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Circular Economy at Scale: Six International Case Studies

These teams are applying radical life-cycle thinking to entire projects—and redefining what building ownership means in the process.

By James Darius Ball and Paula Melton

We don't normally conceive of buildings as disposable. Yet cultural and economic undercurrents make it all too easy for our buildings to become trash.

The typical service life of a commercial building in North America is less than 50 years—and many structures are lucky to hit the ripe old age of 20. Once a building ceases to function, it is extremely rare for materials to be reused or even recycled. The amount of waste from this carnage is staggering. The U.S. Environmental Protection Agency reports that annual construction and demolition (C&D) debris from buildings in the U.S. is around 136 million tons annually—amounting to about 840 pounds of waste per person per year. In the northeastern U.S. (one of the only regions for which reliable statistics are available), only about 10% of that waste is diverted from landfills.

This all-too-typical trajectory of our building materials represents a *linear* system. It is by definition unsustainable because it puts valuable resources permanently out of service after they're no longer useful to their first owner. Linear systems are at the core of our most pressing environmental crises. We send toxic chemicals and carbon dioxide on a one-way trip into our environment, while irreversibly damaging habitat and natural treasures as we extract resources. Linear processes are deeply ingrained in the developed world's economies and cultures; they won't be easy to change.

But it doesn't have to be this way, according to advocates of a *circular* model. Groups like the Ellen MacArthur Foundation and its supporters, which include major global corporations like Philips, Cisco, and Google, believe we can create new economic conditions under which materials and energy retain their value for a much longer period of time—perhaps to the point where "waste" would virtually cease to exist.

New work has begun to apply this circular model to building materials. Product certification systems like Cradle to Cradle and the Living Product Challenge spread these concepts and aim to optimize the material flows of individual products. However, we could keep wasting valiant efforts like these unless we design buildings as a whole to exist within a circular life cycle.

According to the corporations and nonprofits that are actively reviving the philosophical framework of a "circular economy" first developed in the 1960s and 1970s, businesses need to redefine their concepts of value and ownership if we are to shift from a linear economy to a circular one. While work continues at the product scale, project teams—and particularly a group of corporations and firms in the Netherlands—are beginning to apply them at the building scale.



Photo: courtesy Delta Development

The Bosch Siemens Home headquarters features a variety of building components designed for eventual disassembly and reuse.

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Circular Economy: Key Concepts

A *linear economy* takes materials from the earth, makes those materials into products, and disposes of them as waste at their end of life. This "take, make, waste" model is inherently unsustainable due to the Earth's limited supply of resources and limited ability to break down our waste.

A *circular economy* is based on closed loops of material flows and on a financial system that maximizes the value of materials and products at every stage as they move through their life cycle.

The circular economy has deep roots in *systems thinking* and *life-cycle thinking*, both hallmarks of sustainability in the built environment, but it is unusual in identifying two distinct types of closed-loop systems. The terminology will be familiar if you have looked into Cradle to Cradle product certification:

- A *biological system*, whose nutrients can ultimately be put back in nature to be broken down and used within the ecosystem (example: wool or cotton fiber returned to the soil as mulch after a textile is no longer functional as such)
- A *technical system*, whose nutrients provide no value in the ecosystem and are therefore kept in the industrial system (example: nylon fibers recycled again and again for the same end use—not "down-cycled" into something less valuable until they can no longer be recycled)

See the "butterfly" diagram for a visualization of how these two systems interact, and watch this video for a quick primer on the circular economy.

Although no product or project can yet claim to be fully circular, below we highlight a number of firms that are working on at least one leverage point in the conventional construction process by focusing on:

- Long-term value rather than first costs
- Design for continuous cycles of use
- Rethinking building ownership, with value arising from performance rather than from physical objects

Design Is Forever

According to Natesh Magdani, RIBA, director of sustainability at BAM Construction UK, there are two big problems that we need to solve in order to get optimum long-term value from our building materials: we need to "design out waste," he argues, and we need to allow building owners to "procure materials in such a way that they are taken back, or performance is assured over [the building's] life."

Brummen Town Hall: The persistence of the temporary

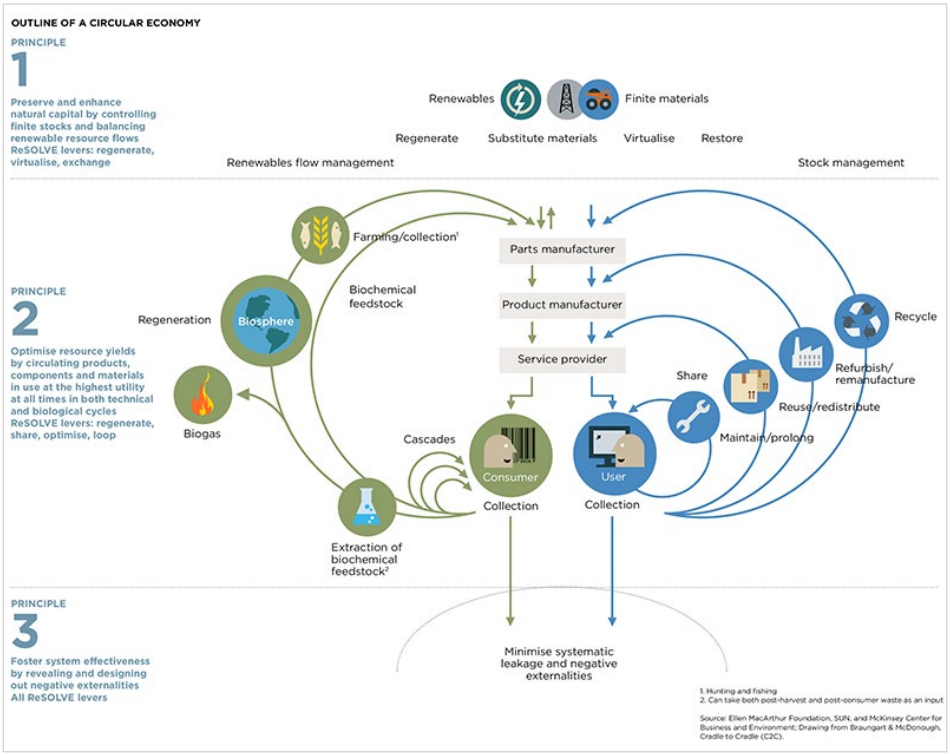
When you think of design for long-term value, the first thing to pop into your mind is probably *not* a temporary structure. But that's the apparent contradiction at the heart of Brummen Town Hall.

The request for proposals asked for a building that would last 20 years. Municipal borders in the Netherlands change relatively frequently, and the Brummen administration wasn't sure the town would need the facility longer than that. Rather than throwing together the cheapest materials possible, all of which would likely end up in a landfill 20 years later, Amsterdam-based architecture firm RAU had a better idea: make a building whose components would be leased to the town by product manufacturers and then taken back two decades later for reuse in other projects.

RAU teamed up with construction firm BAM to win the bid, along with Turntoo, a circular-economy-focused consulting firm that brokers deals between product makers and users. The building systems are in effect owned by their manufacturers and provided to the building "owner" under a 20-year service contract. (More on the nuances of these contracts below.)

For any of this to work, design and installation must permit easy disassembly at the end of the building's life so that materials

The "Butterfly" Diagram



Source: The Ellen MacArthur Foundation

Biological loops occur in "cascades" of multiple uses over a material's lifespan that degrade to the point of placing the materials back into the ecosystem. The technical system operates with inner and outer loops that retain products in their most fully assembled (and thus most highly valuable) form. The final outer loop of recycling should only be used as a last resort.

can be returned to the supplier in a condition that maximizes their value. This was Turntoo's second design-for-disassembly project. On the first one, the firm worked with a roller-coaster manufacturer—an industry centered around safe disassembly and reassembly—to optimize the design.

But there's more to it than safety: materials must remain valuable to the manufacturer after the building is taken apart. For example, Brummen Town Hall's timber posts were designed to be longer than was aesthetically or structurally necessary. Keeping the length more standard will allow the supplier to sell the structural components more easily after they are no longer needed for that space.

Delta Development: "Please wow us"

The financing of many projects is so driven by first cost that designing for long-term value is often an uphill battle.

Delta Development, an international real estate developer based in Amsterdam, made a conscious decision to disrupt this trend after its CEO watched the documentary film *Waste = Food* and promptly outlined his new cradle-to-cradle business direction in a three-page memo to the company.

According to Owen Zachariasse, head of innovation and sustainability for the firm, this commitment from the CEO was critical to the company's new path. But even with leadership and employees on board, success with circularity requires participation from partners, suppliers, customers, and investors, he adds.

Building owners are perhaps the easiest sell. Zachariasse explains that "the client likes that the building is all about them. We are not trying to sell it for as much as possible; we want you to be an integrated part of the team." Delta believes in empowering its clients with a hands-on approach that starts with six weeks of charrettes. These charrettes develop a common language that carries though the project. "We want to get to know the company to see if we have a common vision on the built environment," says Zachariasse. This is much more than what many of us think of as an "integrated design" approach. The firm is looking for clients that share its organizational culture (see How to Make Integrated Project Delivery Work for Your Project).

The transformation of Delta's relationships with product suppliers and subcontractors has been more challenging. "Even when every partner wants it, it is still tough. Right now it is a race to the bottom: getting the cheapest price to work within the specification," says Zachariasse. He goes on to explain how Delta aims to leverage its financial relationship with its suppliers and the trades to incentivize improved building performance.

"The typical situation now is that the technical specs and drawings will go to the general contractor, and legal will try and poke holes in it," explains Zachariasse. "Then the general contractor reaches out to all the 'good old boys' to save pennies and get the very low bottom of the technical specifications—just clear the bar but not do anything exceptional." Delta is breaking down this ingrained culture by no longer asking for the lowest bid: "We give you the $100,000. Use it all, and give us the best quality for it. It needs to be an open dialogue about improved quality: here are the specs, but please exceed them. Please wow us." (This type of model may be familiar to some project teams as part of integrated project delivery.)

The most critical partners to buy into Delta's new circular-economy-based culture are its investors. The mental shift they have to make is that they are investing not in a physical building but in the *discounted cash flow* of the building—a valuation model that takes future returns into account. In other words, Zachariasse explains, what Delta is really securing for the investors is long-term stability arising from happy tenants that will pay a premium for quality spaces—ultimately a less risky approach.

As a result, he claims, Delta now brings in clients and investors that want a more performance-based assurance of success.



Photo: courtesy William McDonough + Partners

Products like these panelized facade components are much more likely to be reused if the materials and their value are known when the building is decommissioned, decades down the road. Delta and its partners are pioneering a "materials bank" concept to facilitate that.

Waste Is Food

One of the core principles of the circular economy is that there is no such thing as waste: every material contains still-valuable technical or biological nutrients that, with the proper economic incentives, product makers can use to "feed" a new process or material.

This isn't only about recovering materials, nor is it only about design for disassembly: green building advocates have been pushing for both these strategies for decades.

What's unique about the circular economy is its combination of the two—its attempt to connect design for disassembly with economic systems that make recovery and repurposing the obvious financial choice.

Why design for disassembly rather than simply "recyclability"? In the circular economy, recycling (total re-processing of materials) is a last resort. It's the final option in a series of more optimal ways of repurposing technical and biological nutrients, coming after reuse (no further processing), refurbishing (repairs or superficial upgrades), and remanufacturing (reassembly or a functional upgrade of components). And design for disassembly—whether at the level of a product or a whole building project—makes all these options more viable.

Bluewater: Banking on BIM

When Delta Development decided to build Park 20|20, it turned to Charlottesville, Virginia-based architecture firm William McDonough + Partners with the goal of pursuing circular-economy principles with direct inspiration from the Cradle to Cradle philosophy. Located near Schiphol Airport, Park 20|20 currently has 990,000 ft² (92,000 m²) of office space, all of which can be completely disassembled.

"Each buildings' materials and components have been selected and designed with the aim of deconstruction in mind, to optimize flexibility for tenants both in the short and long term," says Kira Gould, a spokesperson for the architecture firm. "This approach has been received as a major value-add for the owners," Gould notes, because it can reduce renovation costs during occupancy and between tenants' lease periods.



Photo: courtesy William McDonough + Partners

Products like these panelized facade components are much more likely to be reused if the materials and their value are known when the building is decommissioned, decades down the road. Delta and its partners are pioneering a "materials bank" concept to facilitate that.

The strategy favors mechanical fastenings instead of adhesives and sealants, along with modularity and separation of systems. Prefabricated components in several projects were designed according to a concept known as *Slimbouwen* (Dutch for "slim building" or "smart building"): the idea is to integrate structural components and building services like plumbing and electricity into one module, while keeping them totally separate for later deconstruction. (In the U.S., many are familiar with *Slimbouwen* principles in the form of underfloor air systems.)

If the idea of a building envelope without adhesives or sealants sounds foreign to you, you're not alone. "Product complexity has increased dramatically in recent years, where more products are engineered combining a number of different materials all mixed together with glue," laments Zachariasse. Not only is the adhesive itself a problem during deconstruction, he notes, but also the ingredients of it are seldom available, making it impossible to determine how its nutrients could be used later. "Even windows that would be comprised of Cradle to Cradle-certified components suffer from the same issue, so being able to quickly and properly disassemble them is a challenge," he adds. "If we can't find a direct plug-and-play solution, then these valuable resources are destined to be ripped apart, and much of the value is lost."

Coatings present a similar challenge. "Fire, water, and corrosion protection solutions can be highly toxic to biological systems and humans," so adding them to increase the durability of a structural beam, whether steel or timber, "will most likely compromise and degrade the future value of such resources." The regional market has few alternative options for such treatments. "Safe, healthy coatings at a one-to-one price point are always high on my wish list," he says. These items have even proven problematic at the nearby Fokker Logistics Park, which the developer has used as a test bed for design for disassembly since the warehouses and loading docks have relatively simple construction compared with Class A office space.

Even assuming the engineering will be perfected, design for disassembly facilitates but does not guarantee that materials will be recovered or reused decades later, when the building is decommissioned.

Leasing building systems (as with Brummen Town Hall, discussed above) is one idea building owners are experimenting with to close that loop. Buildings in the Park 20|20 office park are taking another approach—what Delta and McDonough + Partners have dubbed a "materials bank." The name plays on the idea of building materials being in "storage" during use while also emphasizing that they

retain value throughout this time. The system will be, in effect, an elaborate tracking framework managed through building information modeling (BIM) software.

"We have been working on several components of a realistic and practical materials banking business case," explains Owen Zachariasse. "While it is not yet ready for broad-level rollout, we are making good progress." The pilot program for materials banking is the corporate headquarters of Bluewater Energy Services, a consultant to utilities and large manufacturers now located in the new business park.

Step one, Zachariasse says, was to get every project team member to work with the same software program—easier said than done. A central "command center" at the general contractor's office helped facilitate participation among all team members.

Step two? Actually get product data in the system. That turns out to be quite difficult to achieve at the granularity needed (anyone who has worked on a Living Building Challenge project is intimately familiar with how grueling product-by-product scrutiny can be). Most of the core and shell materials have been added, says Zachariasse, who notes the team is holding off on documenting electrical and mechanical systems due to their complexity. "We've identified almost 90% of the products [for core and shell], which is a first step into then exploding products to components, which can then be exploded further down to the nutrient level." In other words, products are broken down into each of their parts (so the team knows what whole components can be reused, refurbished, or remanufactured), and each part is also broken down into a set of materials (recyclables like metals, plastics, or glass).

Fully characterized materials so far include concrete, steel, brick, copper, aluminum, and glass—and these have further been analyzed for monetary value by weight.

Step three is considerably more complex, as it will involve tracking of building materials and their value over time. For this, Delta is working with IBM on sophisticated software that will be "anchored" to the original BIM model of the Bluewater project. When the building is in need of repair or disassembly, the materials can be withdrawn from functional storage and repurposed into the next form. Intelligence developed during design and construction will show the clear economic value of repurposing rather than paying for disposal.

Kalundborg: Industrial symbiosis

It's not just building materials that can partake of the "waste is food" principle: the term can apply to building systems as well. We may recover "waste" heat or water from HVAC or plumbing systems, for example, and repurpose them for other uses.

In industrial ecology, the science of material and energy flows in industrial systems (and the field of study that brought us environmental life-cycle assessment), there is an analogous concept known as "industrial symbiosis" that recognizes similar resource exchanges among multiple industries or entities.

With a coal-fired power plant at its center, the Kalundborg Eco-Industrial Park is perhaps an unlikely paragon of sustainable resource sharing. Yet it's held up as an example of industrial symbiosis because its waste-to-food system was the first (starting in 1959) and remains one of the largest in the world—and it grew in response to economic forces rather than ecological ones.

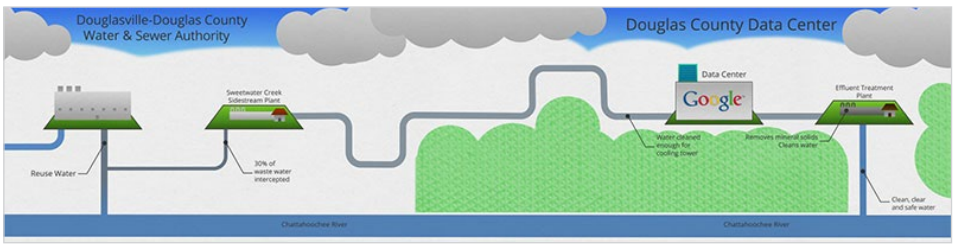
There are currently more than thirty exchanges of materials, including more than 700,000 m^3 of water reuse annually from an oil refinery that captures steam and provides it as cooling water to the power plant. Waste heat from the power plant heats nearby homes, and byproducts from the power plant are resources for a concrete factory and a drywall manufacturing plant on the site. The park has served as inspiration for other economically driven eco-industrial parks, but it could also be a potential model for buildings—and it has the advantage of including strategies that are well within the project team's control during design.

Sharing waste heat among buildings on a campus or in a neighborhood is already relatively common, but more opportunities are available for resource sharing, and this aspect of the circular economy is receiving further attention with the news that Google will join the Ellen MacArthur Foundation as a global partner.

In announcing the decision, Jim Miller, the company's vice president for worldwide operations, noted several examples of industrial symbiosis occurring on Google sites around the world already—mostly notably, using local landfill gas to power its main campus and using treated wastewater from a local sewage plant in the cooling towers of its Atlanta data center.

"Over the coming months," writes Miller, "we'll be working with the foundation to explore and shape a series of initiatives to embed circular economic principles into the fabric of Google's infrastructure, operations, and culture."

Google Water Reuse



Source: Google

The circular economy goes beyond material flows: industrial symbiosis helps optimize water and energy reuse as well. This schematic shows how Google's Atlanta data center uses wastewater for its cooling towers.

Performance Is Value

"I do not have an electricity bill in my office," boasts Thomas Rau of RAU Architecture, expounding on the circular-economy tenet of tying value to functions rather than to possession of an object.

The term often used for this is "product as service." In this case (much like with Brummen Town Hall), instead of buying a bunch of fixtures and luminaires and controls, RAU commissioned Philips to provide *light*: the manufacturer owns the light*ing*. Hence the lack of an electric bill: "I do not need the electricity," Rau says. "Phillips does."

Brummen Town Hall: Guaranteed performance

Philips was also involved in the Brummen project. The company worked with the architect to determine how many lumens each space within the building would need. Their contract specifies the distribution of those lumens, and it is up to Philips to provide not only the lighting system but also the energy required to achieve that performance over the full life of the contract. BAM Construction's Natesh Magdani says that this guaranteed performance—plus the potential for a building that actually improves performance over time as suppliers swap in new, more efficient technologies—is a major selling point for their clients.

Anyone who's ever lost a security deposit on a rental will understand that this kind of relationship could get very complicated very quickly. Under the scheme, there are multiple contracts, one for each system within the building. These contracts are of two distinct types—one for active building services (e.g., lighting, HVAC) and one for passive systems (e.g., structure, envelope, finishes).

Service contracts detail the service and acceptable levels of performance that each system must provide. The system supplier then provides the products that will achieve this performance.

User contracts are for the passive elements within the building, such as the windows, walls, and roof. As the performance of these products is less likely to change, contracts are mainly focused on taking back the materials at the end of their or the building's functional life.

In order to be effective, these contracts must provide mutual financial benefits. For the buyer, the main advantage is a unique financing option: the manufacturer reduces its price by the value of the materials it will get back at the end of use. This is usually calculated as value of the material at the time of sale, not a prediction of what its value will be when returned to the supplier.

For the manufacturer, the contracts bring already-manufactured material back to its supply chain, where it can sell the product again for additional profit. Manufacturers also establish long-term relationships with customers, reducing the financial risks of revenue spikes and dips.

Of course, there are also stipulations in the contract that the material will be returned in an acceptable condition, and any damage caused by the user is their financial responsibility.

A similar concept appears in renewable energy—the power purchase agreement often applied to photovoltaic (PV) installations. The popularity of PPAs has grown rapidly: by 2013, it constituted as much as 90% of the market for PV in some states. However, with a product-as-service model, the fundamental purpose, contractual relationships, and economic drivers may be entirely different.

Power purchase agreements are typically signed because the building occupant wants renewable energy but cannot afford the first cost of the array, while the owner of the PV system can benefit not only from selling power to the building occupant but also from tax incentives for developing renewable-energy projects.

With product-as-service arrangements like those for Brummen Town Hall, this is just one of the incentives. The larger goal is to keep manufacturers accountable for their products through their entire life cycle so the manufacturers cannot readily externalize costs.

"The whole design of buildings is conducted in a way that makes it so no party is responsible for its product," Rau argues. "If you sell the product, you are not responsible for its performance. If you are responsible, then the product becomes a service." The hope at the heart of such schemes, in other words, is to remove any financial incentive to design products for obsolescence—or, as is perhaps more common, to make products without much thought about durability—and instead incentivize design for longevity and reuse.

The Bullitt Center: Pay for what you get

Philips innovated its pay-for-performance model with Rau, but its first experiment quickly evolved into that company's Pay Per Lux program, now installed in offices, airports, and public transportation systems around the globe: building owners or occupants specify their lighting needs and then pay Philips to fulfill those needs, without the user of the lighting system ever having to change a light bulb or pay an electric bill. Two notable examples are Schiphol Airport in Amsterdam and the Metro in Washington, D.C.

Even more innovative is the Metered Energy-Efficiency Transaction Structure (MEETS) that is being pioneered by the Bullitt Foundation in Seattle. Created by EnergyRM, the structure is motivated by a desire to create a stable revenue stream for energy efficiency, much like existing models for renewable energy. The four parties in this program are the utility company (Seattle City Light), the building owner (The Bullitt Foundation), the energy-efficiency investor (also the Bullitt Foundation in this case), and the tenants. Though it's being piloted on the brand new Bullitt Center, the goal is to apply MEETS to deep energy retrofits.



Photo: Nic Lehoux for the Bullitt Center. License: CC BY-NC 2.0.

Daylighting and other energy-saving features at The Bullitt Center rack up "negawatts" whose value redounds to the original investor.

Here's how it works. The investor pays the first cost of a major energy-conserving feature—a daylighting system, envelope retrofit, or HVAC upgrade, for example. All the parties agree on a dollar value for a unit of energy conserved (referred to as a "negawatt").

Based on building energy monitoring that compares the building's baseline performance to its actual performance, the tenant continues to pay the cost of the negawatts to the utility as though the efficiency feature hadn't been installed. The utility in turn pays the value of these negawatts to the energy-efficiency investor.

Tenants do not have to make any financial investment, yet they get a building with improved natural lighting, thermal comfort, and energy efficiency. The tenants in essence are paying (through a standard energy bill) for the service of greater indoor environmental quality without having to buy any products.

Meanwhile, the supplier of the energy-efficiency improvements gets to capture the value of that investment from the utility company and satisfied tenants.

The utility is a pass-through and doesn't get a cut, but it benefits from a near assurance of actual energy savings. This is in contrast with another type of incentive many utilities offer to encourage conservation—rebates for energy-efficient lighting or appliance purchases. Unlike negawatts, such purchases don't come with any guarantee that any energy will be saved overall.

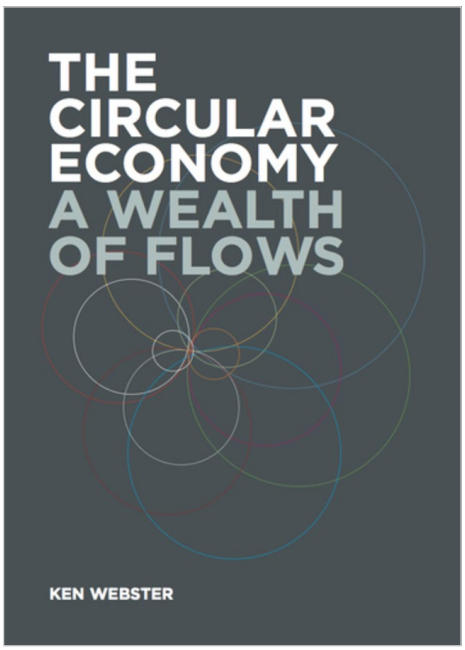
The pilot has huge potential for existing buildings, where a third party (who is not necessarily the owner of the building) can invest in efficiency upgrades that will pay back over a long period of time. Even if the building is sold to a new owner, the investor has a relationship with the utility, so the payback continues.

Circling Back: Information Flows

The new initiatives and efforts going on internationally around circular business models are works in progress, but the green building industry is ripe for innovation in this area. As one indication of this, some building owners are experimenting with performance-based contracts for entire buildings—not unlike performance-based agreements, discussed above, between product manufacturers and building owners. Performance-based construction contracts require an unprecedented level of design-team engagement and collaboration during building occupancy.

Many design teams have discovered through post-occupancy evaluations and engagement that continued dialogue is crucial to building performance. Similarly, circular thinking does not happen once in a building's life: it's not a one-time contract but a continual process throughout design, construction, occupancy, renovation, and reuse of building spaces and materials. It requires engagement and follow-through during the entire building life cycle.

To succeed in a circularity of material flows, there must also be a circularity of information flow—yet another resource-sharing economy that is crucial to achieving a sustainable built environment. And part of that is sharing your own insights and lessons learned with others in the industry. Continuous feedback loops will accelerate the building industry's transformation toward a circular economy.



The circular economy isn't new, author Ken Weeks points out, but the business case is getting stronger. Click to read our book review.

New HPD Promises Better Reporting, More Participation

Version 2.0 of the Health Product Declaration aims to make the rules clearer and the format more attractive for manufacturers.

By Paula Melton

The Health Product Declaration Collaborative (HPDC) today launched version 2.0 of its Health Product Declaration (HPD) Open Standard. The standard sets the rules for disclosing ingredients on an HPD, which is one of the leading tools for building product transparency.

Along with the standard, HPDC released a new format for the HPD itself and is preparing to roll out a new online HPD Builder app manufacturers can use to prepare the forms for publication. (For now, a fillable PDF is available.)

"Not a simplification"

The HPD got a huge boost when it was referenced in a new LEED v4 credit for ingredient transparency and optimization. However, the format was still in its infancy when LEED v4 was approved, and since then, HPDC has gone through growing pains while manufacturers and project teams alike have faced confusion about how to create and read the HPD.

But the new version of the standard is "not a simplification," emphasizes Joel Ann Todd, director of technical and educational programs at HPDC. It clarifies rules that manufacturers found too vague in the first version, adding "more complexity but much richer information," Todd claims. "And the information is put in context," she adds, with hazard data associated with specific materials rather than the overall product.

Todd notes that the the evolution of the standard "was based on listening to manufacturers."

What has changed

Version 2.0 of the standard keeps the basic concept and references the same chemical lists but adds clarity on several points, including:

Summary sheet—The first page of the new HPD is a simplified summary of disclosure level, ingredients, VOC information, HPD verification information, and product certifications. More detailed disclosure begins on the next page.

New terminology—Version 1.0 simply had a list of ingredients in descending order by percentage, much like a safety data sheet (SDS). To harmonize with other product programs, HPD 2.0 newly categorizes products as being made of *materials*, which in turn are made of *substances*—a framework that's particularly helpful for makers of complex products like furniture.

"The harmonization of the inventory portion ... establishes a foundation that any manufacturer can use to get on the path to material health," said Stacy Glass of the Cradle to Cradle Products Institute in a press release about HPD 2.0. "Harmonization ensures best practices, creates ease of use, and saves time and money for manufacturers."

Todd points out that this should make it easier for manufacturers to use the HPD not only for disclosure but also for product optimization. "When a manufacturer puts together a product, they don't use laundry list of ingredients; the ingredients are in the materials." With the new framework, manufacturers can more easily see at a glance which materials may contain problematic substances and start seeking alternatives based on the material's function in the product.



Photo: Lank10. License: CC BY 3.0.

Transparency efforts could increase dramatically if manufacturers prefer HPD 2.0 as expected.

Disclosure thresholds by material—The new nesting of materials and substances also allows manufacturers to give a more granular view of which materials are fully disclosed and which materials have unknowns. For a chair, for example, the structural materials may be 100% disclosed to 1,000 ppm, but the adhesive may have a totally different disclosure level, depending on the suppliers of the two materials.

More work to do

Although Version 2.0 is a big improvement, Todd notes, HPDC is continuing development.

The group is working on how to handle substances that show up as hazardous on an HPD but are widely

considered to be safe in the form used in most building products (see The Five Hazard Warnings You Can Usually Ignore).

There is also new guidance under development for how to characterize residuals and impurities. The HPD asks whether a company "considered" them, but actual lab testing for these trace substances is expensive, so this information may be based on predictive modeling. And that's assuming you know which trace substances you should be looking for. To complicate things further, it's impossible to predict or test for chemicals you don't know are there, as is the case even with minimally processed materials like stone and wood, let alone highly processed materials like recycled plastics.

Finally, HPDC is restructuring its membership policies and technical committees and working on improved communication, education, and guidelines for third-party HPD verification. The group is also talking about a professional accreditation program relating to HPDs.

Todd said there's a lot of work to be done, but she is optimistic about opportunities for growth and further development of the HPD Open Standard as well as manufacturer uptake of the new guidance. "I think it's going to make sense for [manufacturers] to switch to 2.0," she says. Although it's typical for users to resist change when new standards of any type are released, Todd thinks most people will prefer the new HPD because it improves so much on the first version and will soon include the new online HPD Builder app.

BuildingGreen has found roughly 1,800 published Version 1.0 HPDs from 700 companies. Many manufacturers have shared with BuildingGreen that they are waiting for Version 2.0 before updating their HPDs or developing new ones, so we may be adding thousands more to this list in the near future.

Learn more about chemical disclosure

Finding Products for LEED v4: A Guide

Transparency Is the Secret Ingredient in "Declare" Products

Take Control of Your Materials: Four Empowering Lessons from Teams That Beat the Red List

For more information

HPD Collaborative
hpdcollaborative.org

Latest Green Globes Draft Open for Public Comment

New features in the GBI-01 draft include IAQ testing, risk assessment, and design for disassembly.

By Paula Melton

The Green Building Initiative (GBI), developer of the Green Globes rating system, has released a draft of its GBI-01 standard for public comment. The standard provides the technical framework for achieving certification under Green Globes for New Construction.

The current version of the standard was published in 2010, though GBI updated Green Globes in 2013 in a process separate from ANSI standard development. Future updates are set to continue under ANSI's "continuous maintenance" guidelines.

"Users will see that issues like reducing carbon emissions and increasing indoor air quality are heavily weighted to encourage teams to prioritize items that reduce health impacts," notes Vicki Worden, executive director of GBI. "However, they'll also see that flexibility was a priority, and the standard is designed to ensure it is accessible for teams to pursue incremental achievement and to avoid being penalized by credits they cannot pursue." She adds that this is in keeping with GBI's hope that its system will lead more people "to give green building a try."

Major updates

This draft represents an overhaul so extensive that ANSI advised against releasing a redline version, according to Worden, because it would have been too difficult to interpret. Updates include the following:

Weighting—The draft places significant new emphasis on Water Efficiency (now 19% of the total available points, compared to 13% in the 2010 standard) and slightly bumps up the point distribution for the Site section while slightly bumping down the points for Energy.

Minimum requirements—Green Globes doesn't have prerequisites but does have minimum achievement thresholds in each category. For all categories, this threshold is now 20%, a significant change from percentages that heavily emphasized energy efficiency in the 2010 standard.

Service life and durability—The Project Management section includes an incentive to complete either a life-cycle cost analysis or a building service-life plan. It also encourages design for moisture control, referencing ASHRAE 160–2009, which provides guidance for using hygrothermal modeling tools.

Although hygrothermal modeling tools (and this standard in particular) are still working out significant kinks, it is worth noting that moisture and mold are among the most significant health issues in buildings.

Transportation—The Site section has seen significant changes, particularly with newly introduced incentives for transportation alternatives.

Three energy paths—David Eldridge Jr., P.E., an associate at Grumman/Butkus Associates, told BuildingGreen that the committee's major goal with the Energy section was to get more specific with some of the compliance language.



Photo: Geogozz. License: CC BY-SA 4.0.

With 43 certified projects, Whole Foods is one of the primary users of Green Globes.

It also diverges radically from the 2013 version of the rating system. The draft offers three equally weighted options for whole-building energy performance—a predictive-modeling option similar to the approach used in LEED, a method that relies on modeled carbon reductions, and a prescriptive path that references ASHRAE 90.1 and the International Energy Conservation Code.

This section also drastically cuts the total points for whole-building energy reductions (formerly 30%, now 18% of the total points offered), and it abandons the approach introduced in Green Globes 2013 that permitted mixing points between prescriptive and performance paths.

Three water paths—This version of the standard abandons the elaborate system for calculating water points from 2010. A section on water-efficient fixtures references three distinct options: ASHRAE 189.1, the International Green Construction Code (IgCC), or the IAPMO Green Plumbing & Mechanical Code Supplement. Points offered for alternative water sources have nearly doubled.

Risk assessment—The Materials section has been completely reworked, though its primary focus remains on life-cycle assessment (LCA), one of the hallmarks of Green Globes since its inception. The standard offers up to 30 points (out of 1,000) for a whole-building LCA demonstrating improvement over a baseline, and an additional 25 points for choosing products with environmental product declarations (EPDs).

New features include a section encouraging products from manufacturers that divert at least 80% of their waste, as well as an incentive for design for disassembly (see Re-Framing Sustainability: Green Structural Engineering).

In an apparent answer to LEED v4's credit on material ingredient transparency, the draft also introduces a risk-assessment framework for product ingredients. "Incorporating risk-based assessment—which is based on the science of toxicology—instead of hazard-based assessment is of course noteworthy," Charles Kibert, Ph.D., P.E., told BuildingGreen. Kibert, who is chair of the Materials subcommittee and a GBI board member, added, "The consensus of the Materials committee is that this approach is superior to HPDs, red lists, and other banned materials lists."

The credit references NSF 355, a green chemistry standard. Projects can achieve up to 15 points for demonstrating that products have undergone an evaluation of health risks that could result from exposure to chemicals found in the end product.

Risk assessment is an essential tool used by regulatory agencies to determine safe levels of chemical exposure, but it's more contentious when it comes to manufacturers' assessments of their own products (see Building Products and Health: A Look at Risk vs. Hazard). BuildingGreen asked Kibert what he thought would be the most controversial feature of the Materials section. "I suspect the risk-based assessment will draw the most attention," he said. "We hope for a lively public-comment period!"

IAQ testing—The draft provides a new section on actual VOC testing of indoor air before occupancy and overhauls the sections on lighting systems and daylighting while vastly expanding guidance on views, thermal comfort, and acoustical comfort as well. The standard also updates VOC emission standards to the current version of CDPH Standard Method v1.1.

Distinctive features compared with LEED

This draft includes several items that distinguish the standard from the LEED for New Construction rating system:

Still prerequisite-free—Though hotly debated in both subcommittee and consensus body meetings, prerequisites are not part of this draft, and minimum requirements have decreased in all categories.

"N/A"—The draft retains the option to mark certain credits as "not applicable." This reduces the maximum number of points on a case-by-case basis, effectively resulting in a higher achievement percentage.

A thousand points of green—The draft standard continues to offer a total of 1,000 points (LEED has 100). This provides opportunities to offer a wider variety of options (a credit can provide 1 point in Green Globes, the equivalent of an 0.1 points in LEED, which does not offer partial points).

Emphasis on building longevity—Sections relating to a service-life analysis, moisture management, and design for deconstruction are unique to Green Globes and add up to 28 points.

No energy reporting—Though the system has incentives for installing monitoring equipment, there is no requirement or framework for reporting energy or water use, as there is in LEED.

How to comment

Green Globes has spurred criticism in the past, due primarily to its zealous support from the mainstream timber and plastics industries—support that has sometimes been expressed as lobbying for legislation that bans or otherwise restricts the use of LEED. But committee members BuildingGreen spoke with encouraged Green Globes' critics to comment on the draft.

"If that's how you feel, get involved," opines Josh Jacobs, technical information and public affairs manager at UL and vice chair of the Materials subcommittee. "Submit a comment. Show up to the committee meetings. That's where you can make change."

Besides, he says, the standard needs help from the green building brain trust. "We have about a hundred people involved. That's a drop in the bucket when you consider the amount of sustainable knowledge on a North American scale. We need people's comments and ideas on everything."

Worden echoes these sentiments: "Every public comment will be heard and responded to by GBI's Consensus Body. Debate leads to education, and that's something I consider to be an central part of GBI's mission."

A public-comment form can be downloaded on the GBI website, and the comment period will remain open through October 26, 2015.

For more information

Green Building Initiative
thegbi.org

Jason McLennan Steps Down as Living Future CEO

McLennan will focus on his own practice after a decade as head of the International Living Future Institute.

By Nadav Malin

Stepping down as CEO of International Living Future Institute (ILFI) after ten years of pushing the industry, Jason McLennan is moving on to other pursuits while leaving a legacy of high ideals.

Gradual departure

ILFI announced today that McLennan will step down as CEO at the end of 2015. The change isn't as abrupt as it might seem—McLennan has been part-time with ILFI for the past few years—and he is staying on in the volunteer role of chair of the board.

He has also established a capable leadership team, led by executive director Amanda Sturgeon, who will become the new CEO. But it's still a milestone and an opportunity to look back at what McLennan has accomplished.

Rapid progress

In 2006, McLennan surprised many by leaving his position at Elements—the sustainability arm of BNIM Architects that he cofounded with Bob Berkebile—to lead the Cascadia Chapter of the U.S. Green Building Council (USGBC). He landed in that position with a bang, within months using the organization as a platform to launch the ambitious Living Building Challenge and related programs.

McLennan's uncompromising vision, and his penchant for defining goals in poetic terms tied to ideal outcomes rather than relative improvement over the status quo, led me to describe the program early on as "a manifesto in the guise of a standard."

Although the program's growth has been modest in quantitative terms, with 25 certified and 259 registered projects after eight years, its impact has been profound. People all over the world are knocking themselves out to achieve the impossible—net positive, healthy buildings—because it's inspiring in a way that 30% energy reduction or enhanced ventilation effectiveness can never be.

Those pioneers reset our expectations of what's possible, and they raise our expectations for more-mainstream programs that are based on incremental change. (See How to Succeed with the Living Building Challenge: 12 Teams Share Tips.)



Photo: jasonmclennan.com

McLennan

Living expansion

Not one to limit his vision, McLennan has built on the momentum of LBC to create a flock of related programs:

- Declare reveals product contents and exposes red-listed substances.
- JUST rates organizations on their social equity.
- Net-Zero-Energy certification recognizes buildings that don't take on the full Challenge.
- The Living Product Challenge sets an ideal for products.
- The Living Community Challenge scales the Living Building model up to the neighborhood and even city size.

In the process, McLennan has turned the organization inside out, making the Cascadia Chapter—now not only a chapter of USGBC but also of the Canada GBC—into a project of ILFI. The organization has maintained ties with USGBC (see LEED Offers Living Building Challenge Alignment) but long ago outgrew USGBC policies regarding the role and governance of chapters. ILFI has also established its own global network of "ambassadors" and regional collaboratives (see How a Dense Metropolis Can Support a Living Building).

After holding the creative development of these programs close to his chest for years, McLennan, particularly in the last couple years, has shored up the organization's funding and brought on several high-profile leaders, including Greg Norris, ILFI's chief scientist, whose "handprinting" concept is core to the vision for the Living Product Challenge. This collaborative approach is likely to be a hallmark of IFLI moving forward, as incoming CEO Amanda Sturgeon already has a strong leadership team in place, including Norris, Living Building Challenge technical directors Kathleen Smith and Brad Liljequist, and VP of global outreach Eric Corey Freed.

McLennan, meanwhile, will focus his ambitions and passion through his new architecture firm, McLennan Design (which includes a charitable arm he has dubbed the Green Warrior Society), and through ongoing consulting, public speaking, and volunteer work.

Learn more about ILFI and its programs:

How to Succeed with the Living Building Challenge: 12 Teams Share Tips

Is That Drywall "Just"? New Label Aims for Social Equity

Transparency Is the Secret Ingredient in "Declare" Products

For more information

International Living Future Institute
living-future.org

Green Building to Create 3 Million Jobs by 2018, Says USGBC

A new report estimates the economic impact of LEED and green construction to date and predicts a trajectory of growth.

By Candace Pearson

The green construction industry will be responsible for 38% of all construction jobs by 2018, according to a report that Booz Allen Hamilton recently prepared for the U.S. Green Building Council (USGBC).

Its forecasts predict huge increases in green construction spending, rising to the tune of $224.4 billion by 2018 from an estimated $129 billion in 2014. Such growth is expected to have ripple effects, increasing green construction's impact on:

- national gross domestic product (GDP) to $284 billion
- labor earnings to $190 billion
- operational savings to $1.2 billion

That doesn't include economic benefits from improved health or worker productivity.

All told, green construction is expected to directly support 3.9 million jobs between 2015 and 2018.

The findings of the report forecast a hopeful future, says David Erne, senior associated at Booz Allen Hamilton: "Construction is back up, and green construction is increasing its share of overall construction." The analysis gives builders and architects a clearer picture of the demand, he says, and also tells regulators that green building has reached a threshold of adoption where they can expect to increase code requirements without much pushback.

Impact of LEED

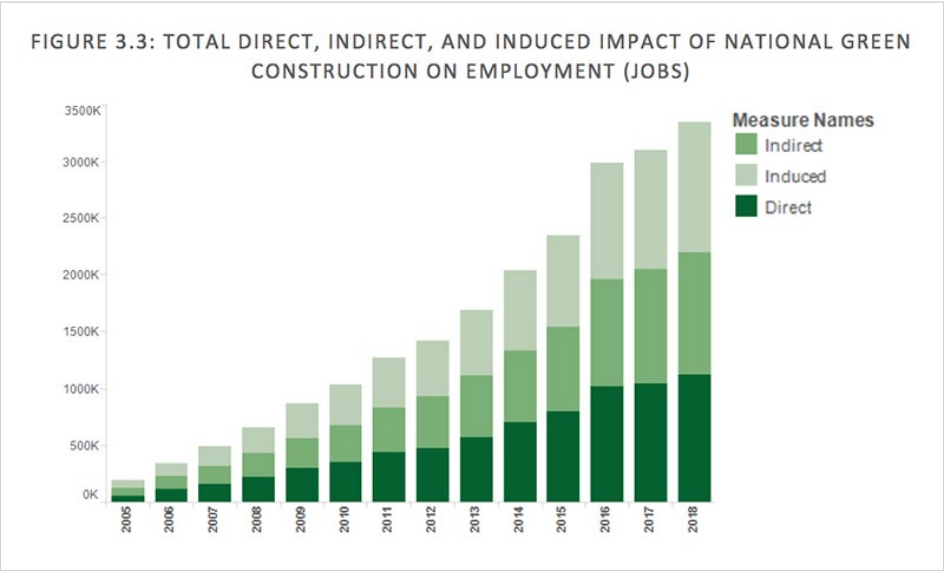
With the report sponsored by USGBC, the role of LEED in this market transformation is often emphasized.

LEED projects comprised nearly 37.5% of green construction jobs in 2014 and contributed $20.7 billion in direct gross domestic product, according to the analysis. The forecasts predict a year-over-year growth rate for LEED construction of 12.3% to 2018, with particularly high growth in LEED-certified residential projects.

The report also attempts to estimate operational savings from LEED within the context of the whole green construction industry, both to demonstrate the extent of operational savings and to factor in jobs that might be lost due to greener buildings, such as jobs in maintenance or trash disposal. The researchers did a meta-analysis of reported savings, which gave them an annual square foot savings for water, trash, energy, and maintenance.

According to these estimates, the scholars expect the green construction market to generate $4.8 billion in savings from 2015 to 2018, with LEED accounting for as much as $2.2 billion. However, in most of the categories, "green" buildings (Dodge defines this as a building that targets green building upgrades in more than one

Jobs in Green Building



Credit: Booz Allen Hamilton

The more than 3 million jobs referenced in the report would be created directly (with jobs like general contracting), indirectly (such as jobs in manufacturing green products), and by induced means (such supplying food or education to those who, as a result of having a job in green building, now have more money to spend on those services).

category across energy efficiency, water efficiency, resource efficiency, site management, or air quality) registered higher average savings than LEED Certified or LEED Gold buildings—something the authors point to in order to indicate that USGBC's sponsorship of the report did not sway its findings.

However, these are some pretty sunny projections, so what *is* behind the findings? We spoke to the authors about their assumptions.

Separating the wheat from the chaff

The report acknowledges that the economic impacts it reports are based on the total value of green buildings "rather than segmented spending separating out green-specific technologies or professions."

This means the $150 billion it reports for green building spending in 2015—and the 1.1 million jobs that green building is projected to directly support by 2018—includes spending on things like framing or roofing that aren't necessarily part of what makes a building green. The rationale is that "green construction creates employment opportunities for both green and non-green professions."

That would be true if green building itself were spurring more people to build more buildings, but more likely green features are being added onto buildings that would have been built anyway.

Diminishing marginal costs

It turns out that separating out green features from general construction costs simply has become very hard to do.

In an earlier report conducted in 2009, Booz Allen researchers used the marginal costs of LEED to estimate the economic impacts, but "more and more, we've seen that green or LEED does not cost more," explains Vinay Couto, a vice president of Booz Allen Hamilton in Chicago. "The only concrete thing we can say is this is what it costs overall to build a green or LEED building."

Acknowledging the assumption ends up being "more defensible," agrees David Erne, than relying on contentious evaluations of marginal costs.

The research relies heavily on the 2015 Dodge Construction Outlook Report and its Green Outlook Report for those cost estimates, but when it comes to analyzing LEED's impact separately, it makes its own generalizations. The researchers used cost-per-square-foot averages by asset type to come up with $61.8 billion in LEED construction spending nationally in 2015, which is expected to increase to $78.6 billion in 2018 based on an "optimistic" modeling scenario. Experience tells us costs per square foot can very widely between buildings—even of the same type—so it is important to note this "concrete" statistic relies on averages.

Stronger data

Nevertheless, the researchers insist that this is the strongest data they've ever had. "When we did the last report, it was based on a history of very strong construction starts—then there was the downturn in the economy and things didn't turn out like we predicted," says Erne.

Now, the Dodge reports have accrued a large sample size over 11 years, and they develop separate forecasts for general construction and green construction. The USGBC database also has more projects and a longer history from which to model projections. The researchers have also learned from the market experience; they took out all the LEED for Existing Buildings projects, which account for approximately 30% of LEED, according to Couto, because certification in that rating system often doesn't require a lot of spending.

Quoting a range is easy…

The study reports values from only one model (what it calls "the optimistic scenario") instead of the range of outputs from all three scenarios modeled, a choice that may come off to some as deceptively confident.

Couto responds with the argument that "quoting a range is easy" but not as powerful in things like policy briefs. Instead, the researchers boldly

threw out the big numbers and chose to let their assumptions speak for themselves.

More about green construction in the economy

Study Shows Green Construction Creates Jobs

Analysis: Economy, Environment Merge to Speed Global Decline

NEWSBRIEFS

Source Energy Is Federally Endorsed Metric for Net-Zero Buildings

DOE releases a definition of zero energy buildings that it hopes will be adopted industry-wide.

By Candace Pearson

Zero energy building (ZEB): it is not a new term, but it has been a confusing one.

First there's the question of whether it is measured by site energy, source energy, cost, or emissions.

Then there is inevitably debate around what area counts as "onsite" for renewable energy production (What if multiple buildings are spread through a campus? Can an urban building place solar panels on a neighboring building?).

Potential options like purchasing renewable energy certificates (RECs) or using wood pellets further complicate the issue of what counts as renewable energy.

A source of clarity?

A report prepared for the U.S. Department of Energy by the National Institute of Building Sciences takes a stance on all these issues in the recently released Common Definition for Zero Energy Buildings.

The definition reads, "An energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the onsite renewable exported energy."

ZEB status is only conferred once performance is demonstrated over a full year of operation. Further clarifications include:

- Delivered energy and exported energy are to be calculated using national average source-energy conversion factors.
- The site boundary is defined as the building site, with special provisions for projects considered a campus, community, or portfolio.
- Wood pellets or other biofuels harvested onsite are considered renewable energy; but such fuels, if delivered to the site, are not.
- RECs can be used for urban buildings only after onsite renewable energy is employed, but such buildings fall under the separate term "REC-ZEB."

The report lands on "zero energy" instead of "zero net energy" or "net-zero energy" (the term most often used in this publication) because in the researchers' market research, "net" proved confusing to consumers and did not add substantive meaning to the name.

Divisions over source energy

The definition was informed by input from a wide variety of stakeholders and industry experts, with one of the most contentious issues being whether to use site energy or source energy. Participants from the electric utility industry in particular submitted comments critiquing the use of national source energy averages, arguing that many states or regions have higher mixes of wind, solar, hydroelectric, or nuclear than the national average.

Since electricity is weighted nearly three times more heavily than other energy sources, they see this as penalizing a source that, depending on the region, might be much more efficient than electricity generated by coal. They also assert that site energy is more familiar to building managers and consumers.

More on measuring net-zero-energy buildings

The Problem with Net-Zero Buildings (and the Case for Net-Zero Neighborhoods)

Measuring Energy Use in Buildings: Do Our Metrics Really Add Up?

Want a Net-Zero Home? Be a Net-Zero Family



Photo: Dennis Schroeder

Zero energy buildings come in many shapes and sizes but should qualify for the title by adhering to a standard definition. This research support facility for the National Renewable Energy Lab is a 218,000 ft² net-zero-energy building.

Surgeon General to Designers: Promote More Walking

The U.S. Surgeon General has made walkable communities this year's nationwide health focus.

By Candace Pearson

Faced with an obesity epidemic *and* rising pedestrian fatalities, the U.S. Surgeon General recently issued a "call to action" urging designers and other professionals to do whatever is in their power to support walkable communities.

People who are physically active have about a 30% lower risk of early death than people who are active, according to the report, and walking presents one of the easiest and most common ways to get that exercise. However, having access to safe, desirable places to walk is increasingly difficult; in fact, of all traffic fatalities involving motor vehicle crashes, the share of pedestrian deaths has increased from 11% in 2004 to 14% in 2014.

The report offers the following guidelines for urban planners and architects:

- Direct people to opportunities for physical activity with "point-of-decision" prompts, such as messages that encourage taking the stairs instead of the elevator.
- Minimize block sizes and increase connectivity around transit hubs. A national study by the Center for Transit-Oriented Development reported that people who use public transit tended to spend around 21 minutes a day walking to and from their stop or station.
- Improve safety for children walking to school by building entrances and exits that do not flow directly into streets.

The report points to plenty of benefits to justify walkability upgrades beyond health, including increasing social cohesion, reducing air pollution, and boosting local economies.



Photo: Paul Krueger. License: CC BY 2.0.

Encouraging healthy behaviors should include making it safe and pleasant for more people to walk, according to the U.S. Surgeon General.

More on walkability

Driving to Green Buildings: The Transportation Energy Intensity of Buildings

Resilient Design: Smarter Building for a Turbulent Future

Walkable Texas Neighborhood Turns Out to Be Walked In

Energy Disclosure Laws Prompt New Standard for Rating Systems

Basic requirements for labeling and disclosure underlie a proposed ASHRAE standard for building energy labels.

By Candace Pearson

As cities and states begin to require building owners to disclose energy use, government agencies are evaluating the labels and rating systems that facilitate such transparency and wondering which is best.

In response, ASHRAE is proposing a standard that outlines the characteristics of a valid rating system. Once complete, the standard could be adopted as an underlying requirement in legislation or policy.

Standard 214P—based on input from the U.S. Department of Energy, the U.S. Green Building Council, and developers of ASHRAE's own labeling program, Building Energy Quotient (bEQ)—focuses on ensuring a rating system's methodology is transparent so that "users know what they are getting," Wayne Stoppelmoor, CEM, chair of the committee, told BuildingGreen.

Most of the requirements are things current labels and rating systems already do, such as describing the parameters and methodology used to predict or measure energy use, clearly defining the inputs that affect the score of a building, and providing a methodology for comparing a rated building to similar buildings in the same climate zone.

However, having a standard will encourage consistency going forward and serve as a guideline for developing future rating systems.

Some of the questions that are up for discussion during public comment include:

1. How should indoor environmental quality be addressed in a building energy rating system?
2. Should "consensus-based" development be a minimum requirement? If so, with a public

review process or balanced committee?

3. Should this standard address energy produced by the building?

The proposed standard remained open for public comment through September 28, 2015.

More on measuring energy performance

Energy Reporting: It's the Law

New Energy Data Is Changing How We Judge Efficiency—And LEED

NYC Buildings Gain Three Energy Star Points in Year Two

PRODUCT NEWS & REVIEWS

Bamboo Flooring: Still Green, for a Price

Bamboo flooring, the rapidly renewable darling of the green building movement, is still sustainable if you are willing to pay for quality.

By Brent Ehrlich

Ten years ago, bamboo flooring was the definitive green building product. It was—and still is—rapidly renewable, versatile, and naturally strong.

Since then, low-quality bamboo flooring products and poor installation have led to floors cupping, warping, denting, and scratching easily, which has hurt bamboo's reputation for durability. Moreover, the use of urea-formaldehyde resins has hurt bamboo flooring's green cred.

But has the industry improved? And is bamboo still as green as it was once perceived to be? Here's an overview of bamboo flooring types, sustainability metrics, and where the environmental bar has unfortunately been lowered. We also provide some criteria that will help you decide if bamboo is right for your next project.

Bamboo flooring basics

"Not too much has changed over the last 20 years" for bamboo flooring, according to Dan Smith, founder and president of Smith & Fong, maker of Plyboo flooring and lumber, "except the industry has aged and matured."

Now that the early green hype has settled down, designers realize they can't take the greenness of bamboo for granted, and the conversation has shifted to cost and performance.

FSC-certified bamboo

Two of the biggest environmental concerns with bamboo flooring—forestry practices and indoor emissions—have lessened since the industry's early days.

Sustainable bamboo plantations were around for centuries before the flooring market existed (see Bamboo in Construction: Is the Grass Always Greener?). Bamboo is a perennial grass and not subject to clearcutting or other modern forestry practices, but manufacturers have obtained Forest Stewardship Council (FSC) certification to minimize environmental concerns regarding the biodiversity of surrounding forests.

FSC certification also makes bamboo flooring eligible for LEED credits and is a powerful sustainability marketing tool. FSC bamboo is expensive, though, and certification is often seen as a luxury for a product that already has some green street cred.

Smith & Fong obtained FSC certification in 2008 as a way to differentiate its products from those of an increasing number of bamboo flooring importers (FSC-Certified Bamboo Plywood Now Available). "We were arguably the first to bring FSC bamboo to the market," Smith said. "We did that by establishing our own forests." But months after they did so, China's Anji County's bamboo plantation was FSC certified, and FSC-certified bamboo is now available from most bamboo manufacturers.

Emissions

Urea formaldehyde, once a common ingredient in bamboo flooring and a source of formaldehyde emissions, has been replaced by low-emitting phenol formaldehyde. Though bamboo flooring is exempt from CARB emissions standards (unless it has a fiberboard core), most manufacturers meet CARB II (0.05 ppm) or the ultra-low emitting formaldehyde (ULEF) standards and are certified by Floorscore, Greenguard Gold, European E0, or other emissions standards.

For customers looking for no-added-formaldehyde (NAF) flooring, there are several available, but ironically Plyboo—which once offered polyurethane and soy-based adhesives—is no longer one of them. "Over the years, it became a smaller and smaller market, and at a certain point it did not have enough economic viability," says Smith.

Coatings could also be a source of emissions in the early years, but the coatings used on flooring now are almost always UV-cured at the factory, so there is little chance of offgassing.

Coating durability has improved but depends on the type of coating used. Aluminum oxide coatings have become popular because of their abrasion resistance, and most flooring now uses an aluminum oxide topcoat, but Nadurra offers Bona Traffic, a coating made for commercial foot traffic, on some of its lines.

Solid bamboo

The age of bamboo and its manufacturing method have a big impact on performance, and virtually all solid bamboo floor manufacturers use moso bamboo (*Phyllostachys pubescens*) that is harvested between four and six years of growth so it will be mature and hard enough for use in solid bamboo flooring. "Solid" is a misnomer, however, because bamboo is a thin material that has to be cut into strips, milled, dried, and glued together either horizontally or vertically to make flooring.



Photo: Nadurra Wood Corporation

This composite bamboo flooring from Nadurra is available with Bona's Traffic matte finish, providing a durable, commercial-grade wear layer that looks like natural bamboo.

Horizontal flooring looks like natural bamboo grain, whereas vertical has a striped, even look. Carbonized products are heated until the color darkens, but the process reduces the hardness of the bamboo. Solid bamboo flooring products, once the most popular style, are susceptible to cupping and warping due to humidity changes and have fallen out of favor and been replaced by strand bamboo.

Strand flooring is made using crushed bamboo, adding adhesives, and pressing them together under heat and pressure. "Strand doesn't rely on the density and hardness of natural bamboo," said Smith, so it can use younger, softer plants. The end result, however, is a very hard, durable flooring that routinely rates above 4,000 on the Janka hardness test (maple, for comparison, is about 1,500).

Consumer expectations and complaints

If bamboo is that durable and is sustainably grown, why have there been so many complaints?

Smith thinks unrealistic expectations are part of the problem. Bamboo is tough, so people think it is indestructible, but despite its hardness, solid bamboo can dent. That's because the Janka test method uses a dropped steel ball to measure how much a material dents. Solid bamboo has some give, so the surface can "spring back." For this reason, the round ball does not dent it easily, but it is also fibrous, so sharp objects can penetrate the surface (strand bamboo has a dense structure and does not dent as easily). And that bamboo surface is protected by a finish that looks cabinet grade, so scratches and dings show up against the polished surface. Once installed, bamboo floors have nowhere to go but down, he claims.

As with hardwood flooring, poor installation can cause cupping and warping, which happen when moisture levels are not consistent from bamboo's surface to its base. This commonly results from issues like:

- an insufficient moisture barrier on the floor
- not allowing the flooring to acclimate to the environment
- dry, cold weather and use of forced-air heating following after a humid stretch

For National Wood Flooring Association (NWFA)-trained flooring inspector Scott Avery of Auburn Refinishing, "Interior air and relative humidity are the most overlooked items," so some commercial settings, such as those with concrete floors, could be problematic if not treated. And, Avery said, dense, click-lock strand products are particularly prone to movement if not allowed to acclimate to the space.

Lifespan

Properly cared for and installed, bamboo flooring should last for years. Although it can be refinished, it is not as simple a job as for hardwood. Strands of bamboo can pop up during sanding, especially with strand bamboo, said Avery, so refinishing these floors may cost more than refinishing hardwood. And changing the color may be very difficult and expensive since bamboo floors don't accept tints evenly.

Bamboozled?

Bamboo flooring quality varies depending on manufacturing process, and in the early years of bamboo flooring, there was a glut of inexpensive products, which tarnished bamboo's reputation.

When it comes to bamboo flooring, you get what you pay for. "It's ultimately a manufactured product, so there is huge variability," said Avery.

Quality manufacturing equipment, processing of the bamboo, proper drying of the resins, and other factors require time, materials, and labor, according to Smith. He claims you cannot get that quality on a tight budget, claims that are echoed throughout the industry.

Though the amount of substandard bamboo flooring is diminishing, the NWFA recognizes it is still a problem and has created a committee that will establish standards for bamboo flooring manufacturing and installation.

BuildingGreen will review these standard as soon as available—but in the interim, when approving products for inclusion in our green collections, we prefer bamboo flooring that is FSC certified, and we require flooring that:

- is third-party-verified as low emitting (through Floorscore or GreenGuard Gold)

- has no added formaldehyde or meets the CARB II ultra-low-emitting formaldehyde (ULEF) standard

For additional information, see BuildingGreen's collection of bamboo flooring products on Designer Pages

BACKPAGE PRIMER

Hygge: The Human Element in Architecture

A Danish term for "home" is gaining attention as designers look for ways to foster wellness in buildings.

By Tristan Roberts

Designers looking to make green buildings not only respected but also loved have turned in recent years to concepts like biophilia, biomimicry, and beauty.

A new interest in a Danish cultural tradition might have us looking not to the natural environment but inward—at human culture and at what makes us feel at home.

"Hygge," pronounced "hYOOguh," is most often translated as "coziness" in English, but it's about much more than a warm feeling.

According to an official Danish website, hygge refers to wellbeing but is also associated with cultural traditions: "Hygge means creating a warm atmosphere and enjoying the good things in life with good people. The warm glow of candlelight is hygge. Friends and family—that's hygge too ... sitting round a table, discussing the big and small things in life."

While each part of the world has its own cultural traditions involving social gatherings, there may be a couple reasons Denmark stands out.

One is that it puts a single name to a complex phenomenon we can all identify with. Another is that the Danes have some credibility on the topic: the country has consistently ranked at the top of the World Happiness Report.



Photo: James Wilson

A hyggelig (that's "hygge" as an adjective) scene in Denmark, featuring light, warmth, and spaces for gathering.

Hygge also provides a fresh perspective on sustainability. In a recent paper, James Wilson, a design researcher at BKSK Architects, argues that the two concepts are closely linked:

- Hygge recognizes how we shape our environment and invites us to do so mindfully.
- Hygge is about presence, which leads to more effective practices of conservation, preservation, and stewardship.
- Hygge is characterized by a sincere contentment with what one has—deemphasizing consumerism.
- Hygge reinforces cooperation, cohesion, and trust—all facets of sustainable enterprise.

Although "wellness" is a trendy design topic, Wilson, who completed a research fellowship in Denmark, notes that conventional measures of well-ness in buildings lack insight on social and emotional factors.

How can designers foster a sense of hygge? Observers such as Wilson have identified a number of common themes:

- Candlelight is closely tied to hygge. Worried about fire codes? Any cheerful lighting can work, and occupant control of various lighting levels goes a long way.
- Comfort, in the form of food, drink, warmth, and a sense of shared safety and trust
- Architecture that emerges from place, not from an imposed program
- Support of ritual or traditional activities like gathering for a festival; a slower pace of life

- Material that registers the passing of time: natural, handmade, salvaged, reused—and maintainable rather than the oxymoronic "maintenance-free"
- Objects that evoke meaning and identity, such as portraits or artwork

While some designers might feel that these concepts are too closely tied to a specific aesthetic, others are finding that hygge brings a human element lacking in contemporary design.

Hygge has already landed in one green rating system: it's referenced in the Living Building Challenge (LBC). Although LBC is known for stringency in prohibiting combustion, it allows an exception, based on the concept of hygge, for rural projects to install a woodstove or fireplace in deference to the cultural legacy of the hearth.

Read more on hygge and related topics

#hygge on Twitter – a constant stream of hyggelig ("hygge" as an adjective) observations

Hygge: Dwelling Poetically – James Wilson (includes bibliography of hygge-related architectural writing)

Green Design: What's Love Got to Do with It?

WELL Building Standard Officially Launches