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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.*

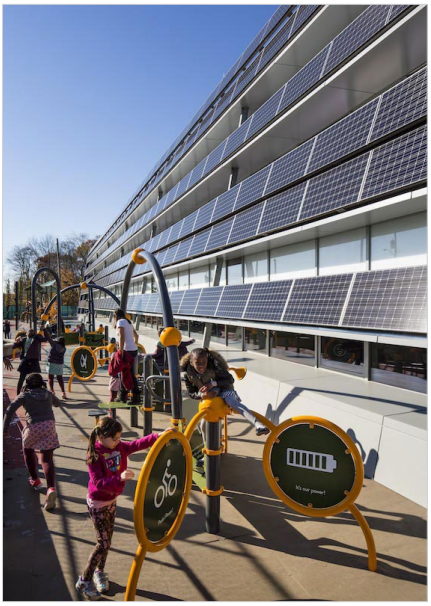

Photo: James Ewing, courtesy of SOM

*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.*