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Sustainable Design Literacy: A Foundation for Transformed Practice

How well does the average designer know sustainable design? And how are the best firms supporting increased knowledge—and action?

by James Wilson and Tristan Roberts

Good morning, choir.

Chances are, if you're reading this article, you care more about and know more about sustainability than the average architect or designer. Your "sustainability literacy" is high.

Sustainable design literacy involves the ability to understand the various ways in which a project can impact—negatively or positively—environmental and human health.

But practitioners with this kind of knowledge are outnumbered. The industry has far more designers—at every level of seniority—who lack basic sustainable design knowledge or literacy.

And it shows. You, the choir, may know a lot, but we need the whole congregation working together.

We recognize many barriers to meeting that goal, but in this article we're going to focus on one: knowledge. A significant proportion of practitioners are either not adequately equipped with the know-how they need, or they are not in an organizational structure where they can apply it in their work.

Collectively we know a lot about how to create buildings that are healthy, resilient, sustainable, and even regenerative, but we continue to see that most projects being built and renovated don't come close to the industry's most shared and critical sustainability goal—carbon neutrality by 2030.

"The Habits of High-Performance Firms," published recently by the AIA Committee on the Environment (COTE), explains the key traits of "high-performance firms"—firms that have been awarded an AIA COTE Top Ten Award three or more times over the past 20 years. The average energy reduction on projects of the 10 firms featured in the report was 51% in 2015—not on track with 2030 Commitment levels, but far ahead of industry averages.

As we reported recently, most of the firms studied have instituted regular staff training to expand in-house capabilities and have a large percentage of LEED accredited staff—48%, more than twice the industry average. This level of in-house knowledge and LEED literacy corresponds with the fact that as a group, these firms actively use LEED on 92% of their projects.

But this report leaves us with more questions than answers:

- Are LEED credentials the most reliable and important barometer for sustainable design literacy? If not, what is?
- What topics or skills should the average architect have in order

Photo: David Baker Architects

Examining design pin-ups at David Baker Architects. What knowledge should designers develop to suport a sustainable practice? What tools and processes can foster sustainable design literacy?

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to engage productively with sustainable design?

- How do successful firms distribute sustainable design knowledge from individuals and groups who already understand it?
- Is architectural education preparing professionals for today's environmental and health challenges?

Why We Need to Know

What we really need is for project teams to take *action* toward sustainability. Is it safe to assume that sustainability *literacy* supports this?

According to a recent white paper, *How Age, Gender, and Education Impact Our Path Toward Carbon-Neutrality* by Heather Jauregui, Sophia Duluk Beavis, and Jerry Duluk, the more designers stay up-to-date on sustainable design concepts—specifically through research, conferences, conversations with colleagues, and webinars—the more likely they are to introduce and advocate for sustainability in client meetings and to implement it during the design process.

This white paper concludes that, "an architect's knowledge has a strong positive impact on the probability of suggesting sustainable design to clients more often. The more you know, the more likely you are to follow through with implementation."

Who Needs to Know

Many practitioners have told BuildingGreen that the model of having only one or a few sustainable design experts in a firm *without also having in place more widespread sustainability literacy*, is not effective. Often a single "sustainability director" will act as an in-house "consultant" that "floats" between projects. According to Heather Holdridge, director of sustainability at Lake | Flato, this does not work. "I couldn't be everywhere all the time. We needed someone to make sure that sustainability performance is always part of the conversation."

Photo: Tim Griffith

The Sweetwater Spectrum Community was designed by Leddy Maytum Stacy to reduce energy use by 88%. The firm's leadership is committed to building sustainability knowledge, deeply embedding it in every aspect of their practice.

When We Don't Know, Sustainability Suffers

A project team can't discuss or engage with sustainable design concepts that are not even being introduced or that they do not have access to. Even if a team relies on specialized expertise, as teams do for all kinds of disciplines, they have to know what kinds of questions to ask, and when. Achieving a level of staff-wide sustainability literacy is a crucial step to building a culture of practice that supports sustainable design.

What Every Designer Should Know

According to the National Institute of Building Sciences' (NIBS) Whole Building Design Guide, there are six fundamental principles that define sustainable building design:

- Optimize site potential
- Optimize energy use
- Protect and conserve water
- Optimize building space and material use
- Enhance indoor environmental quality
- Optimize operational and maintenance practices

A more comprehensive definition of sustainability—one often referenced by sustainable design leaders—would also address social and economic issues, such as social equity on the project

team, and socioeconomic justice for communities affected by material extraction and manufacturing.

LEED credentials

The U.S. Green Building Council developed the LEED credentials in the early 2000s to provide assurance of an individual's level of sustainable design competence.

Some firms have established a policy requiring all staff to earn the LEED Green Associate accreditation within six months of being hired. However, this accreditation is meant to be a non-technical introduction to basic LEED concepts and terminology and is intended for a wide audience, including non-designers. As an introductory credential based on a memorization-heavy exam, it doesn't integrate a great deal of practical content or know-how that would, for example, support designers in implementing sustainability during design and construction.

"I struggle with [LEED Green Associate] as an indicator for anything," says Katie Ackerly, sustainability lead at David Baker Architects. "At least it's something. We've struggled to know what to do in lieu of it."

One step up is the LEED Accredited Professional (LEED AP) credential, which involves more detailed knowledge of one of the LEED rating systems. It also requires a more technical understanding of certain sustainability concepts. Earning a LEED credential makes a designer LEED-literate—a valuable skill, especially for firms that certify many projects under the system. However, knowing everything there is to know about LEED is not the same as understanding sustainable design, or how to integrate key strategies during the design and construction process. And for firms or individuals that aren't very LEED-centric, the LEED AP exam requires a lot of LEED-specific memorization that isn't necessarily productive—such as what would qualify for an Innovation in Design Credit, or how to treat athletic fields when calculating water use reduction for WE credit.

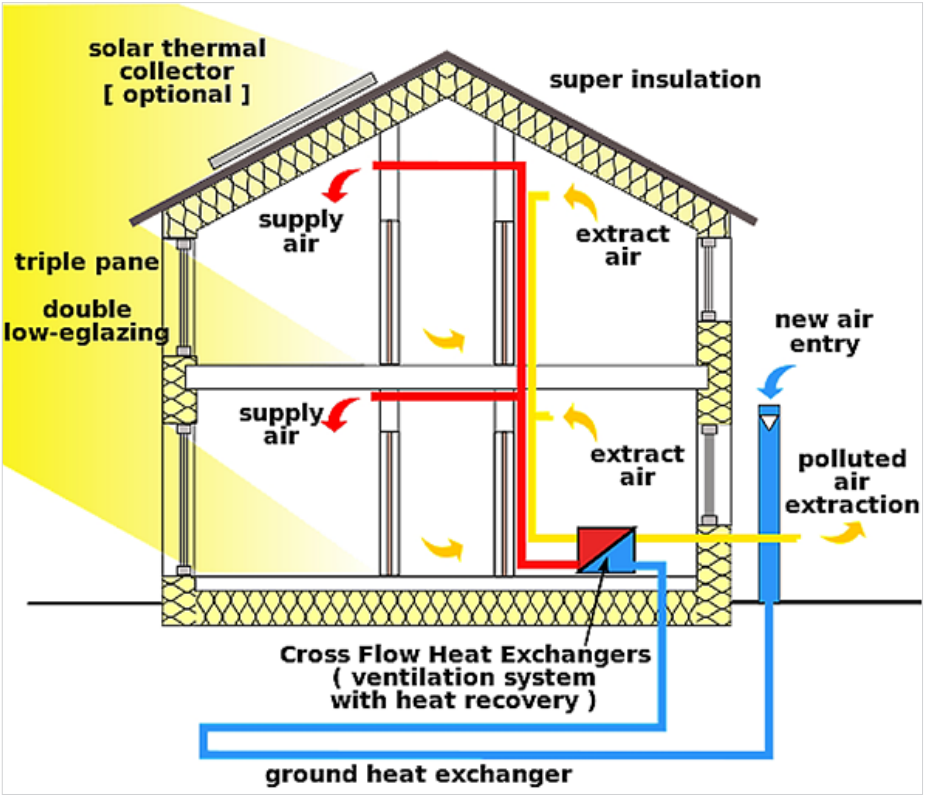


Image: Passivhaus Institut. License: CC BY-SA 3.0.

Certified Passive House Consultant and Designer (CPHC&D) training can reinforce a designer's knowledge and understanding of building science and passive design basics.

Are there credentials that signal true know-how?

One approach to achieving and signifying literacy to supplement a LEED accreditation is to add more specialized professional accreditations such as the WELL Accredited Professional (WELL AP), for knowledge of the WELL Building Standard; and Living Future Accreditation (LFA), for the Living Building Challenge and related programs from the International Living Future Institute.

Anecdotally, designers BuildingGreen has spoken with who have earned multiple credentials like this are more likely to have already achieved considerable project experience with sustainable design, and use these credentials to signal that knowledge. Studying for and earning these credentials augments that—rather than forming the basis of it.

One accreditation does stand out. Training to become a Certified Passive House Consultant and Designer (CPHC&D) serves as a good refresher on the basics of designing passive, energy-efficient buildings. The training involves hands-on group design and calculation exercises and workshops—requiring students to apply the information learned in lectures. Katie Ackerly took the training and says it could also serve as a model for a more general course on building science concepts accessible to a wider audience of designers.

Knowing the lingo, the tools, the rules

Most would agree that—in addition to understanding the goals of sustainability, as outlined by NIBS—knowing the rules of the game is also essential. That includes:

- A firm grasp of the vocabulary (like energy use intensity, VOCs, daylight factor, and more) used to describe and discuss sustainability issues and solutions

- A proficiency with at least some of the basic analysis tools (the psychrometric chart, weather files, sun path diagram, and more) used to inform early climate- and site-based design decisions
- And knowledge of the baseline codes and standards (local energy code, ASHRAE standards, IgCC)

Several designers note that this basic knowledge is the type that must be used regularly in practice—integrated into a designer's working habits and routines. Otherwise it is likely to fall away, overtaken by other information and concerns.

Jim Nicolow, AIA, director of sustainability at Lord Aeck Sargent, underlined the importance of basic knowledge in achieving higher goals. "Before really achieving high goals on the 2030 Commitment," Nicolow says, "the firm had to take a step back and look at the bigger picture and ask, 'How do you measure energy use? Why? Et cetera.'" The firm has created a sustainability forum to introduce staff to advanced concepts and provide in-depth information on sustainable design strategies, but feedback from staff showed that there was just as much interest in reviewing basics, such as, "What's EUI?" (Energy use intensity, usually measured as kBtu/ft^2, is a building's energy use per unit of area.)

Familiarity with codes

In an area like New York City where the building regulations are progressive enough, a thorough understanding of the codes and how to comply with them might serve as an effective measure of sustainable design literacy. Much of the profession's knowledge and methods are a result of regulations. If the code requires it, designers will learn it and apply it.

The Urban Green Council in New York City offers a course called "Conquering the Energy Code." It goes well beyond providing practical guidance on the compliance process. It also provides students a better understanding of the structure of the code and the rationale behind it. In addition, the course builds better understanding of how the building envelope and the mechanical and lighting systems are interdependent, and offers instruction for improving communication and coordination with project team members in order to remove barriers to compliance.

How to engage basic energy analysis

The ability to conduct early performance analysis—for example, a daylight simulation or a shoebox energy model—should be a key part of a designer's tool box, according to practitioners with expertise in sustainable design.

According to several sustainability directors—who are often tasked with leading early analysis efforts—it is important that, even if every designer in an office does not know how to use these tools on their own, they at least know enough about the process to be able to participate in discussions regarding the analysis and to engage with analysis results. For example, a designer should have enough familiarity with the concepts of early performance analysis to be able to present the person running the analysis an appropriate query—a problem or a design decision that can be analyzed—and to then evaluate the results of the analysis.

Parametric analysis tools like the Sefaira Real Time Plugin for SketchUp and Revit; DIVA for Rhino; and the Ladybug, Honeybee, and Grasshopper plugins for Rhino are all designed in such a way as to embed early analysis into the design environment. They contrast with earlier software tools like Ecotect, which required designers to export model geometry to a stand-alone analysis tool, encouraging designers to delegate this expertise.

Building science and passive design

A robust understanding of how buildings are constructed—with special attention paid to wall assemblies and the thermal envelope—and how buildings operate over time would greatly inform design decisions, inevitably leading to higher performance.

And yet, there is a fundamental lack of understanding about even the most basic elements of building science by practitioners—things like the building's orientation to sun and wind, the causes and effects of thermal bridging, and the science of moisture control. Most of these concepts are taught in the construction and environmental systems courses of every design program, but there is often little opportunity for practicing architects to refresh their knowledge.

The right questions at the right time: early decision-making

Early design decisions disproportionately impact the ultimate performance of a building. Knowing and understanding how buildings are put together and how they work in the real world contribute to a designer's ability to ask the right questions at the right times.

Heather Jauregui, sustainability specialist at Perkins Eastman, says sustainable design literacy means

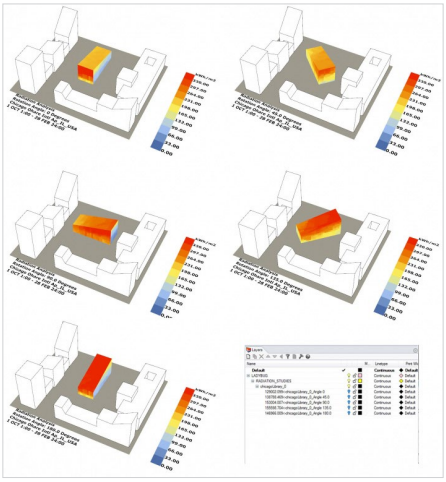


Image: Mostapha Sadeghipour

Using early analysis tools like the Ladybug plugin for Rhino/Grasshopper, designers can do things like set up an automated workflow to study the relationship between orientation and solar radiation. Sustainable design literacy involves the ability to engage with these kinds of analyses and information.

having enough knowledge to know the impact of design decisions such as building orientation.

Rand Ekman, AIA, chief sustainability officer at HKS, emphasized the importance of analytic thinking and an awareness of the connection between every design decision and an outcome. For him, sustainability literacy means having a level of knowledge, comfort, and agency to make choices that are appropriate to the project based on an assessment of its larger context and according to specific, measurable outcomes.

Sustainable design is good design

Designers also support sustainability when they craft environmental experiences of beauty and delight. Not only are such experiences essential to the well-being of occupants, but they also contribute to stewardship of the built environment. A building that is not beautiful—that does not compel people to love and care for it—won't last, and the material and energy that went into constructing it will be wasted. And as long as many designers see sustainable design as an add-on and not integral to their vision for the design of a building, they won't embrace it.

Yee Lin, partner at Amplus Operations, teaches sustainable design concepts as part of the construction technology course in the architecture program at City College of New York. "When I teach my class, I always tell my students, again and again," says Yin, "that sustainable design is not a new topic. It's a very old topic. Basically sustainable design is good design. You need to design beautiful architecture. You need to design comfortable spaces."

Generalist vs. specialist

It's not reasonable to expect all designers to know everything related to sustainability—from building science, to water conservation, to energy efficiency, to reading chemical inventories of products, and on and on. There will always be a need for specialists or experts who are focused on specific aspects of sustainability or building performance. These are the individuals who dive deeply into a subject area, and then teach the rest of us the important, distilled, practical aspects of what they learn. They are often also forecasters who are constantly scanning and paying attention to the cutting edge. These are the individuals who are advancing the profession bit by bit as they add information and knowledge, over time raising the bar of sustainable design literacy.

Simplicity sings

Sometimes sustainable design can muddle the process, according to Ekman. He pointed out that going beyond the basics can cause unnecessary complexity and act as a barrier to sustainable design. "Sometimes the sustainable design community confuses and complicates things in a way that is not helpful. It's possible that often the basic lessons are getting lost. It might be that we should aim for simplicity."

An example of this would be the difference between knowing all the details of how a material's chemical properties are assessed, and knowing basic principles about product and material selection, like those shown in BuildingGreen's 12 Product Rules infographic. Simple but important lessons—like "if you're buying more than a ton of it, know its carbon footprint" and "minimize exposure to the worst substances"—are easy to learn and remember, and can have a significant impact on design decisions.

This represents the kind of basic knowledge that all designers can and should have—as compared to the idea of every designer trying to learn and remember all the details of different toxic chemicals, how they interact, and what the particular health risks and exposure paths are.

Distributing Knowledge: Firm Structure and Culture

Some firms develop their own specific, "institutional" definition of sustainable design based on their strategic plan, mission, or the types of projects they work on.

Photo: Jeff Frey Photography & LHB, Inc.

At firms like LHB, Inc., a culture of diversity, curiosity, and communication means that knowledge and information are shared across project teams. This supports an integrative process that is key to achieving high performance across all projects.

Dee Spiro, director of sustainability at Bergmeyer, told BuildingGreen that, due to the firm's size, project load, and production pace, they've had to be strategic about where advanced sustainable design approaches are implemented. "Because we have so many projects going at any one time, we really have to target our efforts to where we feel we can make a difference."

Bergmeyer has developed a "sustainability checklist" that is used by the project design teams as a guide to efficiently incorporating sustainable design whenever possible, and also provides staff with a clear basis of what the firm informally defines as sustainable design literacy.

Rick Carter, FAIA, who leads the Integrative Design Team at LHB, says his firm's "Thrive" approach can help establish performance goals and outcomes for projects the firm designs. A kind of performance scorecard, it will be used to grade each project based on categories the firm has established as priorities. The scores range from "degenerative" (the worst score), to "sustainable" (neutral), to "regenerative" (the ideal). This system makes clear to design staff the value placed on performance while providing a clear template for goal-setting and strategies to be referenced throughout the design process. It is also a tool for educating clients on the potential impacts and

opportunities of a project, and is a way to record and organize lessons learned.

Each project is a learning experience

Jauregui notes that often particular issues that come up on ambitious or challenging projects are what drive the research at her firm. The firm's definition of sustainable design literacy evolves as project teams learn new information or techniques in order to solve distinct problems, and then share that knowledge with the rest of the firm.

Jauregui shares that the team that worked on the Dr. Martin Luther King, Jr. School learned important lessons after finding that insulation had been incorrectly installed on the project. Had the issue not been corrected it would have prevented the project from achieving its high level of performance. The team shared with the firm what they learned about the need for increased oversight during construction administration—including the education of sub-contractors and regular checks of the envelope. The team's experience on the project also served as a model for how the typical design process might have to be restructured to meet the specific high performance goals of a project. "Stories like this shared across our firm help others begin to understand what it takes to implement high-performance in their work," Jauregui says.

The "why" of sustainable design

Rand Ekman told BuildingGreen, "At HKS we try to understand what's the right set of issues to address—not how, but what. So we do research to get to an answer. Once we put the information in front of a team, it's easy to understand how to design in response. So, as a first pass on literacy—it's not so much how to do it, but on why it's important."

Educating the client is a critical skill

It is a crucial skill for designers to be able to effectively educate the client on the why, what, and how of sustainable design.

"Something I hear a lot is 'my client doesn't care about sustainability, so we're not doing it'," says Jauregui. She adds that one of the main challenges at her firm is that people don't know enough about sustainability to make their clients interested in it. She's observed that designers who don't have a certain level of confidence with a topic won't introduce it.

Sustainable design literacy might mean having enough knowledge to be able to guide a client through all relevant aspects of sustainable design, including, especially, the impacts on schedule, cost, and long-term value.

Jauregui also stressed the need for firms to be proactive rather than reactive when it comes to pursuing sustainable design goals and knowledge. "We're only educating based on what our clients ask for, but what we need to be doing is educating our clients."

Achieving Sustainable Design Literacy

How do we achieve literacy? Do recent graduates have what it takes?

It might seem that the most recently educated designers will be the most knowledgeable about green building, but that's not true, according to the white paper by Jauregui.

"The most recent generation of graduates believes that education around sustainability is our single biggest challenge as an industry," the report found. "They seem to recognize that the education they received had not adequately prepared them."

One problem is that the National Architectural Accrediting Board (NAAB) recently removed specific sustainability criteria from their accreditation requirements (see Class of 2030: Groups Agitate for Sustainability in Architecture Schools).

Yee Lin describes the shift that is currently taking place in architectural education, noting that there is a lag between the current state of sustainable design and what is being taught in most programs. "When we were in school we were taught how to make these systems work," recalls Lin.

College of DuPage Newsroom. License: CC BY 2.0.

Architecture students at College of DuPage install a pavilion they designed and built. Design-build studios provide students the kind of hands-on, multi-sensory learning opportunities that can illuminate the real world relevance of sustainability issues and the consequences of design.

"But not how to make them environmentally friendly. Now we teach the same topic, but we are teaching how to make the systems work to reduce energy consumption. The approach is different. All the teachers need to keep updating their knowledge."

Lin adds that the problem is not so much that the goals of design have changed, but the strategies the industry uses to achieve performance goals have evolved quickly.

Teaching sustainability as a priority

Christian Volkmann, associate professor of architecture at City College, says students are actually "more literate than ever before, coming out of school, but they are not using the knowledge because they don't value it." They don't understand how it integrates with all other aspects of design, like form making."

Volkmann explains that applied learning opportunities are essential. "It's not enough for them to learn the theory. They need to understand how it is applied in practice; this will make it meaningful for them."

Volkmann believes that providing students with hands-on, multi-sensory, interdisciplinary design opportunities that also engage the larger community will make sustainable design "come alive" for them. One such design-build program is Rural Studio at Auburn University. It provides students the opportunity to experience the impacts of sustainable strategies from the construction process all the way through to occupancy.

Sustainable design and licensing

The Architect Registration Exam (ARE), required for architectural licensing, "assesses aspects of architectural practice that affect the integrity, soundness, and health impact of a building," according to the National Council of Architectural Registration Boards (NCARB). Ideally the ARE would provide a backstop for any shortfalls or inconsistencies in architectural education, including those related to sustainability.

However, though each division of the ARE includes questions related to sustainable design, it generally covers sustainability only to the extent that sustainability concepts have become part of the legal codes that govern the construction of buildings. The questions focus more on general, big-picture aspects of sustainability and do not get into specifics of advanced design strategies.

The profession may eventually integrate more advanced sustainable design concepts—such as those related to the design of carbon-neutral buildings—into the requirements of the ARE and the Intern Development Program (IDP). At that point, we may be able to say that a license to practice architecture is equivalent to an adequate level of sustainable design literacy.

Revolutionizing design education

Sustainable design leaders have advocated for the inclusion of specific skills as criteria for accreditation.

A recent discussion on the Society of Building Science Educators (SBSE) listserv started with the question: "What will it take to make every graduating architect competent to design energy-neutral buildings (without ignoring the traditional values embodied in excellent architecture)?"

The discussion resulted in several suggestions for criteria that NAAB should include in its accreditation requirements:

- Knowledge of how to apply ASHRAE Standard 189 or the IgCC to student design projects
- Integration of solar thermal, passive solar, and photovoltaics
- Knowledge of the life-cycle economics of net-zero buildings
- Knowledge of how to measure the performance of a building and compare it against a baseline building

Programs leading the way

Some programs are voluntarily moving ahead to educate students beyond the minimum requirements currently described by NAAB, acting as models for the rest of the field, and advancing the definition of sustainable design literacy.

Richard Graves, AIA, is director of The Center for Sustainable Building Research at the University of Minnesota, where there is both a traditional Master of Architecture (M.Arch) degree program and an advanced Master of Science (M.S.) in Sustainable Design. He says basic sustainable design concepts, originally taught in the M.S. program, are being migrated to the core curriculum of the M.Arch program. For example, NAAB does not require students to learn how to set and design to specific, measureable outcomes. "NAAB doesn't set a target, whereas we're giving them targets of net-zero—very aggressive and absolute targets," Graves explains.

Graves also says the school is more focused on teaching integrative process compared to what is described in the NAAB requirements. "We're trying to teach students how to collaborate with outside experts—how to bring other experts into the design process," says Graves. "We're trying to change the paradigm of the architect. We're trying to teach you how to design beautiful things, but know enough to understand what these others are telling you, and then figure out the design implications."

Deepening Literacy in Design Practice

Continuing education for professionals will always be critical in any case to both develop and maintain crucial knowledge and skills.

As a first step in defining and developing sustainable design literacy, some firms evaluate their staff's current levels of knowledge. Ackerly, at David Baker Architects, created a survey based on one from the

Photo: Lake|Flato Architects

At firms like Lake | Flato, sustainability-focused meetings are held regularly as a way to stimulate dialogue and continuously educate staff about sustainable design concepts and strategies.

Sustainability Performance Institute. The intent in this case was not to evaluate literacy, but to determine the factors that affect whether or not project teams incorporate sustainability goals into projects.

The survey invited ideas from the design staff, who identified the following things as having potential to improve their abilities to incorporate sustainability goals into every project:

- Clear direction via office standards, green project specs, and project manager protocols
- Guides for talking to and educating clients
- Dedicated non-billable time for self-directed training
- More opportunities for training on fundamentals (building science, life-cycle analysis, etc.)

The survey also asked staff to describe a problem in the field they each would like to solve, and the tools and knowledge they think they would need to solve it. The goal was to determine what obstacles are keeping design teams from more fully integrating sustainability goals into their projects. The data gathered now guides the firm as it tries to provide opportunities for staff to pursue specialized sustainable design knowledge based on specific need and interest. Surveys like this could be administered on a regular basis to identify gaps in knowledge, as well as topics that resonate with staff.

Gwen Fuertes, designer at Leddy Maytum Stacy, conducted a similar survey at her office, asking staff:

- To what extent do you feel you are able to use your sustainability knowledge? and,
- Do you feel supported in your use of it?

The survey revealed that the staff want more opportunities to conduct research and more opportunities for risk-taking.

As a way to promote and track the different varieties of sustainable design expertise in the office, some firms—including Leddy Maytum Stacy, and Bergmeyer—have begun to integrate discussions of sustainable design goals into staff performance reviews. This also gives staff the opportunity to advocate for particular sustainability goals.

Promoting, developing, and maintaining literacy

Some firms start training staff on sustainable design concepts as soon as they are hired by using "sustainability orientations" that communicate to new staff the firm's sustainability strategy, priorities, and goals.

Gwen Fuertes says that at Leddy Maytum Stacy, "Whenever anyone gets hired, there's an effort to provide a system of support for them to develop sustainable design skills, and apply these on their projects." At Perkins Eastman, there is a mandatory "Sustainability 101" course that is updated and administered yearly.

Dee Spiro says that Bergmeyer's reputation for sustainability is a big draw that attracts a lot of young designers to the firm. But that, at times, it's a challenge to find enough opportunities for these staff to get involved in sustainable design. Efforts to address this include involving junior staff in 2030 Commitment reporting, and getting them using BuildingGreen's product recommendations as a way of introducing them to the basics of material selection for sustainability and health.

Photo: Dee Spiro / Bergmeyer Associates, Inc.

Some firms promote general sustainability awareness by weaving sustainability into the everyday operations and culture of the office. At Bergmeyer, staff participate in monthly tasks like waste audits.

Make sustainability ambient

Some firms promote awareness and sustainable thinking by making sustainability "ambient"—integrating it as much as possible into office operations and culture. Many firms have formed sustainability committees that are charged with "greening" the office's spaces, practices, and policies. Holdridge told BuildingGreen, "To me it feels like one of the most effective things my team and I have done—making sure that we're always involved in every aspect of how the office operates." This helps staff learn.

Beyond the lunch and learn

Several firms are making efforts to rethink their in-house "lunch and learn" programs to make them more useful and more focused on sustainable design concepts.

At Lake | Flato, "sustainability champions" lead regular, sustainability-focused meetings that balance information about cutting-edge technologies or concepts with project-specific updates, lessons, and issues. These meetings empower the younger designers who are eager to learn by putting them in a position to lead a discussion and ask questions, says Holdridge. "It's about going from knowing to doing," she says. "It's important to have a group of people talking about what they're actually doing and empowering them to do more in between the meetings."

At Leddy Maytum Stacy, teams present projects in design during design pin-ups. Each project team is expected to "tell the story" of sustainable strategies on the project.

Leddy Maytum Stacy also does "post-mortem" discussions among project teams as a way to learn and then share the knowledge gained on each project. The firm also does informal post-occupancy evaluations of each project. The design team will do a one-year walk-through and produce a report detailing what was successful and what was not. This has allowed the firm to create a library of knowledge and experience that all project teams can reference and learn from.

Mentorship: top-down and bottom-up

Many firms are recognizing that mentorship is an effective way to share knowledge and information.

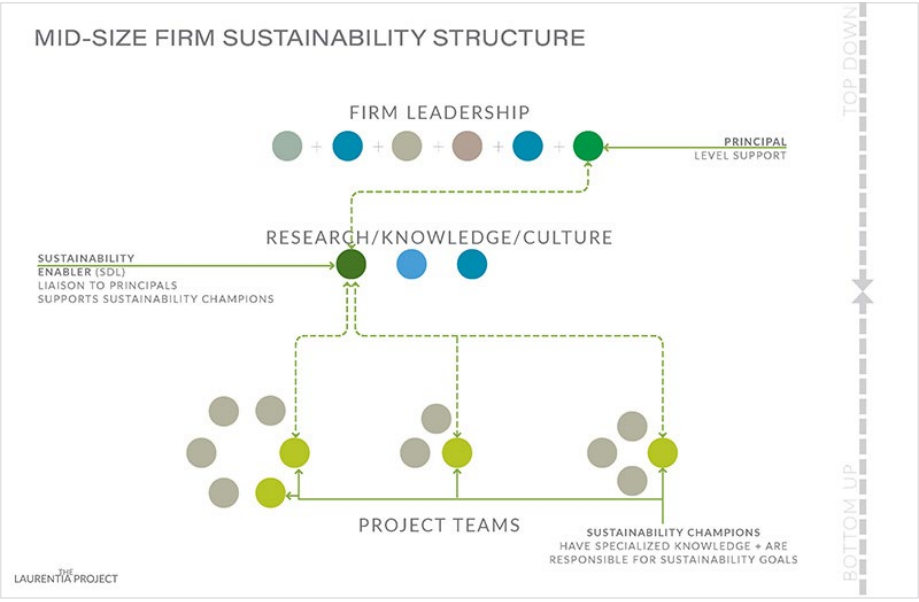
Rick Carter says that at LHB they recognize the need for "two-way mentoring" as many of the younger architects-in-training often come in with knowledge about new modeling tools and research methods, while the senior architects have years of invaluable experience to share about everything from design fundamentals, to codes, to construction administration. "Senior staff have things to teach junior staff, and junior staff have different things to teach senior staff."

"Design direction is controlled by senior level," says Yee Lin, but junior designers may be ahead of the curve on sustainable design concepts and tools. According to Lin, it takes intentional support to get junior staff to use them. "Senior level leadership needs to care," he says. "They need to communicate that it is important and meaningful for the junior staff to actually use whatever sustainable design knowledge they have."

Facilitation and commitment

Several designers told BuildingGreen that the project manager on a design team often acts as a "gatekeeper," either frustrating or enabling the sustainable design efforts of their team. A firm's design staff may have adequate sustainable design knowledge, but in many cases, if a project manager does not facilitate or empower their team to implement these strategies, it will not happen. It can be crucial for project managers to play a leadership role and enable team members with various sustainable design skills or knowledge sets.

Commitment is crucial to developing a sustainable practice. It can have a significant impact if every person in the company sees the value of sustainable design and personally commits to it as a mission. As Heather Holdridge says, "The top-down commitment is critical for success, but it's also a bottom-up commitment. I think you have to have both."



Graphic: The Laurentia Project

Firms that successfully integrate sustainability literacy into most or all of their projects frequently share some things in common: leadership-level support for sustainability, high-level support that spans teams, and placement of "sustainability champions" on all project teams.

Photo: © 2015 Lord Aeck Sargent

Lord Aeck Sargeant's offices feature a range of spaces designed to support collaboration—one of several strategies the firm uses to raise design quality and awareness firm-wide.

Sharing knowledge

Some firms have developed communication tools in an effort to make widely accessible the sustainable design knowledge that is constantly being accumulated. Lake | Flato created "Flakenet," a knowledge management system for sharing data and resources. According to Holdridge, "It's proving to be a really engaging way for people to share information. It's creating a community around environmental issues and driving dialogue."

Bergmeyer and other firms have implemented some form of the "sustainability champion" model as an attempt to deploy a source of sustainable design knowledge on every project team—so that, ideally, sustainability is a part of every single conversation. Bergmeyer's Sustainability Design Advocates work across project teams and are charged with overseeing all projects—no matter size, type, or interest in sustainable design.

Individual professional development

In addition to office-wide education initiatives, firms can develop sustainable design literacy by providing staff with opportunities for self-education and individual learning, most commonly through personal research, conferences, or webinars.

One of the big obstacles is finding the time. At Perkins Eastman, Jauregui says the firm is developing a "multi-media and multi-level comprehensive sustainable education program that will offer staff a variety of different ways to engage." The goal is to offer enough options for access so that all designers can adapt the education program to their own schedule.

Another obstacle is cost. Many designers report that it's difficult to get support for attending professional development events if there is no marketing element attached. There is a danger in attaching staff development to business development if it is acting as a barrier to education. (One way for staff to advocate for support is to play the competition card. Senior leadership will often pay attention if they know the firm's competitors are.)

Some firms also encourage staff to work on extracurricular projects—volunteering, community engagement, advocacy—as a way to develop design skills. "A lot of our staff volunteer outside work and it shows in our projects." says Holdridge.

A number of schools—including University of Southern California, Harvard Extension School, and University of Oregon—offer "Sustainable Design Certificates" or similar credentials through which working architects can gain additional knowledge about sustainable design principles and practices. These continuing education programs are flexible, allowing busy practitioners to adapt their study around their work schedules. The Sustainable Design Institute at Boston Architectural College—which BuildingGreen is affiliated with—offers more than 30 eight-week online courses, focused on topics ranging from daylighting, to indoor environmental quality, to building envelope. (Students are required to complete six courses to earn the Sustainable Design Certificate.)

Just Start: Learning by Doing

Eric Corey Freed, founding principal of organicARCHITECT, says that in his role as the co-author of a guide to studying for the ARE, he has been holding regular "office hours" for young professionals studying for the exam. From his vantage point, young architects know more than they give themselves credit for, and this can be true for anyone. "The issue is confidence," he says. "They

Photo: © Sarah Mechling / Courtesy Perkins Eastman

The Dr. Martin Luther King, Jr. School was designed by Perkins Eastman to operate with an Energy Use Intensity 60% less than the baseline while providing students a beautiful, healthy, comfortable learning environment. By continuously developing the sustainable design literacy of its staff, the firm is making an investment that will have a huge impact on the sustainability and performance of all its future projects.

don't want to start until they feel comfortable, but you're always going to feel as though you don't know enough."

A joke Freed likes to tell: What's the best thing about being a fifth-grade teacher? You really only need a sixth-grade education. "I can't wait till you feel confident," Freed says he tells young professionals. "The world is too screwed up for that. Start somewhere, even if it's only one aspect."

OP ED

Opting Out of Paris Accord Fortifies Global Warming Battle

By making the administration's position clear, Trump's decision unleashed a wave of actions to stabilize the climate.

by Nadav Malin

When President Donald Trump was equivocating about whether to pull out of the Paris Accord, I fervently hoped he would not. When he announced in early June that the U.S. would walk away from the agreement, I was worried that the global effort to mitigate climate change would be seriously set back.

But now, I've changed my mind. In fact, I'm grateful.

Here's why:

By the time the president made the announcement, his administration had already been systematically dismantling many of the regulations and programs that would be needed to live up to the Paris Accord commitments. It gutted the Obama administration's Clean Power Program, green-lighted threatened oil pipelines, opened more federal land to coal mining, and is seeking to weaken automobile fuel efficiency standards. Regardless of the country's official position, in practice, the U.S. government had already ditched the agreement.

But by clearly establishing its position last month, the Trump administration cleared the way for states, cities, corporations, and many others to step up and declare #We'reStillIn. And that, indeed, is what's happening.

The energy and focus released since the president opted out of the accord has been impressive. Entities that are stepping up are not just taking a position; they are taking action. Companies, such as Apple, are expanding their commitment to renewables. States, like California, New York, and Washington, are sending representatives to international meetings and doubling down on their own voluntary commitments. New York and other cities are expanding programs that promote energy efficiency and renewables, while creating jobs.

One of the biggest fears leading up to Trump's announcement was how it might affect the actions of international partners. The Paris Accord is built on voluntary commitments established through peer pressure among the nations. The concern was that if the U.S. pulled out, other countries would feel justified in reneging on their own commitments and the whole thing would unravel. The U.S. is, after all, by far the biggest source of cumulative carbon dioxide emissions and the second largest annual emitter (after China).

But these fears never materialized. Just as it did domestically, the president's announcement has galvanized support for the Paris Accord internationally. Country after country has made strong statements about their intent to meet their commitments. This tweet from a spokesperson for Germany's Chancellor Angela Merkel was typical: "Now more than ever we will work for global climate policies that save our planet."

Of course, none of this means that the planet is home free in terms of climate impacts. By most accounts, the Paris Accord doesn't go far enough. With carbon dioxide levels in the atmosphere over 400 parts per million (compared to the pre-industrial average of 280 ppm) we're already playing catch-up.

Photo: Ana L. Ka'ahanui

Nadav Malin, President, BuildingGreen.

Cities, states, and corporations can make up for much of the shortfall in federal support for emissions reductions, but not all of it. They are unlikely to come up with the remaining $2 billion the U.S. had committed to developing countries by 2020 to help them decarbonize their own economies. We still need a responsible federal policy on climate, and I sincerely hope the president's position is just a four-year pause that can be quickly reversed when the next administration takes over.

In the meantime, there are signs that market forces are pushing us in the right direction. The cost of wind and solar electricity generation keeps dropping. This new economic reality, and health concerns from smog, are hastening the retreat from coal as a power source. For example, in India, the state of Gujarat just cancelled plans for a massive four gigawatt coal power project. All over the world, new coal plants are being cancelled or put on hold, and renewable generation is expanding.

The building sector remains a huge opportunity for decarbonization and progress has already been made. In the past decade, we've seen lighting energy loads plummet with the LED revolution. We have both a pull from

market leaders building Passive House and net-zero buildings, and a push from increasingly stringent energy codes that are being adopted state by state over time.

We still have an enormous challenge ahead of us as we try to minimize the extent of climate change and mitigates its impacts. But with a clear mandate provided, ironically, by an unsympathetic administration, we're making good progress.

#We'reStillIn!

NEWS ANALYSIS

Reality Check for LEED v4 Product Credits

The three "Disclosure and Optimization" or "BPDO" credits in LEED v4 include both some pretty easy points and points that are not yet achievable.

by Nadav Malin

Among the biggest changes that LEED v4 brought to the U.S. Green Building Council's LEED Rating System were three new credits in the Materials & Resources category. These credits cover building product disclosure and optimization, or BPDO: Environmental Product Declarations (EPDs), Raw Material Extraction, and Material Ingredients. Each of these three credits introduced reporting formats that were either entirely new—like Health Product Declarations (HPDs)—or just unfamiliar to the North American market, such as EPDs.

Some of these new reporting formats have gained quick traction, and the points that depend on them are already easy to achieve for most projects. Others are still elusive, with their points effectively out of reach. See the "BPDO Cheat Sheet" infographic for a quick take on which ones are—and are not—worth pursuing.

The easy points

Thanks to the market demand created by LEED, and several supporting campaigns, EPDs, HPDs, and other ingredient disclosure documents are now widely available and are becoming more so all the time. LEED users still have to check to ensure that any EPDs or HPDs they are collecting for documentation meet LEED requirements, as many do not. But for all but the smallest projects, finding at least 20 products with EPDs and 20 with HPDs isn't hard. It might even be possible to double that number and earn an exemplary performance innovation point.

Making things even easier, USGBC has been steadily adding to the list of reporting formats that can be used for the disclosure option within Material Ingredients. When the system first came out, USGBC only recognized HPDs, manufacturers' self-declared inventories, or Cradle to Cradle certifications. Now that list has expanded to include a handful of other options.

While EPDs and HPDs are new to LEED, the old, familiar incentives for using products with recycled content, salvaged materials, biobased ingredients, and certified wood haven't gone away. They've just been demoted to the grab-bag of product attributes that can count towards the optimization point within the Raw Material Extraction credit. Adding to these familiar attributes is any product that's part of a manufacturer take-back program, or "extended producer responsibility."

When LEED v4 was launched, the only forest certification program that could contribute was the Forest Stewardship Council. That changed in March 2016 when the Legal Wood Pilot Credit was published, introducing an alternative compliance path that recognized more œ certifications: Sustainable Forestry Institute (SFI), the American Tree Farm System (ATFS), the Canadian Standards Association Sustainable Forest Management Standard (CSA), and the Programme for the Endorsement of Forest Certification (PEFC). That pilot credit is highly controversial and may well go through revisions over the next year or two, but the inclusion of these industry-backed certification programs isn't likely to go away.

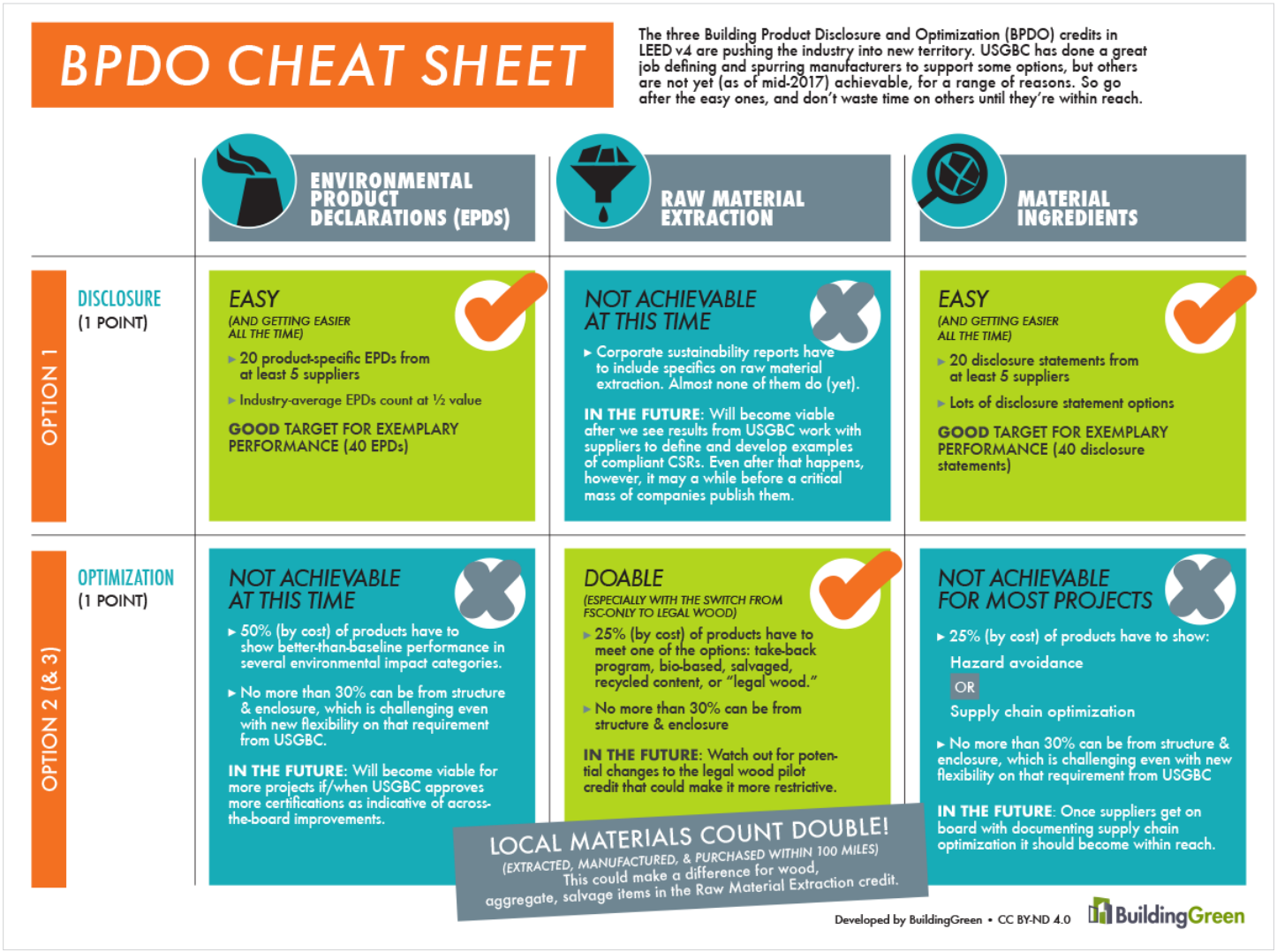
The incentive for using regional materials hasn't gone away either—it has morphed into a force multiplier for any of the optimization points, doubling the value of their contribution. It now draws a much tighter circle, however, requiring materials to be both extracted and manufactured within 100 miles of the project, so it's most relevant to simple, minimally processed products, such as aggregate and wood.

The unsolved challenge: transparency of raw material extraction

It sounds straightforward enough: just find products from companies that provide specifics on the impacts of mining, drilling, or harvesting their raw materials. The problem is that very few of the companies that make the products we specify dig their own raw materials out of the ground, so their corporate sustainability reports (CSRs) don't cover those activities. Even when they do, the information is rarely detailed enough to be associated with specific products.

USGBC recently approved certification under ANSI/NSF 373 Sustainable Production of Natural Dimension Stone as an option here, as long as the stone facility makes its scorecard publicly available and earned either credit 7.2.1 or 7.2.2 within that system. If more such raw material extraction certifications become available this credit will be more achievable.

Unlike the product manufacturers' quick response to the new demand of EPDs and HPDs, however, the industry doesn't seem to have gotten a handle on how to provide compliant raw material extraction reports, and USGBC has yet to issue clear guidance on what would even qualify. There is simply no point in trying to earn this point until the requirements are clear, and enough compliant reports or



Graphic: BuildingGreen, Inc. License: CC BY-ND 4.0.

certifications show up. If you've found any that you think do comply, please list them in the comments area online so we can all help solve this challenge.

A bar too high: optimization for EPDs and ingredients

The optimization point in the EPD credit calls for the use of products with better-than-baseline scores across a range of environmental impact categories. Products that contribute to this point have to come with EPDs that show those scores compared to an industry average, or compared to previous scores for the same product (showing improvement over time).

There are a few products starting to emerge that meet this requirement, but to earn the point, a project has to come up with a whopping 50% of its materials (by cost) that hit the mark. And, if that weren't challenging enough, only 30% of those can be structural or enclosure materials (steel, concrete, large timbers, glass). The USGBC's Materials & Resources Technical Advisory Group (MR-TAG) has just approved new language that makes that 30% requirement less rigid, but even with that change it will be a while before a project can hit the 50% threshold.

The Material Ingredients optimization option has a more reasonable threshold, but even getting 25% of materials by cost is out of reach for almost all projects; simple tenant improvements are the exception. To comply, the products have to meet stiff standards for avoiding hazardous ingredients through a program such as Cradle to Cradle or with full GreenScreen assessments. For the Cradle to Cradle option, products have to have the full certification to the Silver level or higher; Material Health certifications don't qualify.

There is also a third option in the Material Ingredients credit called "Supply Chain Optimization." This option can be combined with Option 2, so that products contributing to either Option 2 or Option 3 can be counted toward the 25% threshold.

Supply Chain Optimization rewards the use of products from companies that have robust environmental and health management systems. This incentive applies not only to the manufacturer that supplies the final product to the jobsite, but also to its suppliers, especially if the final product contains potentially hazardous substances. (Disclosure: BuildingGreen was engaged by USGBC to facilitate the working

group that developed guidelines for implementing this option, and I led that effort.)

While the basic elements of the programs that a supplier needs to support this option are widely available, putting them together in a way that conforms with the guidance released in 2016 by USGBC is not a trivial task, so it will take a while before products with the required documentation become available.

The high threshold, the novelty of Option 3, and the 30% cap on contributions from structural and envelope products, all add up to an optimization point for material ingredients that remains, at least for now, largely out of reach.

Change is hard

The fact that half the points in LEED v4's three Building Product Disclosure and Optimization credits are currently unachievable can be frustrating to LEED project teams, especially if they've spent a lot of time trying to earn those points. But for LEED as a market transformation program, it's merely an indication that USGBC got a little too far ahead of its market on those options.

Considering how unreachable almost everything in these credits seemed when they were first launched in 2013, however, the fact that half the points are now readily achieved is a notable success. Between future revisions to the credits and increasing capacity in the market to meet these demands, the rest of the points will come sooner or later.

In the meantime, exemplary performance points for Option 1 in both the EPDs credit and the Material Ingredients are within reach, and getting easier all the time as more suppliers publish transparency documentation for their products. There are also pilot credits that USGBC is using to encourage project teams to explore this relatively uncharted territory, such as Integrative Analysis of Building Materials and Building Material Human Hazard & Exposure Assessment. We still have some work to do as we learn how to select products that are best for human health and the environment, and these work-in-progress credits are helping us get there.

NEWSBRIEFS

New Zero Energy Certification Powered by ILFI and NBI

Focused solely on net-zero-energy performance, the new certification aims to distinguish projects that verify outcomes with actual data.

by Candace Pearson

As more projects started claiming "net-zero-energy design" without having actual performance data to back them up, a certification and a certifying agency became needed. International Living Future Institute (ILFI) and New Buildings Institute (NBI) have now teamed up to fill this gap and accelerate the net-zero-energy trend.

Earlier in 2017, ILFI took efforts to make its Living Building Challenge (LBC) net zero energy certification more approachable. It removed the requirement that projects would also demonstrate compliance with LBC's Limits to Growth, Beauty, and Education imperatives and eliminated the site visit, in order to reduce costs.

With the most recent collaboration, ILFI will continue to administer that certification—now named the Zero Energy Building Certification—and NBI, which has been verifying energy data from net-zero-energy projects for years, will act as auditor. The set up ensures that there's a third-party certifier, independent from ILFI.

Photo: The American Samoa Environmental Protection Agency

This Environmental Protection Agency Building on the island of Tutuila, American Samoa, became LBC Energy Petal certified. Future projects will be able to choose between Zero Energy Certified and full petal certification.

The certification requires projects to submit twelve consecutive months of net-zero-energy performance data.

Projects using onsite combustion, such as wood pellet boilers, aren't eligible—a position taken by ILFI based on the argument that burning wood releases too much carbon dioxide into our already overburdened atmosphere.

Note that this new offering doesn't affect the similar Living Building Challenge Energy Petal certification. That certification is more demanding in some ways: it does require that teams achieve additional imperatives, sets a higher "net positive" energy standard, and requires some onsite energy storage for resiliency. It is also more flexible, however, thanks to recent rulings that allow for contributions from off-site energy under certain conditions.

While joining forces to certify net-zero-energy projects, ILFI and NBI also agreed to a common questionnaire for developing case studies, which has been incorporated, as an optional section, into the documentation requirements for the Zero Energy Building Certification. Case studies sourced this way will all be entered into NBI's database.

First Standards for Carbon Neutral Buildings Launched in Canada

The new zero carbon standard is designed to assess carbon emissions from commercial, institutional, and multi-family buildings across Canada.

by Nancy Eve Cohen

The World Green Building Council launched its Advanced Net Zero project in 2016, with the goal of eliminating carbon emissions from all new buildings by 2030, and from every building by 2050. Now, the Canada Green Building Council has introduced the first national standard to emerge from that campaign, a certification program focused solely on carbon neutrality.

Eliminating all emissions from buildings "is a very ambitious target," said Mark Hutchinson, vice president of Green Building Programs at Canada Green Building Council, "but it's simply a recognition of what is going to be needed."

Certification requires project teams to:

- Evaluate the type of energy their project will use and the carbon associated with generating that energy;
- Reduce thermal energy demand by meeting envelope and ventilation efficiency targets;
- Offset carbon emissions from the building's operations by the generation of renewable energy either on or off site; and, ultimately,
- Achieve zero net carbon emissions.

Photo: DTHA

Canada Green Building Council's Zero Carbon Pilot Project: Toronto and Region Conservation Authority (TRCA) New Headquarters. Toronto, Ontario.

The standard also requires designers to report on the anticipated peak energy demand of the building. There is no specific target, but by considering peak demand, a designer will better understand the carbon-intensive energy sources that may be used during peak demand periods.

Similarly, the standard also requires the assessment of the embodied carbon of structural and envelope materials—but does not require that low-carbon materials be chosen. "Just by undertaking that exercise there is a significant advantage in moving the industry forward," said Hutchinson.

New buildings can earn a design certification, which requires them to generate 5% of their energy from onsite renewables and to meet targets designed to reduce heat loss from a building's envelope and ventilation.

Existing buildings can earn a performance certification. It's based on twelve months of operations, with the performance verified every year.

New buildings that have earned the design certification can, after a year of operation, apply for dual certification in both design and performance.

Besides Canada, nine other green building councils have also committed to developing a carbon neutral buildings standard. Australia is expected to release its next. That standard is being developed jointly by the government and the Green Building Council of Australia.

For more information

Canada Green Building Council Zero Carbon Standard
www.cagbc.org/zerocarbon

Australian Government's Carbon Neutral Buildings
http://www.environment.gov.au/climate-change/carbon-neutral/buildings-precincts

World Green Building Council
http://worldgbc.org/advancing-net-zero

PRODUCT NEWS & REVIEWS

Modular, Onsite Graywater System

Grayworks is a modular, plug-and-play commercial graywater treatment system that simplifies installation and maintenance.

by Brent Ehrlich

When we turn on a faucet in the U.S., it's easy to think that the clean water that comes pouring out is a limitless resource. But fresh water is a precious commodity and it takes a lot of energy and resources to filter, sanitize, pump, and transport potable water into our buildings, and then out again as wastewater.

We can reduce our water consumption—and the amount of waste flowing through our aging water infrastructure—by reusing the "graywater" from showers and sinks for irrigation, flushing toilets and urinals, and other uses. To do so, that graywater has to be filtered, sanitized, and stored.

The sophisticated commercial systems that treat graywater are typically assembled by engineers using individual components, including filters, UV or ozone sanitation, storage tanks, chemical treatments, and controls. These systems are complicated and if not installed or maintained properly, can lead to sanitation problems, odor, and corroding fixtures.

Grayworks, developed by Critical Flow and Rainwater Management Solutions, is engineered to simplify water reuse in commercial buildings through a modular, plug-and-play design.

Treating wastewater naturally

Nature does a good job treating wastewater. Soil and wetlands act as filters, and microbes help break down contaminants. These same biological processes are used in municipal high-volume, centralized waste-

Image: Critical Flow / Grayworks

Grayworks includes all the necessary components for a commercial graywater system in one modular, secure structure.

water treatment plants. Replicating natural graywater processes at the building scale is typically expensive and requires a lot of space. Living Machines—which use custom-built wetlands and other systems to filter and treat wastewater onsite—are a good example.

Eric Lohan and Nate Nickerson, P.E., principals at Critical Flow, used to work at Living Machines, and bring a similar biological treatment approach to Grayworks. "Chemistry, chlorine, and filters do not give reliable treatment," says Lohan. So, Critical Flow focused on making biological treatment more compact. The company now offers systems capable of handling from 1,000 up to 10,000 gallons of graywater per day (gpd). Grayworks is able to meet NSF/ANSI 350, *Onsite Residential and Commercial Reuse Treatment Systems* (see First National Standard for Graywater Systems) using the following steps:

- Vortex prefilter screens remove hair, lint, and other debris. The cyclonic action of the water helps keep the low-friction surface clean and concentrates solids at the center, while an automated high-pressure spray periodically rinses the screen.
- A bioreactor uses microbes to break down pollutants. The company claims the proprietary media in the bioreactor increases the rate of treatment, allowing for a more effective process and smaller overall footprint.
- Another filter removes remaining solids and an ultraviolet light disinfects the water. Debris from both filters are removed to the waste stream.
- Chlorine treatment (which is required by most codes and fixture manufacturers if water is to be reused indoors) and dye system (to mark treated water as graywater) can also be integrated into the unit.
- A polypropylene tank with ¾"-thick walls stores the water.
- Controls integrate into building management systems, providing information that can be accessed via a dashboard and internet.

Simplifying installation and maintenance

"Instead of buying a bunch of skids [individual component pieces] and tying them together, spending a lot of time on contractors and project management, we wanted to put it together in one modular system," Lohan says. Nickerson adds, the modular approach does not take engineers out of the equation, but allows them to focus on flow rate and how the system fits into the building.

Maintaining and commissioning graywater systems are keys to their long-term performance, and Critical Flows suggest that manufacturers—rather than engineers or maintenance personnel—are in a better position to provide support after the system is installed. "If the building system changes over time or your UV unit manufacturer goes out of business, having a vendor you can work with provides a lot more security to the owner than going back to the engineer who has moved on to ten other projects."

Just getting started

Grayworks' first installation is at the Chicago Journeymen Plumbers Local Union 130 Training Center, a 50,000 square foot facility used to train its members. The center opens in late July 2017 and has mock ups of all standard plumbing fixtures. The center will not use any potable water. Instead they installed a 1000-gpd Grayworks system along with a rainwater system to meet its water needs. According to James M. Majerowicz, the center's training director, "We have a graywater system that handles the showers and lavatories that will feed outside subsurface irrigation."

The fact that graywater is the focus of a plumber training center is a sign that the industry's awareness of water as a limited resource is growing. Majerowicz says there is a lot of industry interest in graywater systems and plumbers need to be ready. "We need to put this water to beneficial use instead of putting it down the sanitary sewer," he says. And since they are going to be installing graywater systems, they wanted to train on the latest equipment.

Ironically, because the center's Graywork system is integrated into the building for training purposes, it did not arrive at the center in modular form. Though the system was designed and engineered by Critical Flow, "all the components were shipped separately and our plumbers from local 130 installed all the components on site," says Majerowicz. This gave the plumbers additional training installing a graywater system.

But this points to a limit of modular systems—their footprint. The smallest 1000-gpd system is 5'x5'x6' and the largest 10,000-gpd system is 12'x7'x6'. These will not squeeze through a standard door opening. "We know that in the future, where these are added on [such as retrofits with limited space] these are not always going to fit into rooms," said Majerowicz.

These modular "boxes" might not fit through a standard door, but Lohan points out the benefits of having a graywater system in a contained, secure enclosure. "We are a little bit bigger than other systems in terms of footprint, but it is simpler to run," he says. "It can also be installed in a parking garage or outside the building in the landscape, and has its own

Estimated Grayworks Simple Payback[1]

Location	Commercial Office 675 Employees 1,000 gpd	Mixed Use Development 100 Residents / 300 Employees 4,000 gpd	Dormitory 300 Residents 10,000 gpd
Atlanta, GA	4 yrs	2 yrs	1 yr
San Francisco, CA	8 yrs	3 yrs	2 yrs
National Average[2]	12 yrs	5 yrs	3 yrs

1. Simple payback includes capital cost of system and operational costs due electricity, chemical consumables, and scheduled replacement. Installation costs and additional operational costs will vary by location.
2. National average is estimated at $10.00 per 1,000 gallons of water and wastewater combined.

Source: Critical Flow

inherent security to it as opposed to having to build a room around it."

Is graywater worth pursuing?

Graywater systems make the most economic sense in buildings that can reuse water in a cost-effective way. College dormitories and other buildings with a lot of sinks and showers can see paybacks in as little as two years, according to the company, but Lohan estimates the payback could take longer— two to ten years — depending on the facility and location.

But in some locations graywater is becoming a must, due to sewer costs and/or regulations. "Seattle and Atlanta don't seem like they should be the two most expensive places for water in the country, but they are," says Lohan. "It is very difficult to meter sewage, so almost all areas are metering you on water coming in and double charging on sewage going out. If you are treating onsite you are removing both of those costs."

For some areas, such as Southern California, using non-potable water is now required for irrigation— graywater's main use— so the Grayworks system could be an especially good fit for these applications.

For more information

Critical Flow
www.grayworks.com

PRIMER

Reading Sustainability

What are the books that all designers should read? This reading list on sustainable design, gathered from experts, is a mini-degree on green building.

by James Wilson

As a supplement to this month's feature, Sustainable Design Literacy: A Foundation for Transformed Practice, BuildingGreen has compiled a list of books that can help designers develop and maintain their sustainability knowledge.

The list includes recommendations from sustainable design leaders and educators, as well as some of BuildingGreen's trusted, "go-to" books. A varied mix of older classics and notable newer books, what follows is by no means an exhaustive or comprehensive list, but a selection of great places to start for building well-rounded sustainability literacy.

In addition to books that cover the basic principles of sustainable design and how to apply them, we've also included a few books to spark inspiration and creativity that may help energize and renew the designer's sense of purpose.

What would you add to the list? Tell us what books you've found to be indispensable in your work.

Sustainable design in context

***The Big Rethink series*, Peter Buchanan**

These thought-provoking critical essays examine the history of the architectural discipline from a variety of perspectives and propose a number of radical shifts, all in the pursuit of a "complete architecture."

***The Web of Life: A New Scientific Understanding of Living Systems*, Fritjof Capra**

This book explains how complexity theory and systems thinking illuminate the ways in which all living things connect through interdependencies.

***Behind the Green Door: A Critical Look at Sustainable Architecture Through 600 Objects*, Rotor**

Based on an exhibition at the Oslo Architecture Triennale of 600 "alleged sustainable objects"—including building models, samples, construction tools—this book raises many important questions about how sustainable design is evolving. For example: how "sustainable" is an insulation product that requires the installer to wear full-body protective gear? (This book may be a bit tricky to track down, but it looks to still be available for order through Rotor's website. Or, next time you're in Brattleboro, stop by BuildingGreen's office and you can review our copy.)

***Drawdown: The Most Comprehensive Plan Ever Proposed to Reverse Global Warming*, Paul Hawken**

Paul Hawken's most recent book collects 100 existing and economically feasible practices that researchers believe could be scaled both to dramatically slow global warming, and, more importantly, to reach "drawdown"—the point at which the amount of atmospheric greenhouse gases peak and start to decline.

***Designing Regenerative Cultures*, Daniel Christian Wahl**

This is a book about changing the way we think about nearly everything—from finance systems, to design,

to agriculture—in order to build a "regenerative culture" that can better adapt to the uncertainties and crises we will continue to face.

BuildingGreen's The Big Picture topic overview page discusses how building design is situated within the larger context of sustainability with articles like: 20 Ways to Advance Sustainability in the Next Four Years.

The basic strategies

***The Philosophy of Sustainable Design,* Jason McLennan**

This manifesto-like introduction to basic sustainable design principles is unique in that it teaches the philosophy of sustainability instead of focusing on "how-to" information. An understanding of the foundational theories behind sustainable design strategies could fundamentally alter every aspect of how a designer works.

***The Green Studio Handbook,* Alison Kwok & Walter Grodznik**

This is a go-to reference guide for information on how to integrate a wide range of sustainable design techniques.

Passive design

***Sun, Wind & Light: Architectural Design Strategies,* Mark DeKay & GZ Brown**

This is the classic, trusted resource for clear, illustrated explanations of how buildings interact with sun, wind, and light.

***Buildings Without Architects,* John May**

There exist around the world many examples of sustainable buildings, "designed" by resourceful communities that understood how to build in response to the conditions, constraints, and opportunities of a place. This book documents a wide range of vernacular building styles, highlighting the principles of local, contextual, passive design.

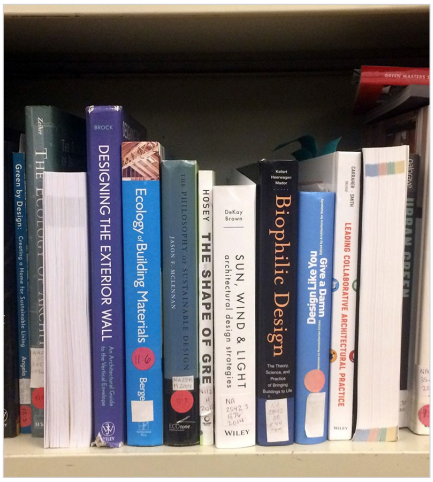


Photo: James Wilson

Building science

***Designing the Exterior Wall: An Architectural Guide to the Vertical Envelope,* Linda Brock**

This book translates the basics of building science for architects—dealing with both the science and aesthetics of designing and constructing building envelopes. It includes detail drawings and case studies to show the reasons that cause buildings to either fail or last.

***Water in Buildings: An Architect's Guide to Moisture and Mold,* William B. Rose**

If you want to understand the effects that water has on buildings and how design can prevent moisture problems, this guide explains the behavior of water and how it can be managed.

If you're looking for some brief refreshers on building science concepts, check out BuildingGreen's Building Science topics, including: Building Envelope, Moisture Management, and Heating & Cooling.

Sustainable materials

***The Ecology of Building Materials,* Bjorn Berge**

This book explores building materials in the context of climate change. It examines the interaction between materials and the indoor environment, ventilation, and energy use; and offers practical information on things like conducting a Life Cycle Analysis and detailing for durability.

For focused information on the different impacts of building materials, see BuildingGreen's Sustainable Materials topics, including: Material Selection, Avoiding Toxic Chemicals, and Efficient Use of Materials.

Sustainable design & analysis tools

***Design Energy Simulation for Architects: Guide to 3D Graphics,* Kjell Anderson**

This book, written by a practicing architect and containing many case studies, explains how designers can use simulation tools to make better, more informed early design decisions.

***Daylighting Handbook I,* Christoph Reinhart**

This introductory guide to daylighting—besides including useful rules of thumb for designing with the sun—also provides a practical, foundational understanding of how natural light influences our circadian rhythm and perception of our surroundings.

See BuildingGreen's Software Tools for Architects topic overview page for articles like: Energy Modeling: Early and Often and webcasts like Shoebox Energy Modeling: How to Do Quick, Early Simulations.

Health, wellness, well-being

***Building Materials, Health and Indoor Air Quality: No Breathing Space?,* Tom Woolley**

This recently published book is one of the first texts focused on how to avoid hazardous building materials and improve indoor air quality.

See BuildingGreen's Design for Health topic overview page for articles like Why Chemical Transparency Matters and Sitting Is the New Smoking: Fad or Fact?

Beauty, comfort, delight

***The Shape of Green: Aesthetics, Ecology, and Design,* Lance Hosey**

In the first book to focus on the aesthetics of sustainable design, Hosey explains—using practical design applications as examples—the importance of how "sustainable" things and spaces look and feel.

***Thermal Delight in Architecture,* Lisa Heschong**

This short book demonstrates how the thermal qualities of a building can be designed to offer more than a minimum, static sense of comfort. Referencing traditional examples of thermal spaces like the sauna, the Roman bath, and the Islamic garden, the book explains how spaces can be designed to engage the thermal sense—and how this can affect the way people use and care about their environments.

***The Eyes of the Skin: Architecture and the Senses,* Juhani Pallasmaa**

This poetic and insightful book advocates for the design of multi-sensory environments by showing how buildings that engage all of the body's senses enhance human experience and well-being.

***A Pattern Language,* Christopher Alexander**

This classic sourcebook contains a wealth of ideas—a language—that communities can use to create "whole" places that support human well-being.

***Nesting: Body, Dwelling, Mind,* Sarah Robinson**

This book uses findings from cognitive research—along with poetry and philosophy—to explore and explain the "ways in which our built environment shapes us as significantly as we have shaped it."

On BuildingGreen's Comfort & Productivity topic overview page you can find articles like: Neuroarchitecture: Thinking with Our Buildings and Hygge: The Human Element in Architecture.

Biophilia

***Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life,* Stephen R. Kellert**

This comprehensive guide to biophilic design explains the strategies that can be used to connect people to nature—and thereby enhance their health, wellness, and well-being. The book also explains the theory and science that make these strategies effective.

If you want a brief summary of how to apply concepts of biophilia in your design work, see BuildingGreen's feature article Biophilia in Practice: Buildings that Connect People with Nature.

Resiliency

***Adapting Buildings and Cities for Climate Change,* Sue Roaf, David Crichton & Fergus Nicol**

Combining theory with practical guidance, this book explains how to use design to protect our buildings and communities not just from extreme weather, but also from the related social and economic risks associated with it.

***How Buildings Learn: What Happens After They're Built,* Stewart Brand**

This is a book about how buildings are changed both by time and the humans who live in them. It presents a wide range of examples to demonstrate how buildings improve as they age and offers guidelines for "designing with time rather than against it."

BuildingGreen's Resilient Design topic overview page includes articles that give brief practical descriptions of resilient design in practice, like: The Four Core Issues to Tackle for Resilient Design (And the Programs That Can Help).

Socially responsive design

***Design Like You Give a Damn,* Kate Stohr & Cameron Sinclair (editors)**

This was one of the first books to showcase humanitarian architecture. It is a collection of projects from around the world that demonstrate the impact that conscious, innovative design can have on the lives of "the other 99%," and especially on the lives of the most vulnerable—those in need of basic shelter.

***Design for the Real World: Human Ecology and Social Change,* Victor Papanek**

The message delivered by this book is that all designers should recognize that their work affects and is affected by a social context.

***Spatial Agency: Other Ways of Doing Architecture,* Nishat Awan, Tatjana Schneider & Jeremy Till**

This collection of alternative modes of architectural practice highlights the many ways in which designers have addressed social issues around the world, and explains the role of the built environment in efforts to create sustainable and just communities. The focus is on the consequences of design.

Check out BuildingGreen's Social Responsibility page for articles that discuss the social impact of design, including: Building for People: Integrating Social Justice into Green Design.

Sustainable economy

***Natural Capitalism: Creating the Next Industrial Revolution,* Paul Hawken, Amory Lovins & L. Hunter Lovins**

This introduction to the concept of natural capitalism includes examples of companies that are leading the way by adopting an industrial approach that assigns appropriate economic value to all material resources, especially natural resources.

***Deep Economy: The Wealth of Communities and the Durable Future,* Bill McKibben**

This book is a manifesto for a new way of thinking about how we consume and the things we value. The idea proposed here is that we need to move beyond a focus on "growth" and focus instead on prosperity.

***Building a Healthy Economy from the Bottom Up: Harnessing Real-World Experience for Transformative Change,* Anthony Flaccavento**

This new book argues that the creation of a healthy economy depends on effective public policy driven by active, engaged citizens. A set of examples serve as a practical guide for those looking to take immediate, direct action to change their local economy.

This recent BuildingGreen article discusses how new economic models

are being applied to support progressive design: Embracing the Economy as a Design Challenge.

Integrative design practice

***The Integrative Design Guide,* Bill Reed and the Seven Group**

This integrative design "how-to guide" introduces the concepts of whole building design and whole systems, and explains how integrative thinking reframes the definition of sustainable design.

***Integrating Project Delivery,* Martin Fischer, Howard W. Ashcraft, Dean Reed & Atul Khanzode**

This new book is the first to explore Integrated Project Delivery in depth. It focuses on "IPD in every-day operation," providing practical guidance for implementing IPD in the real world.

***Leading Collaborative Architectural Practice,* Erin Carraher & Ryan E. Smith**

This book offers practical guidance on how to foster a culture of meaningful collaboration and includes hands-on exercises that project teams can use to support an integrative design process.

For a brief overview of the integrative design process and practical tips on how to implement it, see BuildingGreen's Integrative Process topic overview page, which includes articles like: How to Make Integrated Project Delivery Work for Your Project.

Human-centered design

***Ethnography for Designers,* Galen Cranz**

This is a book about listening. It explains how designers can use social science research methods to generate innovative and sophisticated design solutions that respond to human needs and cultural values.

***The Architecture of the Well-Tempered Environment,* Reyner Banham**

This book was among the first to discuss how environmental engineering impacts design. Banham was an early advocate for an architectural practice that integrates technology, human needs, and environmental concerns.

***Design for an Empathic World: Reconnecting People, Nature, and Self,* Sim Van der Ryn**

This book is a resource for designing with empathy. It describes a way of designing that focuses on human needs and preferences.

For more information on how designers can involve occupants in the sustainable design process, check out BuildingGreen's Occupant Engagement topic overview page, which includes articles like Design Strategies for Occupant Engagement—and Why They Boost Performance.

Thinking sustainably

***New Directions in Sustainable Design,* Adrian Parr & Michael Zaretsky (editors)**

The essays in this book forecast the ways in which sustainable design might evolve by highlighting the connection between the theories and practices it involves. The book is a guide to "thinking sustainably."

***Earth in Mind: On Education, Environment, and the Human Prospect,* David W. Orr**

This book about rethinking education focuses on the value of ecological intelligence and other qualitative forms of knowledge that keep us connected to the living world around us.

***Life Is a Miracle: An Essay Against Modern Superstition,* Wendell Berry**

This book argues that the creation of healthy, durable communities requires more than just empirical knowledge—it requires imaginative knowledge, "a way to know things intimately, particularly, precisely, gratefully, reverently, and with affection."

***The Sense of Wonder,* Rachel Carson**

This is a book to help us nourish and support the next generations of environmentalists and sustainable designers. Carson wrote, "If a child is to keep alive his inborn sense of wonder, he needs the companionship of at least one adult who can share it, rediscovering with him the joy, excitement and mystery of the world we live in."