

Using currently available building strategies and renewable-energy technology, the city could cut CO2 90% by 2050, authors argue.

By Erin Weaver

Stabilizing the global climate will require industrialized countries to reduce their carbon emissions 80% by midcentury, according to the Intergovernmental Panel on Climate Change. President Obama's 2013 State of the Union address and New York City's PlaNYC program have set lesser goals, but a new study from Urban Green Council argues that New York City could reduce its carbon emissions 90% by 2050.

According to the study, *90 by 50* , buildings are responsible for 75% of the city's CO2 emissions, with transportation producing another 21%. Based on modeling eight major types of residential and commercial buildings, the authors conclude that using techniques that are "in almost all cases currently available," such as increased insulation and heat-pump technology, the building sector could be nearly free of carbon emissions.

Retrofits and improved building methods, combined with the expansion of electrified mass transit, will greatly reduce dependence on polluting fuels in exchange for slightly increased use of electricity —which the authors say can be supplied by a combination of rooftop photovoltaics, sewage-treatment biogas, and upstate or offshore wind turbines.

Carbon-free technology currently supplies 39% of the city's energy for buildings; if overall building energy use were reduced to 50% of its current total, the building sector would require only 11% more clean electricity by 2050. The authors estimate the cost of building improvements between 2015 and 2050 at $94 billion, of which 92% would be offset by financial savings from energy use reductions.

March 28, 2013

BuildingGreen

Global Warming Making Outdoor Labor More Dangerous

Hot, humid conditions could make heavy labor such as construction unsafe to maintain for a full workday.

By Erin Weaver

Global labor capacity in hot summer months has declined 10% since the mid–twentieth century—a decline that could double by 2050, according to a new report released by the U.S. National Oceanic and Atmospheric Administration (NOAA) and published in *Nature Climate Change*.

According to a new study from NOAA scientists, by 2050 increased heat and humidity will reduce people's ability to safely work outdoors by 10% during the hottest months in much of the world.

"No amount of labor can be safely sustained"

The increased summer heat brought by climate change is naturally accompanied by greater humidity, making peak summer months more dangerous for outdoor laborers like construction workers and farmers. Under very hot and humid conditions, the human body cannot give off heat as fast as it creates it—a hyperthermic condition that can lead to low blood pressure, organ failure, and death.

Based on existing guidelines regarding heat stress, the authors measure labor capacity as wet-bulb temperature thresholds at which an individual's ability to perform heavy, moderate, or light labor is reduced. Under most conditions, productivity could be maintained by adding workers, but with 77°F (25°C) as the limit for 100% heavy labor, the authors estimate that beyond 91.4°F (33°C), "no amount of labor can be safely sustained over the typical eight-hour work period."

Summer labor reductions of 60% in U.S.

Current middle-of-the-road climate projections will mean large parts of Asia, Australia, and North

America—particularly the eastern and southern U.S.—will be severely affected in coming decades, with summer labor capacity for heavy labor such as roofing and carpentry reduced more than 60% by 2200.

In some regions, workers adapt to high temperatures by working at night or taking time off during the hottest months, but many of the world's workers may not be able to take such precautions; according to lead author John Dunne, the only way to maintain labor capacity is to stabilize global warming at less than 5°F (3°C).

The paper does not assess the economic implications of its conclusions—a project that Dunne hopes will soon be taken up by others.

March 27, 2013

IMAGE CREDITS:

1. (no credit)

BuildingGreen

Warm-Water Cooling Translates to Data Center Efficiency

A government facility conducting renewable-energy research will capture and use its new data center's waste heat.

By Erin Weaver

A new government data center supporting clean-energy research will take advantage of advanced energy-efficiency technology to cool its computers.

The U.S. Department of Energy's National Renewable Energy Laboratory (NREL) will soon complete its new high-performance computing (HPC) data center and Energy Systems Integration Facility (ESIF) offices and laboratories in Golden, Colorado. The data center will use warm-water liquid cooling, with 75°F water pumped in from cooling towers to achieve a power usage effectiveness (PUE) rating of 1.06.

The temperature of the cooling water is set higher than is conventional, allowing the use of the cooling towers instead of compressor-based mechanical chillers. The water will exceed 100°F by the time it leaves the data center; it will then provide the primary heat source for the ESIF offices and labs and will also run under outdoor walkways to melt snow and ice.

NREL hopes to save $800,000 annually compared to conventional data centers, with another $200,000 saved by reusing waste heat.

March 26, 2013

BuildingGreen

Two New Resources Help Implement LEED-ND

New guidance helps local governments "zone in" sustainability measures like narrower streets, mixed use, and walkability.

By Erin Weaver

Traditional zoning codes have created low-density sprawl, which has resulted in habitat loss, high fuel use for transportation, and other issues.

Two new resources aim to help municipalities use LEED-ND to combat zoning codes responsible for low-density sprawl.

Now the U.S. Green Building Council (USGBC) and the Land Use Law Center at Pace Law School have developed two documents to help local governments "zone in" sustainability measures that are often "zoned out" by existing codes, potentially allowing them to achieve certification under the LEED for Neighborhood Development (LEED-ND) rating system, according to Land Use Law Center founder John Nolon.

The "Technical Guidance Manual for Sustainable Neighborhoods" uses case studies and research on dozens of municipalities that have used LEED-ND to reform their planning regulations, while "The Neighborhood Development Floating Zone" provides a model ordinance and addresses situations in which extensive zoning updates are not an option. USGBC defines "floating zones" as location-specific zoning classifications authorized when a developer demonstrates compliance. Both documents are available to download at usgbc.org.

March 26, 2013

IMAGE CREDITS:

1. Lynn Betts /

BuildingGreen

Research Connects Cleaning Jobs with Asthma

Occupational chemicals may carry more asthma risk than smoking, a new study finds.

By Paula Melton

Job-related hazards were the single largest risk factor for adult-onset asthma in a recent Imperial College London study published in the journal *Thorax* . Cleaning chemicals stood out in the findings, which identified 18 high-risk occupations: four of these occupations were janitorial, and three others involved routine exposure to cleaning chemicals.

Although many conventional cleaning products contain VOCs and other airborne hazards known to cause respiratory problems and other illnesses, this is the first time medical research has directly linked cleaning jobs with asthma risk. Occupations already known to increase risk—such as farming, hairdressing, and printing—also made an appearance, and both metalworking and textile production were identified as high-risk occupational exposures.

"Occupational asthma is widely under-recognized by employers, employees, and healthcare professionals," said lead researcher Rebecca Ghosh. "Raising awareness that this is an almost entirely preventable disease would be a major step in reducing its incidence."

March 26, 2013

BuildingGreen

Presidio Neighborhood Is First LEED-ND 2009 Certified Project

The historic San Francisco redevelopment is the first to earn LEED for Neighborhood Development certification since the rating system was formally launched.

By Tristan Roberts

The Presidio, a former army base and an urban national park site located at the base of the Golden Gate Bridge in San Francisco, is home to the world's first community certified under LEED for Neighborhood Development (LEED-ND 2009) since LEED-ND left its pilot phase, as recognized by the U.S. Green Building Council (USGBC). The Public Health Service District (PHS District), the first "green" neighborhood in the Presidio, is a mixed-use 36-acre site featuring 172 housing units, office space, a preschool, hiking trails, scenic views toward the Pacific, and 25 acres of open space and native habitat.

This aerial photo shows the LEED-ND certified Presidio district, with the Presidio Landmark (formerly the Public Health Services Hospital) in the center.

First to earn Stage 3 certification

LEED-ND certifications have been awarded in the past at the planning stages—Stage 1 and Stage 2, in LEED-ND's terminology, as well as in the LEED-ND pilot. Stage 1 is a conditional certification designed to help a developer attract partners; Stage 2 is pre-certification based on a more complete plan and partial construction. The Presidio neighborhood is the first Stage 3 certification, signifying full LEED-ND documentation and certificates of occupancy for all buildings.

With 47 points, the project attained the Certified level. It features drought-resistant landscaping, a water recharge system that captures rainwater and reduces runoff, and dark-sky-friendly streetlights. Not all buildings within a LEED-ND project need to be LEED-certified. In this case, the neighborhood includes three individually LEED-certified buildings out of 14 total—including the Presidio's largest historic building, the former Public Health Service Hospital, which reopened in 2010 as the Presidio Landmark apartments. The nearby Belles Townhomes, the only newly constructed residential buildings

in the Presidio, earned LEED Platinum, while the rehabilitation of the historic nurses' dormitory earned LEED Gold certification as a core and shell project.

A milestone for a former military base

The non-LEED buildings in the neighborhood also contribute to LEED-ND requirements for energy efficiency, water conservation, and other measures. They include seven rehabilitated historic homes on Wyman Avenue, which once housed physicians and their families.

Homes on Wyman Avenue are part of the LEED-ND Presidio district.

"This is an exciting milestone," said Craig Middleton, executive director of the Presidio Trust, the federal agency managing the district. "We take great pride in our track record of applying green building and design practices to historic preservation to create welcoming and beautiful contemporary spaces."

More than 2,700 people live in the park's former military housing, and more than 200 organizations have located in the formerly dilapidated Presidio buildings, according to the Presidio Trust. Until its closure in 1995, the Presidio was the longest continuously operated military base in the U.S. Congress established the Presidio Trust in 1996 and tasked it with becoming financially self-sufficient by 2013, which it achieved in 2005, according to the *San Francisco Chronicle*. To learn more, visit Presidio.gov.

March 26, 2013

IMAGE CREDITS:

1. Presidio Trust
2. Presidio Trust

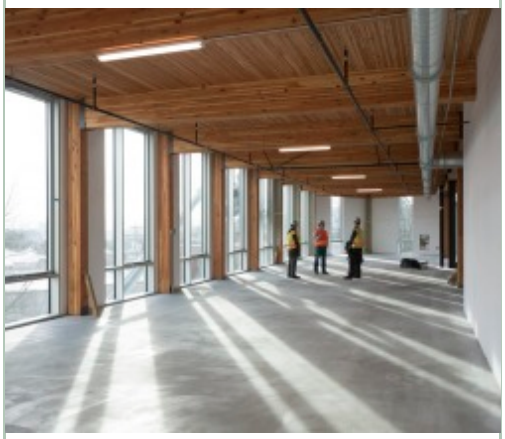
BuildingGreen

Bullitt Center Achieves FSC Project Certification

Seattle office is the first commercial building to score the designation in the U.S., with 100% FSC wood in the core and shell.

By Paula Melton

Seattle's Bullitt Center has become the first commercial building in the U.S. to achieve project certification from the Forest Stewardship Council (FSC). The certification verifies that 100% of the wood in the core and shell is FSC-certified.



The Bullitt Center project uses FSC-certified wood for both structure and finish.

The six-story building will be the first heavy-timber commercial structure built in Seattle since the early 20th century, according to a press release. Wood used in the project includes laminated structural timbers, dimensional lumber, and structural plywood. It will serve as the headquarters for the Bullitt Foundation, which supports ecosystem restoration and other environmental initiatives in the Pacific Northwest.

The building also received the top 2013 Design & Build award from the U.S. affiliate of FSC and is pursuing Living Building Challenge certification, which will require verified net-zero water, energy, and waste for at least one calendar year after occupancy.

March 20, 2013

IMAGE CREDITS:

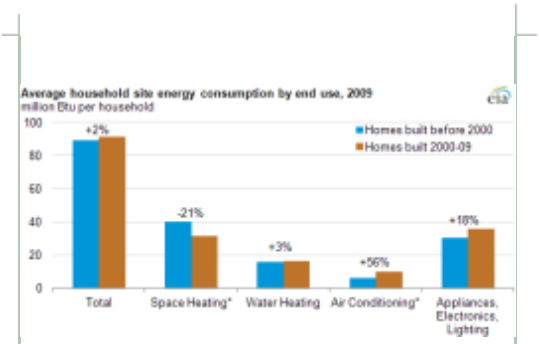
1. Photo: John Stamets

BuildingGreen

Home Size, Appliance Glut Cancel Out Efficiency Gains

By Erin Weaver

As houses are built to more stringent energy codes and appliances increase in efficiency, the average U.S. home might be expected to see reduced energy use. Ever-increasing square footage and the accompanying glut of appliances, electronics, and lighting, however, mean that the average home built in the 2000s actually uses 2% more energy than the average home built prior to 2000.



Homes built since 2000 tend to be larger and contain more appliances than older homes, so despite efficiency gains they consume 2% more energy on average.

The U.S. Energy Information Administration (EIA) continues to release analysis of data from its 2009 Residential Energy Consumption Survey (RECS), comparing housing units built between 2000 and 2009—about 14% of U.S. housing stock, from single-family houses to high-rise apartments—to those built in previous decades. The latest results show that homes built in the 2000s use 21% less energy for space heating than older homes; this is due not only to increased thermal efficiency but also to the increased share of construction happening in warmer parts of the country. At the same time, this migration to warmer areas has led to greater energy use for air-conditioning.

Homes built in the 2000s are 30% larger on average than older homes—and 17% larger than those built just a decade earlier—and are more likely to house dishwashers, clothes washers and dryers, and multiple televisions, computers, and refrigerators, as well as requiring more lighting for the additional space. The resulting 18% greater energy use for appliances, electronics, and lighting offsets the savings on heating energy, for an overall 2% increase in energy consumption.

March 15, 2013

IMAGE CREDITS:

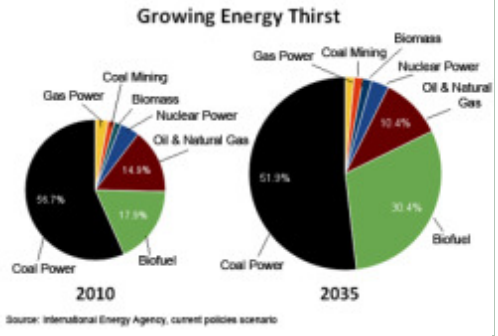
1. Energy Information Administration

BuildingGreen

Energy Could Be Twice as Thirsty by 2035

By Erin Weaver

Along with a projected population of nine billion people to feed—two-thirds of them living in water-stressed locations—the coming decades could see a doubling of the fresh water devoted to energy production. The International Energy Agency (IEA), in its "World Energy Outlook 2012," attributes much of that rise to a continuing global increase in coal-fired power generation and biofuel production—both water-intensive processes.



The International Energy Agency predicts that the fresh water used in global energy production could double by 2035.

Coal currently fuels 41% of power production worldwide; with demand for electricity expected to increase 90% by 2035, IEA predicts coal plants will continue to be responsible for more than half of all water used for energy production. Newer plants, which may cool their discharge water to protect aquatic ecosystems, can actually lose far more water to evaporation in the cooling process. Demand for coal is expected to grow in most parts of the world except the U.S., where it is being outpaced by natural gas. Despite the local impacts of hydraulic fracturing to obtain natural gas, at millions of gallons of water per well, IEA calculates that it will constitute a small percentage of global energy-related water use, with oil and natural gas production combined amounting to only 10% of the total demand in 2035.

Biofuels are predicted to use the second-largest share of water, at 30%, largely through evaporation during spray irrigation of fuel crops. While other methods of irrigation can reduce evaporation, they tend to use more electricity than surface spraying—thus contributing indirectly to the demand for water.

IEA recommends a shift to renewable energy as the best way to reduce the stress on the "water-energy nexus," with electricity generated from wind and solar power requiring minimal water to produce.

March 15, 2013

IMAGE CREDITS:

1. International Energy Agency

BuildingGreen

Royal Institute Recognizes Passive House Founder

By Erin Weaver

The Royal Institute of British Architects has recognized the "father of Passive House," Wolfgang Feist, Ph.D., with one of twelve annual Honorary Fellowships awarded to non-architects for their contributions to the field.

Feist, who founded the Passivhaus Institut in Germany in 1996 and is its current director, says the award "shows that architecture is aware of the environmental challenges" it is facing, and notes that "high levels of energy efficiency and excellent architectural design go hand in hand." The awards ceremony was held in London on February 6, 2013.

Another nod to sustainability in this year's awards was the Honorary Fellowship given to Harry Mallgrave, Ph.D., director of the International Center for Sustainable New Cities at the Illinois Institute of Technology.

Wolfgang Feist, founder of the Passivhaus Institut in Germany, has been awarded an Honorary Fellowship by the Royal Institute of British Architects.

March 11, 2013

IMAGE CREDITS:

1. Green Building Advisor

BuildingGreen

EPA Reveals Chemicals Used in Thousands of Products

By Erin Weaver

Information on 7,674 chemicals manufactured or imported by more than 1,500 U.S. companies has been published in the first reporting cycle since the U.S. Environmental Protection Agency (EPA) reformed its Chemical Data Reporting (CDR) program in 2011.

The database does not provide information on toxicity, but it may be a powerful tool for product research along with material safety data sheets (MSDS) because of new EPA reporting rules about chemical use.

Based on information provided for that year, the report identifies chemicals used in commercial, industrial, and consumer products, including toys and furniture. Established under the Toxic Substances and Control Act (TSCA) in 1986, the CDR rule was amended in 2011; changes included lowering the reporting threshold to 25,000 pounds per year, requiring substantiation for confidentiality claims, and replacing the option of reporting information as "not readily obtainable" with the more stringent "not reasonably ascertainable."

EPA's New Chemical Database

This screen capture from the online version of the database shows both innocuous and less innocuous chemicals used at a specific Johns Manville manufacturing site, where both insulation and paper are made.

The online version of the database can be searched by chemical name or CAS number, or by company name. The entire database can also be downloaded for use in Microsoft Access.

Based on the data, EPA has proposed a list of 83 chemicals for further risk assessment, 25 of them fast-tracked for study by 2014. These include the chlorinated flame retardant tris (chloroethyl) phosphate (TCEP, used in furniture foam, textiles, carpet backing, and many other products), trichloroethylene (a VOC used in some adhesives and coatings), and antimony trioxide (used as a flame retardant in some coatings and adhesives).

The CDR database is available to the public on EPA's website.

March 6, 2013

IMAGE CREDITS:

1. Screen capture: U.S. Environmental Protection Agency

BuildingGreen

Building Owners Responsible for Bird Deaths, Judge Rules

A Toronto court tells owners of glass buildings that reflected light is a form of pollution, and they must mitigate bird deaths.

By Erin Weaver

A verdict handed down in Toronto establishes that building owners and managers must take action to prevent their buildings' windows from causing excessive death or injury to migratory birds.

A judge in Ontario has ruled that building owners are responsible for bird deaths resulting from buildings' reflected light—a "contaminant" that, in the U.S., results in up to one billion bird fatalities every year in collisions with windows like that seen here.

Canadian nonprofit Ecojustice filed charges against Cadillac Fairview, owners of Toronto's Yonge Corporate Centre, claiming that the three buildings' highly reflective windows caused the deaths of more than 800 birds in 2010, including threatened species. In the trial, which began in April 2012, Ecojustice accused Cadillac Fairview of violating the Environmental Protection Act (EPA) and the federal Species at Risk Act (SARA), which prohibit the discharge of contaminants harmful to wildlife.

Ecojustice charged that "contaminants harmful to wildlife" should be interpreted to include reflected light that confuses birds or lures them toward reflected sky or trees, resulting in collisions and injury or death. Judge Melvyn Green of the Ontario Court of Justice ruled the interpretation valid, meaning that the Ontario Ministry of Environment will now regulate buildings reflecting light that leads to bird fatalities.

Judge Green acquitted the company of the charges, however, because it has already taken steps to mitigate the problem by installing window films on the sides of the buildings with the highest bird fatalities and has committed to retrofitting the rest.

March 7, 2013

IMAGE CREDITS:

1. (no credit)

BuildingGreen

Islandable Solar—PV For Power Outages

With the right technology, a grid-connected solar-electric system can still provide electricity during power outages.

Many people assume that an onsite renewable-energy system will give you power during a utility outage. That's not necessarily the case.

The vast majority of PV systems today are grid-connected. If the grid goes down, these systems not only leave houses dark at night but also won't deliver electricity when the sun is shining. This is in part a safety precaution to protect utility workers repairing downed lines.

For access to solar-generated electricity during power outages—a feature of resilient design—there are three options today.

This Sunny Island inverter from SMA America, coupled with a 48-volt battery bank as small as 100 amp-hours, allows a grid-connected PV system to function when the grid is down.

1. Standalone (off-grid) PV systems

Standalone PV systems work without any connection to the utility grid, so they are unaffected by utility power outages. These systems have battery banks that store power during the daytime for use at night or in cloudy conditions. They are reliable, but a battery bank large enough for a typical home is expensive, and the batteries have limited lifespans and carry significant environmental impacts.

2. Islandable grid-connected PV systems

An *islandable* grid-tied PV system relies on a battery bank (which can be fairly small), a standard grid-tied PV inverter, and a second, more specialized inverter (sometimes referred to as a *bi-modal*or *bi-directional battery inverter*) with sophisticated controls that is capable of creating a *micro-grid*. When the utility grid fails, this special inverter disconnects from the grid and pulls electricity from the battery bank to produce AC electricity. Once it's producing electricity of the proper waveform, the micro-grid can also incorporate AC electricity coming from the standard PV inverter.

In other words, with just a small amount of battery storage, the full output of the PV system (up to the capacity of the bi-modal inverter) can be used when the utility grid is down and the sun is shining. Several bi-modal battery inverters are available, including the Sunny Island from SMA America.

3. Grid-tie inverters that produce electricity when the grid is down

The micro-grid system with its multiple inverters is complicated. A simpler system would be a standard grid-tie inverter that would safely disconnect from the utility grid during a power outage, as required, but retain an ability to convert the direct-current (DC) electricity from the PV system into usable electricity for the house. The industry isn't there yet, but there are some promising recent developments.

Several of SMA America's newest Sunny Boy grid-tie inverters now feature an emergency power-supply feature that allows a small amount of power to be drawn from the inverter even when the grid is down. This emergency power is provided through a separate 12-amp, 120-volt outlet; the electricity cannot be delivered through the building's wiring system. While it may not be enough power for major household loads, it can provide critical cell phone and laptop computer charging and other daytime needs. We expect that other manufacturers will follow suit.

March 29, 2013

IMAGE CREDITS:

1. Photo: Alex Wilson