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Why Schools Are Embracing Net-Zero Energy

Schools are leading the way in net-zero energy, but some designers question whether these goals create the best learning environments.

by Candace Pearson

In Portland, Maine, the chair of a building committee dreamed of a schoolhouse that could offset the transportation energy required for students to commute to school.

In Arlington, Virginia, a school architect argued he could reduce energy costs without increasing his budget.

In Cambridge, Massachusetts, the school district, inspired by a climate action plan adopted by the City Council, requested project proposals with a sustainable wish-list.

Each—through sometimes surprising turns—resulted in the pursuit of a net-zero-energy school. It is rare that a building trend is so closely tied to one building type. But aside from homes, more schools have targeted net-zero energy than any other sector. By one count, there are 89 school projects in the U.S. that have pursued net-zero energy.

With their traditionally short operating calendars and lack of intensive energy loads, schools are relatively approachable candidates for net-zero-energy goals. But is there more behind this trend?

Why schools?

The K-12 building type has some useful program and occupancy characteristics that make net-zero energy relatively feasible (see full list in sidebar). Added on top of that are the mission-driven motivations. Pursuing environmental sustainability is likely to resonate with educational institutions, which by definition are geared to think about the next generation. Even more directly, a high-performance building can be utilized as a teaching tool for applied math and science.

School boards are usually receptive to upgrades that will improve the quality of learning environments for the sake of the young minds that will spend so much time there. So, a good case can be made for energy-saving features like daylighting, ventilation, and a good thermal envelope. Net-zero energy can also be a strategy for fiscal responsibility, given that public schools currently spend more on energy bills than computers or books combined (more on how energy performance impacts school budgets later in the article).

Low barrier to entry

According to professionals, there are also some more human-driven reasons that teams are finding success in schools. BuildingGreen interviewed over a dozen project teams that have pursued net-zero energy in schools as part of a research project for the U.S. Department of Energy's (DOE) Zero Energy Schools Accelerator Program. Their answer? Schools are the low hanging fruit.

A look through the school case studies hosted on the Department



Photo: Lincoln Barbour Photography

Architect Wyck Knox takes questions from students at Discovery Elementary about the design of their new net-zero-energy school.

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of Energy's Buildings Catalog shows that designers and builders have figured out a fairly predictable recipe for zero energy in schools. It's nearly always some mixture of a tight envelope, LED lighting, limited plug loads, and—usually—ground-source heat pumps. (Although there are those who question the cost-effectiveness of ground-source heat pumps as compared to air-source mini-splits—Marc Rosenbaum, P.E. from South Mountain Company among them.) This is not to say the process is not rigorous, but the tools are there. "I think most architects have the knowledge to do net-zero energy," said Edward McGraw, founding partner and CEO of AshleyMcGraw, the design firm of the recently completed MacArthur School in Binghamton, New York. "It is more about committing to follow through on what is right."

It also helps that many school districts are already familiar with these technologies. Many have already experimented with ground-source heat pumps or converted to LED lighting. And because utility bills are such a major aspect of the budget every year, a school district has likely seen how these technologies can make a difference with energy costs. For example, in Arlington County, the school district had already installed a solar array and ground-source heat pump system on a high school building. So, by the time a new project came along and net-zero energy was proposed, the district had already debated the benefits and cost effectiveness of ground-source heat pump systems. "That path had already been cleared for us," Wyck Knox, AIA, associate principal at VMDO Architects told BuildingGreen.

Making the headlines

Meanwhile, the public relations pay-off for achieving a net-zero energy school can be huge. Knox's project, Discovery Elementary, recently won a COTE Top Ten Award. In Maine, when the Friends School of Portland broke ground, Sen. Angus King (I) was present for the opening and pledged his commitment to expanding renewable energy. Net-zero energy is still a novelty to the general public, so projects are often covered in mainstream news outlets.

Net-Zero Energy Definition

A net-zero-energy project refers to a building that produces enough energy through onsite renewable energy systems to offset the amount of energy that it consumes in a year. (See this article for more on definitions.)

Achieving net-zero energy is, at some level, simply a task of putting various design concepts together—relatively straightforward for the design team, and not a huge jump for district officials. And yet it is an achievement that garners a lot of cachet—which can be very attractive for all involved.

Potential scalability

Another reason net-zero-energy schools are a good bet from a business development perspective is that they are more likely to be thought of as replicable, raising the stakes for making sure things are done well the first time. Some districts—especially in suburban settings that are growing rapidly—intentionally hire a design team for one project and then replicate the design several times over for future projects, so they're keen to make sure the base design is a great one.

Such was the case with a cluster of schools in the Davis School District in Utah and a set of schools built in Kentucky. In Davis, the design for the net-zero-energy school Odyssey Elementary laid the groundwork for two more schools, Kay's Creek and Canyon Creek. The same architect, VCBO Architecture, was retained for all three projects.

Even when replicability isn't built in to a specific district's development plans, the world of K-12 school design trends toward an attitude of copy-what-works. In Kentucky, the success of the net-zero Richardsville Elementary School led to the completion of eight other net-zero-energy-ready schools in and around Bowling Green by the architecture firm Sherman Carter Bernhart. Friends of Portland, the small

Ten Reasons Why Schools Are a Good Fit for Net-Zero Energy

(List adapted from Ken Edelstein from The Kendeda Fund)

1. Low energy demand: Schools usually operate only nine months of the year and for limited hours. Occupancy levels are predictable and constant, and only partial after hours. Plug loads are low compared with buildings that run more appliances or computers.
2. High renewable energy potential: Suburban and rural schools are usually one or two stories—providing a large footprint for photovoltaic panels relative to the square footage inside. Most demand occurs during the day, when the photovoltaic panels are able to generate electricity.
3. Owner occupancy: School boards have an interest in reducing utility expenses, and they usually possess bonding authority to fund long-horizon projects.
4. Sustainable mission: Educators express a desire to pass on sustainability to the next generation. Schools can become a place to model and teach this behavior.
5. STEM emphasis: Technology incorporated into net-zero-energy schools can be incorporated into math and science curricula, enabling a building to serve as a living lab. A high-tech facility communicates leadership and competitiveness.
6. Better learning: Features related to net-zero design—such as daylighting, improved ventilation, and great thermal performance—can create a healthier, more comfortable indoor environment that stimulates learning, reduces student absences, and increases teacher retention.
7. Community resilience: In natural disasters, schools that have their own onsite power supply can continue to function and can serve more effectively as community centers.
8. Familiar systems: School districts are an owner group that faces construction projects relatively often and consistently track utility bills. They are likely familiar with most energy efficient technologies—they just haven't yet had a chance to incorporate them all into one school.
9. Scalable design: The potential to repeat a design for other schools within a district can spread design fee premiums across multiple projects.
10. Advocacy instrument: When a school district builds a new school, it is a big event. Celebrating a highly energy efficient school brings green building into the public eye.

Quaker School in Maine, was built to be net-zero energy and Passivhaus certified. Within two years, three other schools in Maine decided to pursue Passivhaus certification. The design and consulting firm Stantec has been involved with an impressive eleven K-12 schools designed to be net-zero energy. With this building typology, scalability is possible within a district and within a particular firm's project reach.

Are good learning environments sacrificed?

Some designers argue that a devotion to a narrow energy goal could create tunnel vision where design teams may begin to sacrifice the quality of children's learning environments. Daylighting, fresh air, and low-VOC materials may be linked to students performing better in schools, but such features aren't guaranteed in a net-zero-energy school even if they are typically qualities of green schools in general. Meanwhile, they are potentially vulnerable to the same common downsides, such as bad acoustics. The critics worry that all the attention being given to zero-energy schools is becoming a red herring for the industry.

Consider lighting. Kenny Stanfield is a principal at Sherman Carter Barnhart and the designer of the cluster of net-zero-energy schools in Kentucky. He told BuildingGreen that as LED technologies have gotten better, schools save more energy by relying on electric lighting rather than daylighting. "We still do clerestories in hallways. But as far as classrooms, we're better off to not do light shelves and clerestories," said Stanfield. Such a decision might save energy and money, but some argue it could negatively impact the quality of the space.

The design team of Discovery Elementary in Virginia faced the same quandary, but decided that the benefits of daylighting outweighed the energy penalty. "There is a prescriptive approach that said the glazing goal should be 30%," according to Knox. "But we felt it was important to have light and the feeling of transparency, so we pushed back on the engineers and said, 'We're going to have to find other places to be more efficient.'" The resulting design had a glazing percentage of 38% and many of the indoor partitions are glass as well. And yet this decision may have caused another tradeoff. When BuildingGreen visited Discovery, we saw that a teacher working with a student in one of the school's open common areas had to move to a different room because the space was too loud. (Glass can have high sound transmittance). Though to the designer's credit, at least the student and teacher had a space to relocate to!

Asked whether he could foresee net-zero-energy goals resulting in decisions that detract from the quality of a space, McGraw told BuildingGreen, "I see it happening already." McGraw points to the recently constructed Kathleen Grimm School for Leadership and Sustainability (P.S. 62) on Staten Island as an example of a project that raises this kind of question. If people are focusing too narrowly on the zero-energy goal, "they are going to want to minimize the surface area of the perimeter," effectively creating



Photo: Lincoln Barbour Photography

At Discovery Elementary in Virginia, the architects pushed for a higher glazing percentage than the engineers advised because they believed it was crucial for the quality of the school's learning environment.

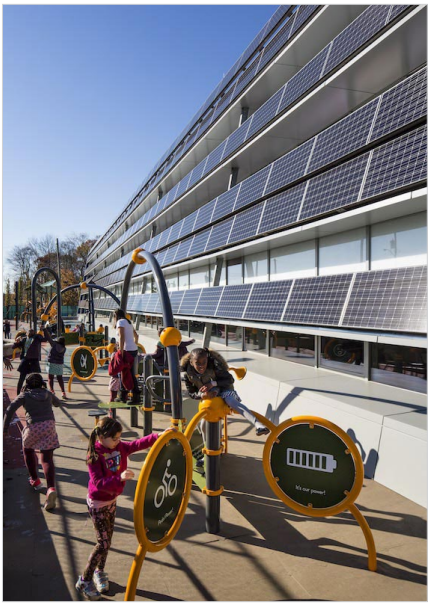


Photo: James Ewing, courtesy of SOM

At the Kathleen Grimm School for Leadership and Sustainability in New York, the solar panels wrap down along the building facade adjacent to the playground.

a box. "Is that going to be the best educational space inside?" he asks.

Ventilation is another area where a net-zero-energy goal may be at odds with an ideal learning environment. In MacArthur Elementary in New York, the AshleyMacGraw team was tempted to do "pure" on-demand ventilation, because it would save energy and—the engineers argued—have minimal impact on air quality. The state, however, had guidelines calling for continuous operation at minimum set points. There isn't good data about what should be considered optimal ventilation (see Clean, Fresh Air: Getting What We Need), so theoretically any amount of cutting back on ventilation might be criticized as negatively affecting indoor environments. One engineer who works on net-zero-energy buildings anonymously told BuildingGreen that he consistently ventilates under ASHRAE Standard 62.1 and still sees CO_2 peaking only around 800 parts per million (1,000 ppm is generally considered the maximum threshold). Net-zero energy goals could sway practitioners to make such decisions, but as long as actual air quality is measured to be at least as good as the benchmarks on which the Q are based, it is difficult to cast a judgmental eye until there is clearer evidence on how much fresh air is best for human health and productivity.

Putting net-zero energy into context

Though McGraw believes these tensions exist, he trusts they can be overcome if designers commit to multiple aspects of high performance. On the MacArthur school, net-zero energy was just one of five goals for the process—the others revolved around creating an effective educational environment, developing a safe and welcoming place for the community, and restoring the school's relationship with the river (the previous school on the site had been flooded in Tropical Storm Lee and Hurricane Irene). And in fact, ultimately, the project did not achieve net-zero energy, because not enough solar could be accommodated on the roof, even to offset MacArthur's very low energy use intensity (EUI) of 23 kBtu/ft².

"We could have had net-zero energy if we had put in covered parking and solar panels above the parking lot, but there were urban design aspects that we wanted to incorporate in the neighborhood," said McGraw. "At the end of the day we have to solve more than just energy. We have to ask whether there is a social cost to putting a lot of PV on everything."

Other design teams agree that net-zero energy shouldn't be the be-all end-all for the overall project. For the Martin Luther King Junior School in Massachusetts, the design team was challenged with designing a 660-student school on a very small building lot, requiring four stories. "We knew that there was not going to be an appetite for covering 50% of the site with photovoltaics. We would have been taking away the playground," said Jana Silsby, associate principal at Perkins Eastman. All agreed that they could not compromise the function of the school, but the Cambridge district still wanted to take energy use seriously. "So we developed the design as if we were going for net-zero energy and we did the best we could." They had ten days of net-zero workshops and user group meetings to discuss behavioral change.

In the end, the school's EUI came in above the 30 kBtu/ft² goal (more on this later), but a post-occupancy evaluation indicates that the project was very successful from a user standpoint. Almost all survey respondents agreed that the design of the school building creates a pleasant place to work and learn, and teachers reported 66% greater satisfaction with visual comfort compared to their old classrooms. Furthermore, having gone through the net-zero energy analysis process, Cambridge still wants to make its next school (which will have more site area) net-zero.

Although McGraw believes a net-zero-energy goal should be placed in context, he still thinks that it is the most logical way to approach the energy side of design. "For us, we are trying to make net-zero energy part of our design process—the way we should always think about energy." And for the client, it was a simple concept to rally around compared to LEED, which attempts to balance energy targets with other parameters. "LEED has a ubiquitousness, but it is hard for people to define. They kind of know what it is, but they also don't," said McGraw.

The element of success

Though the biggest criticism of net-zero energy is that it is *just* about energy, when BuildingGreen spoke to project teams about why their net-zero-energy school projects were successful, the answer was often that the pursuit of that goal led to something else. For some it was about advancing the industry and beginning to tackle actual performance instead of predicted performance. "As designers we are used to doing the design phase portion but then moving on when the building is actually built. With zero energy, how you gauge success is by tracking into operations," said Calvin Ahn, of AshleyMcGraw, who was also involved with MacArthur.



Photo: Falcon View Aerial Photography

At MacArthur School in New York, the roof area alone was not able to accommodate enough solar panels to enable net-zero-energy performance, but the design team did not want to sacrifice other communal spaces simply to meet the energy goal.

For others, the fulfillment of a clear goal was a source of inspiration that had unforeseen ripple effects. "Once you start that process of getting everyone to ask 'Why not?' then the doors kind of open," said Knox. "I don't think that the principal and the teachers and the students would be teaching and learning in [Discovery] the way they are if that fundamental mindset hadn't been there." The AshleyMcGraw architects agreed. "I feel like building these schools gives these kids another thing to think about—a way to do things better," said McGraw. "What you're really establishing is a way for kids to have a reciprocal relationship with their school," said Ahn. They are used to a one-way interaction where they constantly receive knowledge from the school through their teachers, but in a net-zero-energy school they learn that their actions contribute to the school's performance—that there's a two-way interaction, he says.

These elements extend beyond the fact that the building can be used as a "teaching tool" in a specific math or science class about solar usage. The ultimate product is a physical manifestation of choosing a meaningful goal, making the right choices to achieve it, and then continuing to learn from the process. Like any design concept, net-zero energy could be pursued to such lengths that other things might be compromised. But many of the designers that BuildingGreen spoke with were wrestling with tradeoffs and integration to keep the big picture in view. That is what design is all about, and it embodies what learning is all about. What could be a better outcome for a school?

Facing the school board

Net-zero-energy schools might make sense from all these practical and mission-driven angles but, in the case of public schools, the ultimate gatekeeper is likely to be budget-strapped districts worried about financial payback. And yet, according to successful project teams, this pressure for fiscal responsibility often made school boards their biggest proponents.

Separate pots of funding

In public school budgets, capital costs are distinct from operational funding. Most school districts raise funds for building projects through bonds, which might be supplemented by grants from the state. Local voters approve a bond amount, investors purchase the debt, and then the municipality uses property taxes to pay back the loan. Capital projects are infrequent events that taxpayers usually approve before design.

Money that is obtained through a bonding process can't be used for operational expenses, so it doesn't directly compete with paying teacher salaries and purchasing student supplies (although, ultimately both pools of money draw from local taxes and thus depend on residents' tolerance for tax levies). Paying for high energy bills, however, does compete with other expenses and the drain on resources is significant. K-12 schools in the U.S. spend $8 billion annually on energy, according to the U.S. Department of Energy, more than on computers and textbooks combined. Since operating budgets are approved annually, they are more subject to the whims of public pressure. Whatever is left over, after the energy bill is paid, is fought over fiercely.

For this reason, school districts—especially ones with good borrowing power—are highly incentivized to pay a little more upfront if they can reduce their long-term operating expenses. All of this sets the stage for designers to make a good argument for net-zero-energy; the goal essentially reduces the ongoing cost of energy bills to near zero and shifts the cost to an upfront payment on a solar array with a predictable payback period. Most districts use the



Photo: Dana Sohm, courtesy of VCBO

Total construction costs for Odyssey Elementary in Utah amounted to a total of $19,609,700, only $9.58/ft² more than a conventional school in the same county.

operational money that is saved on teacher salaries. "We really use that as a reason to do schools this way," said Stanfield.

Stanfield's first net-zero school, Richardsville in Kentucky, saves $1,170,000 a year in energy costs compared with an average Kentucky school. It also generates an additional $1.5 million in revenue from solar power that it sells to the utility as part of a program that offers $0.12/kWh more than the going rate. The cost of the solar array pencils out to a simple payback of 15 years, which is funded through the bonded capital budget. But, the school district doesn't have to wait 15 years to start seeing the financial benefit—$2.6 million more per year is available immediately because the energy cost savings are attributed to the operational budget instead of going back into the capital budget. The cost and the return are accounted for in separate pots of money.

The financial model of a net-zero-energy school must be successful if it checks out from a developer perspective, and it does, according to Robbie Ferris, president of SfL+a and its sister development company Firstfloor. Ferris was hired to design Sandy Grove Middle School in Lumber Ridge, North Carolina. The district had pulled together the capital for a school, but it estimated that a new building would cost $1.5 million in annual operating expenses, while their budget could only accommodate $450,000 annually.

Ferris determined that Firstfloor could make a profit if it owned and built a net-zero-energy school and leased it back to the district. The district pays only what it is able—the budgeted $450,000 per year on top of rent—but that ends up being a decent margin for Ferris given the very low actual utility costs that net-zero-energy brings. The deal went through and because Ferris retains ownership, he continues to enhance his profits by driving down energy use in operations. SfL+a is now involved with designing five net-positive-energy schools for Horry County in North Carolina.



Photo: David Kurtis

Warren Construction helped keep costs low for The Friends School of Portland in Maine by assuming all the risk for the air sealing performance instead of passing it on to subcontractors who might have raised their rates.

It is worth noting that the financial model of many of these school projects relies on relinquishing renewable energy credits in return for utility incentives or as a part of a Power Purchase Agreement (see How RECs Work—and Why You Might Not Own Your Clean Energy). Technically, if one were going by the DOE's definition of a zero-energy project, this would mean the project couldn't claim to be a net-zero-energy building. Since the project is effectively selling the right for someone else to claim they are using renewable energy, it would be "double dipping" to also claim that the school is net-zero energy, according to Paul Torcellini, Ph.D. PE, principal engineer with the National Renewable Energy Laboratory. This distinction is meant to protect from Federal Trade Commission rules against greenwashing, but from BuildingGreen's perspective, the larger issue by far is that of projects claiming to be net-zero energy without having actual performance data to prove it.

No need to oversell

To shift costs from operations to upfront capital, the public often needs to be convinced to pass a higher bond measure, right? In many cases, they don't need to. Several project teams sidestepped this issue altogether by delivering a net-zero-energy school within the budget established by an original bond measure.

Most bond measures are passed before a design is fleshed out. In the case of Odyssey Elementary, "The bond was passed in 2009 without any conversation about net-zero energy," Bryan Turner, AIA, told BuildingGreen. "The idea for zero-energy and LEED certification came about during the design process and was presented to the board at a later date. It was unanimously accepted."

The same was the case with Discovery Elementary. The school presented the design team with a budget based on achieving LEED Silver and the team figured out a way to achieve net-zero with those resources. "We didn't really make a big deal out of it because we didn't come back and ask for more money than the original budget. No one was really going to argue against energy efficiency if it would help the school save money from day one," said Knox.

Knox found that the community he was working with was more concerned about other aspects of the project, such as how the school

was going to impact the feel of the neighborhood. "In some ways letting it ride a little under the radar might have even helped us some."

To meet budgets, projects need to maximize the energy efficiency of the building in order to reduce the cost of the PV array. Several teams told BuildingGreen that they used a concept of "photovoltaic offset" to test every decision. Does an energy-saving upgrade like increased insulation or better glazing cost less than buying the photovoltaics to produce the same amount of energy?

For the most part, this strategy prevents expensive solar panels from being plastered onto a poorly designed building, but there are some circumstances where more solar panels turns out to be the less expensive choice. On Discovery, the design team was analyzing whether upgrading from double- to triple-glazed windows would be prudent. The window upgrade was estimated to cost $110,000 more, while the difference in energy performance could be made up in a few added solar panels costing only $9,000, according to John Chadwick. "That was a fairly easy decision. We knew it would be worth buying a few more panels if we had space for them, or upgrading to higher efficiency [panels] if we didn't." This process kept costs low enough that the team didn't have to request a budget increase to meet the goal.

Resisting the urge to oversell the concept of zero energy could help with other stakeholders as well. On the Friends School of Portland project, the contractor was worried that some subcontractors might be intimidated by the performance goals of the project and decide not to bid or increase their contingency cost because of perceived risk. Therefore, the contractor decided not to emphasize the net-zero-energy nature of the project to subcontractors during procurement, and instead took on responsibility for all the air sealing himself. "It fell to the general contractor to police the project very carefully, but it was part of why we were able to keep costs down," according to Jesse Thompson, principal at Kaplan Thompson.

It might be assumed that proselytizing about energy efficiency is a pre-requisite for taking on a project with such ambitious energy goals, but these teams found it was more effective to hunker down, do the work, and let a successful project speak for itself.

Minimize demand charges

When jumping on board with net-zero energy, school officials sometimes assume that the school will have hardly any utility bills, so they are surprised when the bill arrives. Even at Discovery Elementary, which is energy positive, the school was charged $17,640 in the first year—a significant decrease from the average $118,580 that it takes to run a school in the district, but still not zero. Two policy trends are making this a more common occurrence: very strict demand charge policies and net metering fees.

At the Friends School of Portland, which is one-sixth the size of Discovery and currently operates at a net EUI of 3.67 kBTU/ft², total operating costs amounted to $12,344 in the first year, including the fee for the Power Purchase Agreement. An estimated half of that is from demand charges (a charge based on the highest rate at which one uses energy at a given time), according to the project team. "We've recommended that the facility manager not set back the temperature at night because the demand spike is so intensive in the morning," said Thompson.

The MacArthur Elementary team has faced the same challenge. "In New York, if your building over consumes during any 15-minute period, you'll be charged the demand fee for the whole month," according to Ahn. The district was familiar with how extreme the demand charges could be and requested that a gas boiler be included in the project to provide back-up heat if needed at peak hours. Other districts have requested the same thing, like Davis County where Odyssey is situated.

On projects that don't use back-up gas boilers designers are "thinking about how a building itself can act as a battery and store energy," according to Ferris. At Sandy Grove in North Carolina, peak loads were projected to be 450kW, but Ferris has managed to bring peak demand down to 250kW. "It's all about optimizing start times," he said. "It is a simple concept, but hard to figure out," and only made possible through extended commissioning and continued optimization.

The concept of the building as a battery inspired the use of insulated concrete forms (ICFs)—polystyrene blocks filled with concrete—in the Kentucky schools where Stanfield operates. This wall system has a relatively high "steady-state" R-value because the concrete that is partially inside the thermal envelope serves as thermal mass when outdoor temperatures fluctuate above or below the indoor temperature, which can help dampen demand charges (see BuildingGreen's product guidance on specifying Insulating Concrete Forms). CMTA Engineers, the company that has designed ICFs for multiple net-zero-energy schools, has been gradually tweaking its thermal models because they noticed that schools built with the system continuously outperformed their expectations.



Photo: U.S. Army Corps of Engineers. License: CC BY 2.0.

Some net-zero-energy schools have used insulated concrete forms, shown here, to better float indoor temperatures through the night and lower morning demand charges.

Verified Net-Zero-Energy School Buildings

School	Location	Architect	Year Completed	Site EUI kBtu/ft2•yr	Net EUI kBtu/ft2•yr
Sandy Grove Middle School	Lumber Bridge, NC	SfL+a	2013	24.4	-10.1
Locust Trace AgriScience Campus	Lexington, KT	Susan Hill, Tate Hill Jacobs	2011	9.4	-0.7
Lady Bird Johnson Middle School	Irving, TX	Corgan Associates	2011	17.0	0.0
Richardsville Elementary	Bowling Green, KY	Sherman Carter Bernhart	2010	19.0	-2.6
Discovery Elementary	Arlington, VA	VMDO Architects	2015	16.2	-0.7
Odyssey Elementary	Woods Cross, UT	VCBO Architecture	2014	15.0	-3.3
***Sacred Heart, Stevens Library**	Atherton, CA	WRNS Studio	2011	16.9	-12.2
***Hood River Middle School Music Building**	Hood River, OR	Opsis Architecture	2011	20.3	0.3
***Hawaii Preparatory Academy Energy Lab**	Waimea, HI	Flansburgh Architects	2010	11.0	-17.0
***Bertschi School: Living Science Wing**	Seattle, WA	KMD Architects	2011	48.1	0.0
***The Putney School Field House**	Putney, VT	Maclay Architects	2009	9.7	-0.8
***Willow School: Health, Wellness and Nutrition Center**	Gladstone, NJ	Farewell Architects	2015	21.8	-13.1

*These are wings or buildings that are part of a larger school complex

Source: Adapted from research performed under contract of National Renewable Energy Laboratory

This table shows the number of net-zero-energy schools known to the Department of Energy that have been verified with actual performance data.

The same system was recently used for Discovery Elementary in Virginia. Architect Wyck Knox points out an interesting side advantage that might be useful for any energy efficient project. "Since ICFs are part of the structural system, it is less likely to be value engineered out." When looking for cost savings, it is easy to reduce cavity insulation by one or two inches, but changing the thickness of ICF blocks would force the whole project to be re-engineered, he said. As a result, the design of the envelope system—arguably the most high-impact system for energy efficiency—is more likely to survive value engineering. A similar benefit might exist with structural insulated panels (SIPs).

Depending on location, net-metering usage fees could also add to a net-zero-energy school's monthly bill. About 30 states are considering proposals by utilities to increase fixed charges on grid-tied solar installations, arguing that customers producing their own energy aren't contributing their share to maintain the grid (see Solar Homes Slapped with Fee by Arizona Utility).

"The utilities are really floundering in responding to a changing environment," said McGraw. "They are trying to hold onto their traditional business models and getting really crazy about how they are charging people who are generating their own energy."

For both of these reasons, Stanfield said, "We would love to see a situation where a school wouldn't have to be grid-tied. At the scale of a school, we just haven't found a way of doing it yet." In the meantime, it is worth discussing these issues with district officials so that they are not blindsided by unexpected costs.

Early Lessons Learned

The Department of Energy has counted 89 schools marketed as net-zero energy, but only 12 of those have been verified with actual performance data. (And performance data is increasingly important to making a credible net-zero claim: the New Buildings Institute runs the Getting to Zero Database and the International Living Future Institute now runs a Zero Energy Certification, both of which rely on data.)

The rest of those 89 schools fall into one of these categories:

- The majority were promoted as net-zero energy but never obtained the funding for the needed solar array and thus are really net-zero energy *ready*.
- A portion of these unverified schools might actually be operating at net-zero energy, and for one reason or another DOE researchers weren't able to track down the data (as a paid DOE researcher, BuildingGreen is familiar with the obstacles: architects might not be tracking operational performance and districts are forced to request consumption data directly from their utility if their energy bill only shows a net reading).
- The remainder were able to obtain the amount of solar that the design called for, but the building consumes more energy than was predicted so the project hasn't yet met its goal.

At least seven projects fall into this last group, indicating that a significant proportion of projects that aim for

net-zero energy end up missing the mark. This should be expected from a group of projects that are on the leading edge of a very new trend. But as net-zero energy becomes a more widespread goal, future projects shouldn't make the same mistakes twice.

Extended programming

Not all schools have the low energy demand that makes the building type generally so attractive for net-zero energy. Urban schools—especially those in heavily populated districts—often have extended hours of operation. Such was the case at Dr. Martin Luther King School in Massachusetts, which operates from 6:00 a.m. to 11:00 p.m. and continues to stay open over the summer, serving as a hub for multiple community functions. Combine that with a high occupancy requirement on a small urban site, and net-zero energy became unachievable. "Most projects that are talked about are so small," said Silsby. "I wish there was more of a focus on big ones that are struggling instead of small ones that are achieving."

Even if a school is not initially expected to have summer programming, lower operating costs may make it tempting to transfer those programs from other schools. In Davis County, all summer activities are now directed to the schools with ground source heat pumps, because those systems allow the district to delay starting up the cooling tower. Odyssey Elementary thus now hosts programs for a few weeks during the summer. The school generates excess energy so the added programming hasn't threatened its net-zero-energy status, but even more programs might come to the school next year. "With Odyssey over-producing we don't want to give that power back to the utility," said Anderson. "We want to keep it in the district's buildings." Even if Odyssey no longer performed at net-zero energy because of more programming, the project wouldn't be a failure. It would merely demonstrate the success of a building being so well-loved that it can't meet that target any longer. Such a building might be brought back into compliance anyway by adding more PV.

Culture change

It is no secret that building performance depends heavily on occupant behavior—some estimate it can account for up to 50% of a building's energy load (see Design Strategies for Occupant Engagement—and Why They Boost Performance). "Your numbers will not be good if you don't have champions," said Stanfield. "In a school, you have to get the kids to be your champion."

It might be surprising, however, how seriously teams have taken this to heart in order to achieve net-zero energy. At Discovery Elementary the principal took into account openness to adhering to the energy efficiency policies and excitement about incorporating aspects of the building into teaching curriculum when she was hiring teachers and staff.

On the part of designers, many have devoted hundreds of hours to customizing energy dashboards. While working on MacArthur Elementary, Ahn worked with a dashboard developer to make sure the graphics that would be displayed would be relatable to their young audience. "When you looked at the dashboard initially, it was very static and informational, like a clock. We wanted to find a way to make it engaging over the long term—to really communicate how the building lives," said Ahn.

The team came up with a dashboard that is voice-activated and has a personality. His name is Arthur and on any given day his mood changes based on the energy use of the building. Arthur can answer a large range of questions about why he is happy or sad, allowing children to discover for themselves what's at the root of good or bad performance. Teachers and the school board eventually bought in, and other educational programs that were appropriate for each school grade were installed. Pentagram, the software developer, is now in discussions with Google about how to scale up the product for other schools.



Photo: John Griebsch Photography

The energy dashboard at MacArthur Elementary uses a custom-designed software that also includes age-appropriate games related to the school's curriculum.

Training and simplicity

It is not just about commissioning or post-occupancy evaluations: net-zero-energy schools need constant monitoring. "High performance-buildings can't just be set-it-and-forget-it," said Raynor Smith, P.E., of Spring Creek Middle, one of Robbie Ferris's more recent net-zero-energy projects in Wayne County. "Even



Photo Still: StoryShop Films

At Discovery Elementary in Virginia, the ground-source heat pump system is distributed with 58 of these residential-sized units serving different parts of the school.

after thorough commissioning things change or aren't as anticipated during design." One year after commissioning at Spring Creek, it was found that the science room exhaust fans were set to run continuously and that some of the solar inverters stopped working, hurting production numbers and leading the building to narrowly miss its net-zero-energy target. "It is critical that high-performance buildings be continuously monitored and optimized," said Smith.

At Odyssey Elementary, the district hired EnerNOC, an energy management company, to train staff not only to run the building management system, but also to document ongoing energy tracking and maintenance histories so that lessons would not be lost with personnel turnovers. The district also has a robust energy committee that audits every power bill and makes recommendations to the school board. But even with savvy staff and an embedded culture of energy use awareness, it is sometimes a struggle to glean useful information, according to Doug Anderson, director of utility services at Davis School District. Odyssey has submeters for many of its systems, which leads to lots of data. "You have to really think through how you are going to use that data, and how you are going to report it properly," said Anderson.

Another strategy for ease of operation is to focus on maintainability. At Discovery, the ground-source heat system is distributed through dozens of small heat pump units instead of having one large central unit. This allows for different parts of the building to be turned on or off based on the need, according to Knox, but also "there's a much broader array of people in the workforce who have the skills to work on residential-sized heat pumps versus a boiler or a chiller." Reducing the school's dependence on specialty services will make servicing the system much easier. Furthermore, the units are purposefully floor mounted so that they are easy to access. "If you want clean air in your building, you have to make it easy to get to the filters," said Knox. "Architects can be bad about that. We want to shove all that stuff behind the ceiling."

So far, these little steps seem to be working. "One thing that Arlington always tells us about this building is that the green lights are always on," said Knox, referring to the indicator lights for each system on the building automation system. The lights would turn red if a facilities person had overridden the automation controls to solve some problem or occupant complaint. If too many lights turn red, the automation system becomes useless and it is difficult to identify the source of creeping energy usage. "Being able to operate things in a simple way is absolutely key to being able to keep energy costs down," said Knox.

Teaching the industry

In the context of schools, net-zero energy is proving to be both aspirational and achievable. In most cases it is technically feasible, practical, and fiscally responsible. It makes sense from many perspectives, as demonstrated by the various professionals who have set these projects in motion. Critics are right to point out that good design is more holistic than simply net-zero energy, and in schools especially, it is important to keep a watchful eye on how such goals impact daylight and air quality.

But there is much more to net-zero-energy schools than the energy savings. As schools are transformed, more students will learn in a space that embodies in its very form the achievement of a difficult goal. And the industry will learn a little more about how design correlates with actual performance in real classrooms. In this way, the concentration of net-zero energy strategies applied on K-12 facilities is teaching the industry important lessons about good design and real-life operations.



Photo: Dana Sohm, courtesy of VCBO

At Odyssey Elementary in Utah, more summer programs are being routed to the school because the building is so inexpensive to operate and because students simply enjoy being there.

NEWS ANALYSIS

Case Study: Structure Tone Headquarters, New York, NY

Well-being at Work: The first WELL-certified project in New York City supports employee health and promotes collaboration.

by James Wilson

When Structure Tone, a construction management and contracting company with offices around the world, decided to move its New York headquarters into a new space, it wanted to make an investment in support of its most valuable resource—people. The company's new office at 330 West 34th Street is the first project in New York City to achieve WELL certification and provides a workspace that supports a culture of healthy living and collaboration. Now happily situated in its new office, Structure Tone says the project—far from being a financial risk—was an excellent investment, and that the company will be advocating for the rating system with its clients.

Designed to feel good

The 82,000-square-foot office space received a Silver rating by incorporating features like filtered air and drinking water, circadian lighting, sit-stand desks, enhanced acoustic insulation, and finishes that contain low levels of volatile organic compounds (VOCs).

Key Parameters

Location: New York, NY
Completed: 2016
Gross area: 82,000 ft²
Program: Office

Team

Architect: Gensler
Owner: Structure Tone
Engineer: Robert Derector Associates
Consultants: Cerami (acoustics); HDLC Architectural Lighting Design (lighting)
General Contractor: Structure Tone
WELL AP: Jennifer Taranto, Structure Tone



Photo: Michael Verzella/Structure Tone

The central open stair promotes active circulation through the space.

A central open stair—the project's most striking architectural feature—connects the two floors of the office, encouraging employees to engage in physical activity as they circulate through the office. An onsite "WELL café" provides employees with options for healthy snacks and prepared meals, and an automated health profile system allows employees to track their diets and learn to make more nutritional choices. The company also offers employees subsidized memberships to a local gym and to CitiBike, New York's bike share program.

Having visited the project in person, BuildingGreen can report that measures taken to enhance acoustic and visual comfort do contribute to a sense of balance and calm throughout the space. Daylight is maximized, especially in the open office areas, which are not vast expanses of desks but are divided and arranged to create a series of well-scaled, neighboring spaces. The color and reflectivity of the finishes contribute to the quality of the interior light. James Donaghy, the company's chairman, noted the effect these design features have on his mood and energy level, describing how, at the end of the workday, he leaves the office feeling lively and alert rather than fatigued.

Donaghy says he not only feels better while at work, it's also affected his habits in other parts of his life. For example, he finds that he's more conscious of selecting foods that will make him feel well and avoiding those that don't. He notes too the impact on the culture of the office. Not only do the employees feel better, there's also a heightened sense of community and collaboration.

Cost per person

For leasing reasons the company had to move to its new space quickly and did not initially target WELL certification. The accelerated project schedule meant that added-cost features were given only brief consideration. However, when it became clear how WELL certification would impact employee well-being, there was a sudden shift in perception—what had been understood as just an added cost was seen instead as an investment. The decision was made even easier when the additional cost was expressed in terms of cost per person rather than cost per square foot.

Jennifer Taranto, director of sustainability at Structure Tone, added, "The way that the WELL certification spoke to the culture of our company and what we were trying



Photo: Michael Verzella/Structure Tone

The onsite "WELL café" is equipped with an automated health profile system that encourages more conscious eating habits.

to do and be in our new space—and the benefits to the employees in the space—that part I felt was a really robust argument that turned their heads at the end of the day."

Donaghy notes that, when compared to total personnel costs, the added cost for WELL certification was "pennies," ($0.99 per employee per day) and that though there are ongoing costs relating to maintenance—such as replacing filters—the cost per person is expected to decrease each year of operation. Taranto reports that certification ultimately required a 0.66% increase in hard costs—an additional $1.10 per square foot—mostly to cover non-conventional items like carbon dioxide sensors, special signage, task lighting, and additional noise remediation.

It took a team

Both Taranto and Donaghy stress the importance of a robust, integrative process. "Because of all of the different systems, and all the different parts and pieces that have to go into place, there's no way that you could do it without including all the stakeholders—it's just not possible," Taranto told BuildingGreen.

The integrative approach was also essential to controlling cost. By working with the entire team to establish a clear plan and budget at the outset of the project, the company was able to keep added costs low.

The involvement of a wider range of stakeholders also helped the project team overcome specific challenges. As a tenant in an existing building, the company inherited an existing air handling unit. To meet filtration requirements, the project team relied on close coordination with the base building facilities staff. Another big challenge had to do with the Nourishment feature. In order to meet the requirements, the project team had to work very closely with the food vendor (and the vendor's various suppliers) to verify ingredients and curate a wholesome food selection to stock the onsite café.

After construction, the verification part of the certification process was aided by the involvement of the WELL Assessor. Working closely with the assessor provided more clarity about the requirements and procedures than what the team was used to on LEED projects. "WELL behaves in the way that everyone wishes LEED did," Taranto said. "It's the openness and transparency all the way through the process that's a huge benefit," she explained. "Knowing this can alleviate some of the anxiety going into performance verification."

Becoming an advocate

Taranto said the effects of the WELL certification process have "transcended the one office" and "opened the door for conversations about new company-wide policies." The company is also exploring the possibility of certifying more of its spaces and many employees have expressed interest in becoming WELL Accredited Professionals.

In an effort to better serve its clients, the company has been surveying its end users about the barriers to incorporating sustainability and wellness into their projects. According to Taranto, the number-one answer is always cost, but now that the company has gone through the process of certifying its own project and has shown it can be done without much added cost, it can better advocate for wellness by helping clients to see past the "cost stigma." The company

Three Takeaways

1. By first experimenting with health and wellness features in their own spaces, design and construction companies can promote a culture of well-being in their workplaces while gaining familiarity with products, strategies, and rating systems—allowing them to implement these on client projects with greater efficiency and cost-effectiveness.

2. Project teams advocating for health and wellness features can frame the discussion around added costs as a "per person" rather than a "per square foot" investment. This puts the financial element of health and wellness features in the right perspective—after all, health and wellness is about the people, not the building.

3. An integrative approach can control the added costs of health and wellness features and certification. Strong project management that promotes transparency while fostering close collaboration and clear communication with consultants can help project teams to achieve quality design outcomes in an efficient, cost-effective manner.

also hosts project interviews in the new space as a way to demonstrate to clients both the immediate, visceral impact of designing for wellness and the company's commitment to the values it advocates for.

For more information

Structure Tone
structuretone.com

New Report Helps Leverage the Overlap between WELL and LEED

IWBI's new guidance reduces documentation for projects pursuing dual certification.

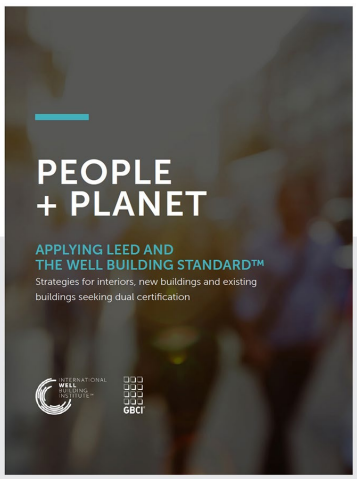
by James Wilson

A new "crosswalk" document aims to support the efficient, simultaneous application of the LEED Rating System credits and WELL Building Standard. The report—published by International WELL Building Institute (IWBI) in collaboration with U.S. Green Building Council (USGBC) and Green Business Certification Inc. (GBCI)—shows how LEED credits and WELL features overlap and align.

Which credits earn which features (and vice versa)

The document contains sections mapping out how LEED credits correspond to WELL "features" in each of the three LEED rating systems for new and existing buildings and interiors: BD+C, O+M, and ID+C.

Most helpfully, the document identifies which LEED credits and WELL features are considered "equivalent"—that is, credits and features in each system that can be used for full verification of a feature or credit in the other system. The promise here is reduced documentation. For example, if you've achieved a LEED credit that has been approved as equivalent to a WELL feature, you only have to submit the final scorecard and identify which credits are being used to claim features. The process is the same if you are using WELL features to claim LEED credits.



A new crosswalk document describing how WELL features and LEED credits are compatible is the first step in an ongoing process to harmonize the two standards and make it easier for project teams to pursue dual certification.

The document also describes which credits and features can be used for partial achievement of a credit or feature in the other system, as well as which credits and features are "aligned"—meaning credits and features that do not have fully equivalent requirements but that have similar intents.

In all there are 18 WELL features that can be fully achieved by earning corresponding LEED BD+C credits and an additional six features that can be partially achieved by earning overlapping LEED BD+C credits. In comparison, there are only a handful of full LEED credits that can be earned by achieving WELL features—and some of these require three or more features for complete equivalency. (We've created a graphic for quick reference that shows which credits and features overlap for BD+C projects.)

Project teams can use the crosswalk document during the kickoff and initial goal-setting phase to identify design strategies that will have the greatest impact across certifications, and to produce an integrated scorecard of LEED credits and WELL features to target. This can be a useful tool for understanding how certain project goals are interrelated and help the team to develop an efficient, integrative strategy for achieving these goals.

Complementary systems

Brendan Owens, chief of engineering at USGBC, told BuildingGreen that, though LEED and WELL are often perceived as competing systems, USGBC sees the two as interdependent. "We want to see project teams do a deep dive on issues that LEED will not be able to facilitate," Owens said, explaining how WELL complements LEED. He added that the crosswalk document is really only the first part of the process and that it "represents the things we could work on right now."

In the short term, the crosswalk is meant to encourage project teams already familiar with LEED and that use it regularly to integrate the WELL standard for a more holistic approach. "We really want to provide project teams a mechanism for deeper engagement around health-related issues," Owens said.

As LEED and WELL continue to evolve, USGBC and IWBI will work together to further enhance how the two systems interact. Owens encourages project teams using both standards to share their ideas for improving the relationship.

An ongoing process of harmonization

Rachel Gutter, chief product officer at IWBI, explained to BuildingGreen that the crosswalk is part of "an ongoing evolution toward making the systems interoperable." The idea is to encourage project teams to see the two systems as a single integrated approach. "Along with USGBC, we're striving for best practices—if we can harmonize systems, it will make it easier for users to pursue dual certification," Gutter said.

As the next version of the WELL Building Standard is developed, additional strategies for streamlining the process and the cost of dual

LEED and WELL Compatibility

Achieve these LEED Credits...	and earn these WELL Features
Bicycle Facilities (1 pt)	Active Transportation Support
Enhanced Commissioning (2 pts, or 5+ pts)	Air Infiltration Management
BPDO – Material Ingredients (Option2)	Enhanced Material Safety
BPDO – Material Ingredients (Option1)	Material Transparency
Minimum IAQ Performance AND EA Fundamental Commissioning and Verification	Ventilation Effectiveness
Environmental Tobacco Smoke Control	Smoking Ban
Enhanced IAQ Strategies (Option 2)	Increased Ventilation
Low Emitting Materials (3 pts)	VOC Reduction
Indoor Air Quality (1 pt)	Air Flush
Thermal Comfort (1 pt)	Thermal Comfort AND Individual Thermal Comfort
Interior Lighting (Option 2E + 2F)	Surface Design
Interior Lighting (Option 2A)	Electric Light Glare Control
Daylight (1 pt)	Solar Glare Control
Daylight (2 pts)	Daylight Modeling
Quality Views (1 pt)	Right to Light
Acoustic Performance (1 pt)	Reverberation Time AND Sound Barriers
Achieve these WELL Features...	**and earn these LEED Credits**
Smoking Ban	Environmental Tobacco Smoke Control
Solar Glare Control AND Low-Glare Workstation Design AND Automated Shading and Dimming Controls AND Daylight Modeling	Daylight (3 pts)
Ventilation Effectiveness	Enhanced IAQ Strategies (Option 2, 1 pt)
Healthy Entrance AND Air Filtration AND Direct Source Ventilation	Enhanced IAQ Strategies (Option 1, 1 pt)
Air Quality Monitoring and Feedback	Enhanced IAQ Strategies (Option 2, 1 pt)

Source: BuildingGreen, Inc. based on data from IWBI

Up to 18 WELL V1 features can be earned by achieving corresponding LEED BD+C credits, and achieving certain WELL features will earn select LEED credits.

certification are being developed. For example, there are plans to reduce the documentation burden on teams pursuing both certifications by introducing various technical functions that will integrate elements of LEED Online and WELL Online for a more efficient administrative process.

This interoperability with LEED will also extend to the WELL Community Standard—the district-scale version of the rating system that will soon be launched. Projects certified under the LEED for Neighborhood Development system will automatically be awarded all 10 possible Innovation features in the new system. This is meant to encourage communities that have acted to support ecological health to adopt a systems-based approach to sustainability by integrating strategies for human health.

For more information

International WELL Building Institute
standard.wellcertified.com

NEWSBRIEFS

Study Reinforces Carbon Benefit of Renovation

A new study of the U.N. headquarters demonstrates how retrofitting existing buildings is a critical strategy for addressing the urgency of climate change.

by James Wilson

When the United Nations planned the multi-year, campus-wide renovation of its New York City headquarters, it made sustainability a priority. The



Photo: Neptuul. License: CC BY-SA 3.0.

The decision to renovate the United Nations headquarters in New York City rather than demolish and rebuild it resulted in significant carbon savings, which were quantified by a recent study.

resulting project, completed in 2015, was designed and built to meet the equivalent of a LEED Gold rating and the iconic Secretariat Building to meet the equivalent of a LEED Platinum rating. But according to a new analysis, the greatest impact on sustainability stems from the decision to retrofit the existing buildings rather than demolish and replace them.

The U.N. study quantifies the benefits of this decision by assessing the carbon cost—both embodied and operational—of renovation compared with demolition and new construction.

The study (led by Michael Adlerstein, assistant secretary-general and executive director for the U.N. Capital Master Plan, and prepared by Vidaris, Inc. and Syska Hennessy Group) confirms that the retention of the structural components, opaque envelope, and core walls of the U.N. complex's existing buildings has resulted in significant carbon savings—both in terms of embodied energy and carbon emissions. The savings are substantial enough to not be easily offset by the more energy-efficient building operations of new construction.

The study was based on life-cycle analysis calculations and energy modeling. It found that, had the existing buildings been demolished and replaced with new construction, it would have taken 35–70 years to offset the associated carbon cost with the improved operating efficiency of new buildings.

The findings of this study gain further significance considering the critical timeframe that climate change confronts us with. As noted in the report, climate scientists believe there is a small window for stabilizing and reducing greenhouse gas emissions. This means that the extra energy and carbon required to replace existing buildings with new construction is counter-productive, especially when we consider the rate at which carbon is purged or reabsorbed from the earth's atmosphere. (Scientists estimate carbon's atmospheric life to be between 100 and 300 years—which means that the carbon burden of the original U.N. construction is still in the atmosphere.)

For more on the topic of the value of existing buildings and carbon, read:

- Building Materials and the Time Value of Carbon
- Historic Preservation and Green Building: A Lasting Relationship
- Raze or Retrofit? Six Extraordinary Answers to an Everyday Question

For more information

Vidaris, Inc.
vidaris.com

LBC Projects Get Head Start on WELL Certification

Describing how their rating systems complement each other, ILFI and IWBI encourage use of both certifications.

by James Wilson

There is no shortage of different tools, initiatives, and certification programs available to guide building professionals in the design and construction of healthy, sustainable buildings. Rather than creating competition, however, organizations like International Living Future Institute (ILFI) are creating partnerships and collaborating with other initiatives to transform the built environment. Recent examples of this include the relaunch of ILFI's Reveal label to align with Architecture 2030's new Zero Tool, and the organization's just-announced partnership with New Buildings Institute (NBI) to streamline the tracking and certification of zero-energy (ZE) buildings.

In the same spirit, ILFI has partnered with International WELL Building Institute (IWBI) to create a new crosswalk document explaining how WELL "features" and Living Building Challenge "imperatives" align.

The goal, as with similar crosswalk documents describing equivalencies between rating systems (see New Report Helps Leverage the Overlap between WELL and LEED), is to simplify the certification process by reducing the amount of documentation project teams must do to demonstrate compliance.

Project teams pursuing both WELL and LBC certification can achieve up to ten WELL features by meeting the requirements of certain LBC imperatives. Conversely, teams can use certain WELL features to contribute toward compliance with the requirements of 13 LBC imperatives.

Though WELL and LBC intersect in several places, the guide also



Image: ILFI

A new crosswalk document explains how Living Building Challenge and the WELL Building Standard intersect.

illustrates that there are many areas in which they do not—emphasizing why the two rating systems should be used in combination rather than interchangeably. Though LBC incorporates a number of requirements related to human health, it leaves out many things a project could do to achieve more in this area. There are more than 100 features focused on human health and wellbeing in the WELL Standard—a certified Living Building would earn only ten of these. As a system focused solely on the health of the occupant, WELL complements the more holistic sustainability concerns of systems like LBC and LEED.

For more information

International Living Future Institute (ILFI)
living-future.org

Workbook Provides Hands-On Exercises to Cultivate Integrative Design

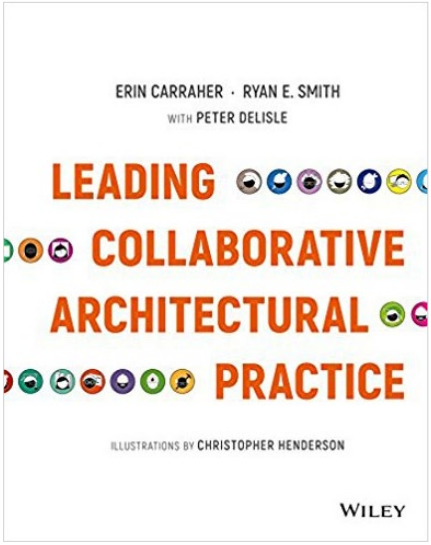
A new book offers practical guidance on how to foster a culture of meaningful collaboration.

by James Wilson

Architectural practice must react and adapt as technological and cultural change continuously disrupt established ways of working. As the tools, processes, and priorities of the building industry evolve, the profession has responded by adopting increasingly collaborative models of organization and operation.

In *Leading Collaborative Architectural Practice*, authors Erin Carraher, Ryan Smith, and Peter Delisle offer building professionals strategies for an integrative approach to architectural production and show how a culture of collaboration supports innovative design solutions.

The book follows a two-year AIA research project that focused on defining the particular values, attitudes, and abilities associated with effective project team leadership. A unique, practical resource, it is organized as a workbook containing hands-on exercises to help readers implement leadership and communication techniques.



Leading Collaborative Architectural Practice *(Wiley, 2017) provides practical tools for strengthening leadership and communication skills, leading to more effective collaboration.*

An example of the exercises included in the book is an activity intended to improve self-awareness. After introducing Luft and Ingham's "Johari Window" model describing categories of perception and how these affect communication, readers are guided through a real-world scenario and a series of reflection prompts. Another exercise focuses on building understanding of various types of feedback and how these motivate different types of behavior.

By developing team members' interpersonal skills, and promoting awareness and commitment in working relationships, these exercises can help foster a highly collaborative culture.

The book also includes case studies illustrating the successful strategies that real-world firms have implemented on a variety of projects. Descriptions of the particular leadership and communication dynamics of different project teams show readers how to develop and reinforce collaborative modes of practice.

In addition to discussing practical matters of successfully managing integrated project teams, the book also raises the question of what it means to facilitate integration at all levels of an architectural practice and how this can transform the organization's work—and even, potentially, its mission.

For more information

John Wiley & Sons, Inc.
wiley.com

GreenScreen Launches Certification for Textile Chemicals

The hazard assessment program jumps into the certification business to promote textile chemicals with reduced health hazards.

by Candace Pearson

Clean Production Action recently tossed its hat into the ring of those attempting to recognize whole formulations with greener chemistries by releasing Greenscreen Certified Standard for Textile Chemicals. The certification relies on GreenScreen, the hazard assessment framework



Image: Clean Production Action

There are three levels to the new GreenScreen certification for textile chemicals, which are based on performance indicated by the GreenScreen List Translator and GreenScreen for Safer Chemicals assessment tools.

behind Health Product Declarations and other transparency programs. Now the framework will feed into the organization's own suite of certifications.

Greenscreen's first certification is limited to textile chemicals. It was chosen because of demand from the apparel industry, Mark Rossi, Ph.D., executive director of Clean Production Action said during a webcast about the certification's launch. (The only chemicals currently certified are made by Garmon, a denim supplier.) But demand from one industry might serve another if this certification it becomes a useful addition to the few other certifications that apply to woven fabrics used for upholstery or interior design—products that have a troubling environmental and social-equity record.

To be certified, a textile chemical must meet the requirements of the Zero Discharge of Hazardous Chemicals Group B Manufacturing Restricted Substances List and report all intentionally added substances as well as impurities greater than 100 ppm. Once that criteria is met, there are three levels of certification that become increasingly more rigorous, both in terms of the level of hazard permitted and precision of the evaluation required:

- Bronze: Contains no chemicals with an LT-1 score
- Silver: Contains no BM-1 chemicals as assessed using the GreenScreen for Safer Chemicals method
- Gold: Contain no substances or impurities that have a GreenScreen score of BM-1 or BM-2

To understand these levels, see Understanding GreenScreen and List Translator Benchmarks. For comparison, Option 2 of MRc4 in LEED v4 currently requires that 25% of products by cost contain no chemicals with an LT-1 score.

Sustainable Development through Open-Source, Participatory Design

Alejandro Aravena wins Gothenburg Award for offering revolutionary strategies for social housing.

by James Wilson

The Gothenburg Award for Sustainable Development—based in Gothenburg, Sweden—recognizes organizations and individuals that contribute toward a sustainable future through work that conserves resources, develops greater global justice, or leads to systematic change.

Chilean architect Alejandro Aravena—who has suggested that "sustainability is nothing but the rigorous use of common sense"—is the first architect to receive the Gothenburg award. He is recognized for his simple, synthesized solutions for affordable social housing—identified by the jury as both an urgent contemporary issue and something that is crucial for sustainable cities.

Aravena's firm, Elemental, has become known for executing on the idea that building occupants should be actively involved in the design process rather than be perceived as a problem to be solved. In an attempt to address the economic challenges of providing quality housing for all, the firm has developed a concept of incremental, participatory design. Families move into a fully constructed "half" of a house that provides all the basic necessities of a dwelling—along with the foundation and framework for the building's other "half." With information and guidance from the architect, the homeowners build the remainder of their home themselves—as needed and as fits their financial situation.

This inclusive process empowers people and can help foster trust between citizens, business, and government—just one way in which Aravena and his colleagues are experimenting with architecture as a tool for solving social and political issues.

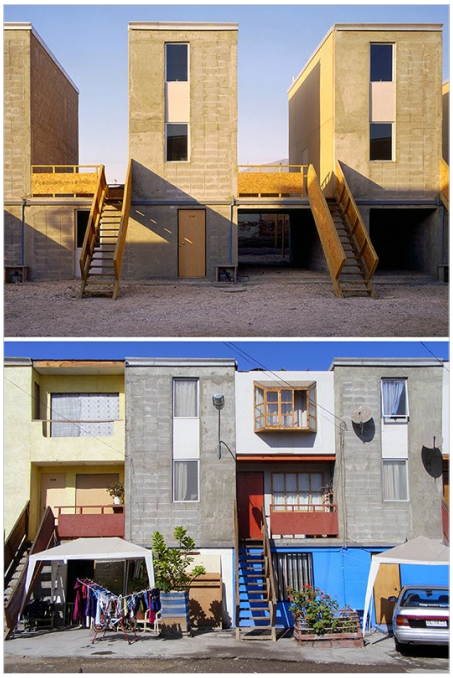


Photo: Tadeuz Jalocha

A view of the Quinta Monroy housing project in Iquique, Chile, before and after the families have moved in and expanded their homes.

The firm has also made the plans for four of their social housing projects available for download as an "open-source" tool for others to study. By sharing the drawings for these projects, the firm is trying to foster collaboration, and shift the ways markets and governments address the rapid urbanization happening at a massive scale around the world.

For more information

The Gothenburg Award
gothenburgaward.com

Mineral Wool Batts Now Formaldehyde-Free

Thermafiber and Roxul have introduced the first formaldehyde-free mineral wool batt insulations, following the example set by the fiberglass insulation industry.

by Brent Ehrlich

BuildingGreen has been asking for formaldehyde-free mineral wool insulation for years (see The Search for Better Insulation). In 1996, fiberglass batt manufacturers began replacing formaldehyde—a carcinogen and respiratory irritant (see our primer on formaldehyde)—with acrylic resins. In 2008, formaldehyde-free biobased resins arrived. And today, the entire fiberglass batt insulation industry is formaldehyde-free. Yet, somehow, the mineral wool insulation industry missed this trend and continued to use urea-extended phenol formaldehyde binders…until recently.

Thermafiber announced an industry-first, light-density, formaldehyde-free SAFB (sound attenuation fire blankets) batt insulation at the 2017 AIA conference in Orlando, Florida in April. And shortly thereafter, Roxul informed BuildingGreen that it too is offering a formaldehyde-free batt insulation, AFB EVO.

Thermafiber: same performance, safer resins

Thermafiber's new resin is formaldehyde-free and biobased, according to Gale Tedhams, sustainability director at Owens Corning, Thermafiber's parent company. The company claims it has removed all Red List chemicals from SAFB, and that it is being certified GreenGuard Gold and UL Formaldehyde Free. "We will be working on transparency information for documentation for LEED and other programs," Tedhams said, "but these are not published yet."



Image: Thermafiber/Owens Corning

Thermafiber's formaldehyde-free SAFB insulation provides the same performance as the company's standard products but has a darker brown color.

Thermafiber's formaldehyde-free SAFB has the same performance characteristics as its formaldehyde-based cousin and is available in the same dimensions: 1.5″–7″ thicknesses, 15″–25″ widths, and 48″ lengths (a higher density 1″-thick board is also available). Made from 70%–75% pre-consumer recycled content, SAFB resists temperatures in excess of 2000°F, has an R-value of 3.7 for its 2.5 pounds per cubic foot (pcf) density batt, and the 4″-thick batt has one of the highest noise reduction coefficients (NRC) in the industry at 1.20 (3.5″-thick fiberglass batt has an NRC of about 0.95).

Roxul AFB EVO

Roxul is also offering a similar formaldehyde-free product, AFB EVO. As with SAFB, the Roxul AFB EVO is a fire- and sound-attenuating batt. It too contains about 75% pre-consumer recycled content, and is available in either 2.5 or 2.8 pcf densities (depending on thickness). Available in 1″–6″ thicknesses, 16″ and 24″ widths, and 48″ lengths, AFB EVO has an R-value of 4.1 (for the 2.8 pcf), and an NRC of 1.10 (4″ thick). AFB EVO will also be certified Greenguard Gold and UL Formaldehyde Free.

Will future products be formaldehyde free?

The introduction of formaldehyde-free binders is an important evolution for mineral wool insulation, but it is likely to take some time before formaldehyde-based resins are replaced entirely. Rollout of formaldehyde-free versions will depend on making certain products meet current performance criteria. "Each product requires testing, and may also need further research to incorporate the non-formaldehyde formulation and maintain properties," said Tedhams.

Both SAFB and AFB EVO will be available in July 2017, with additional products coming after, according to the companies. Thermafiber says its formaldehyde-free UltraBatt products will be available later in 2017. In the meantime, both Thermafiber's SAFB and Roxul's AFB are still being made with formaldehyde resins, so design teams looking for formaldehyde-free products need to be specific with their specifications.

Do Living Walls Make for Cleaner Indoor Air?

Nedlaw Living Wall Biofilters do more than most green walls to remove VOCs, but it's unclear that they provide a true fresh air supply.

by Brent Ehrlich

Living walls, or green walls, can provide a powerful connection with nature in otherwise sterile urban interiors. But plants used as interior decorations have been consistently overhyped as tools for everything from cleaning indoor air to increasing productivity (see Bringing Nature Indoors: The Myths and Realities of Plants in Buildings). Worse, living walls have the potential to add CO_2 and excess moisture into a space, causing more indoor air quality (IAQ) problems than they solve.

Nedlaw has a long history of building successful living walls, having installed more than 30 systems over the years, beginning with its first (and still functioning) living wall in 2003 at the University of Guelph-Humbert in Toronto, Canada. The company's Living Wall Biofilter is different from other living walls because it incorporates a ventilation system behind the plants so that air is drawn through plants' root zone, where microbes break down volatile organic



Photo: Tom Arban Photography

Nedlaw's Living Wall Biofilter at Drexel University's LEED Gold-certified Papadakis Integrated Sciences Building is used as a living research laboratory, and at five stories tall is the largest Nedlaw system in North America.

compounds (VOCs) and clean the air, according to the company.

Anecdotally, there is a positive perception of air quality in spaces that use Nedlaw systems, but the company's performance claims have not been verified by independent, peer-reviewed research. Let's take a deeper look at the company's systems, and whether its claims hold up.

How does it work?

Nedlaw's biofilter is similar to other hydroponic living walls: water and nutrients, pumped from a reservoir at the base to the top of the wall, trickle down through growth media. It differs from standard living walls because its aluminum frame contains internal air diffusers and fans that pull air through a porous synthetic growth medium that contains plant roots and microbes (the system can be directly integrated into the building's central HVAC system). "As the air goes through, the contaminants are pulled out, and the contaminants are biologically broken down by the beneficial microbes," says Alan Darlington, Nedlaw's founder. The cleaned air flows into a manifold at the top of the wall and can be either blown directly into the space, moved through a dedicated duct system, or drawn into the building's ventilation system.

Costs and maintenance

Nedlaw makes custom systems engineered to suit each project's requirements, so costs vary, but Nedlaw says they run about $200–$300 per square foot installed, which includes a year of maintenance. The systems have other impacts as well. Lighting is critical for the plants' survival in indoor environments, so supplemental electric lighting might be necessary (hint, use LEDs). Darlington points out that moving the air also requires energy. Incorporating a living wall into the building's HVAC system increases the load on the ventilation but uses much less energy than a standalone system with fans—typically about 90% less, says Darlington. Ongoing maintenance for plants and other systems costs 10%–15% of the capital costs of the system per year, according to the company.

Does Nedlaw actually reduce VOCs?

Darlington stresses that it is the microbes on the roots that break down VOCs in the indoor air—this principle was verified by independent research as early as 1984. Verifying the effectiveness of the Nedlaw system through independent research is harder. A 2014 study by Darlington and researchers at the University of Guelph in Ontario, presented at the Green Roof & Walls Conference, reported removal of 47% of TVOCs (total volatile organic compounds) with one pass through the system under real-world conditions. The company's case study from the University of Ottowa's installation claims 80%–85% VOC removal. But, to date, there are no independent, third-party studies that verify these performance claims.

Drexel University has a Nedlaw Living Wall Biofilter and is using it as a living laboratory. The school did not respond to BuildingGreen's request for an interview and has not published system performance data, but we will keep an eye out for future studies from them. (Nedlaw notes that the system does not process chlorine or halogenated VOCs such as those in the air around indoor pools, as the microbes simply don't consume those.)

Because Nedlaw purportedly reduces indoor air contaminants, the company also claims that cool, humidified air produced by the system can replace outdoor makeup air—and the energy needed to condition it. The company

claims this can result in a 30% reduction in HVAC energy costs when using a fully integrated system.

The company has not fully explained how the Nedlaw system provides air that's equivalent to fresh outdoor air, however, since introducing fresh air not only reduces VOCs but also provides more oxygen and lower levels of carbon dioxide (see Clean, Fresh Air: Getting What We Need). Even though plants do consume CO_2 and produce oxygen, CO_2 levels can rise in a building with a living wall due to nutrients decaying and other factors, reducing its ability to meet fresh air requirements.

Birgit Siber, RAIC, is a principal at Diamond Schmitt Architects in Toronto, which installed the first Nedlaw living wall in 2003 and has specified 20 additional systems since then. Siber does not use Nedlaw specifically for fresh makeup air. "Our engineers prefer to stick to prescriptive requirements for air quality," Siber says, which means incorporating HVAC systems to bring in fresh air. Despite this, Siber says the walls do significantly augment the code-mandated fresh air, they have other positive indoor environmental impacts, and clients love them (more on this later).

Hal Levin, a researcher and building ecologist at Building Ecology Research Group, has studied the relationship between IAQ and plants, and is skeptical of a living wall's ability to clean indoor air. Though, as noted, the microbiology at the heart of the Nedlaw system is proven to consume certain VOCs, there is a complex interplay of water, nutrients, plant species, microbes, and photosynthesis required for this process to work effectively. Levin says introducing pollutants to microbes in the root zone is an inefficient way of removing them from buildings when compared with standard systems.

Make sure a living wall is right for your project

The Nedlaw living walls do provide a visceral connection to nature and help with sound attenuation, so they can become sanctuaries where people decompress from school or work. This can help attract and retain employees and students, says Siber, who notes, "There are certain clients that want them so much that they even survive terrible value engineering." Siber knows that her client's installations are augmenting the ventilation rather than replacing fresh air outright, but she claims that occupants report that the air feels better in the spaces that contain the Nedlaw system.

Living walls can thrive in buildings, but they require dedicated maintenance, requiring a serious commitment on the part of the building owner. And routine maintenance is critical since plants have to be trimmed and replaced; the system cleaned; lighting adjusted; pumps maintained; pests controlled; and water, nutrients, and waste products kept in balance. Failure to do any of these properly can lead to plant death.

Though Nedlaw's system is not a drop-in replacement for fresh air ventilation, teams willing to install and commission a Nedlaw system properly may just get some cleaner air along with their lobby centerpiece. But we encourage the company and others to get independent testing to verify the long-term performance and effectiveness of the system.

PRIMER

Product as a Service: Buying the Lumen, Not the Lightbulb

Proponents of the circular economy point to PaaS as one of the strongest tools we have to take control of our energy and material waste.

by Candace Pearson

What if instead of buying a light bulb you paid a company to provide you with light? That's the idea behind product as a service (PaaS)—a business model that could extend to any type of building product and seeks to bring about a circular economy.

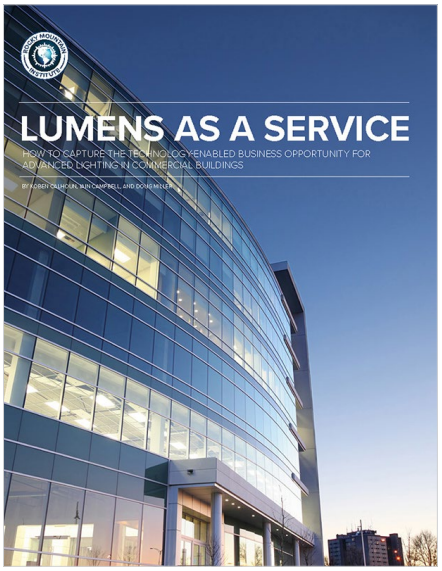


Image: Rocky Mountain Institute

Rocky Mountain Institute has published a report (Lumens as a Service) *describing the concept of "product as a service"—a business model that could revolutionize manufacturing and promote a circular economy.*

This is how it works. An owner specifies the desired performance level for a certain system. For lighting this might include illumination level, occupancy responsiveness, and maintenance obligations. Then a service provider chooses and installs a system that meets those specifications. In the lighting example, owners would choose lumens; providers would pick the luminaires.

The owner then pays a recurring fee to the service provider, including the price of the baseline energy cost to run the system. If the provider installs equipment or monitoring programs that enable the system to save energy over the baseline, then the energy savings go to the provider. The service provider also has the right to any additional revenue streams, such as incentives from utility demand-response programs or tax breaks for energy efficiency retrofits.

Laundromat style

Such an arrangement is similar to sending laundry to a cleaner. Instead of buying a washer/dryer, a laundry

service does all the work with its own equipment for a per-load fee. If the company upgrades to more energy efficient washing machines, it keeps the energy cost savings. The client doesn't have to worry about owning or maintaining his or her own equipment, and the service provider gets to keep more of its fee.

The deal is even better for the owner in PasS agreements because often a service provider will agree to pay "rent" for the right to install a given system in the owner's space. Or, the service provider will offer a share of the savings (essentially passing on some of the savings to the customer). Meanwhile, the building owner and tenants directly enjoy the ancillary benefits of any upgraded systems, such as better color quality as LED technology advances. (For an example, read about Brummen Town Hall in Circular Economy at Scale: Six International Case Studies.)

Creating circular material flows

The premise of PaaS works best with systems that might experience large jumps in energy efficiency—like lighting technologies—because service providers earn profit by realizing energy savings. Some have argued that such markets are limited. (How often do laundromats update their equipment to capitalize on the energy savings?) Another issue is training owners (or their design advisors) to set meaningful performance targets. Few owners know how to express their desires in lumens, and some performance expectations might not have an associated metric.

If such barriers are overcome, however, PaaS agreements could potentially bring many sustainability benefits.

Service providers are incentivized to choose highly efficient systems because they stand to gain from the energy savings.

The set-up also removes the motivation for manufacturers to design for planned obsolescence. Some experts have forecasted that PaaS agreements will save the LED market, which is facing constrained financial growth under the traditional model because the technology's markedly longer service life means consumers won't have to buy as many products. Providing companies a revenue over the entire lifecycle of their product (through the fee-for-service mechanism) and providing an additional revenue stream (through energy savings) means manufacturers can be rewarded for product durability.

At the end of the agreement period, the service provider still owns the equipment. And because the provider has likely been tracking maintenance histories and which products were actually installed, take-back procedures would be relatively straightforward. The provider can reuse older products in projects that have lower performance standards, or—if the service provider is also a manufacturer—recycle them directly back into the manufacturing stream since they know the material constituency of the products.

Amory Lovins famously said, "People don't care about kilowatts; they want a cold beer and a hot shower." The PaaS model makes use of this thinking to potentially introduce circularity to the supply chain, reducing both energy and material waste.