



Discovery Elementary School is one of the first zero energy schools on the east coast of the United States. *Photo from VMDO Architects/©Alan Karchmer*

Zero Energy Schools: Architects Take the Lead

Zero energy schools are possible and practical, and architects are leading the way.

Imagine a school so inviting that students want to come to school. Now imagine this school housed in a beautiful, light-filled building that produces more energy on an annual basis than it uses. Finally, imagine that the district built this school on the same budget as a conventional school, using typical materials, equipment, and tradespeople.

Sound too good to be true? Discovery Elementary School in Arlington, Virginia, is living proof that zero energy (ZE) schools are feasible, affordable, and sensible.

What Is a Zero Energy School?

A ZE school is first and foremost an extremely energy-efficient building. In fact, it is so energy-efficient that a renewable energy system—often solar photovoltaics (PV)—can provide all of the building's energy (see *A Common Definition for Zero Energy Buildings* in Helpful Resources).

These buildings are connected to the utility grid, and, in most areas of the United States, feed electricity back to the grid when the PV system is producing more electricity than the building requires. The owner earns credit for the excess, and can use that credit at night and during other periods when the PV system can't meet the building loads. If, over the course of a year, the building produces as much or more energy than it uses, it is a ZE building.

So How Did Arlington Public Schools Do It?

“The architect came to us even before submitting a proposal and said, ‘We think you can do [zero energy] here and we think you have the budget for it,’” said John Chadwick, assistant superintendent for facilities and operations at Arlington Public Schools.

Discovery Elementary School is successful thanks in large part to the vision, skill, and perseverance of the architect. And this project is not an anomaly—the commitment and skill of the architect are pivotal in many ZE school projects.

“Once we got agreement on it, we had to look at everything, from how food was prepared to how the [information technology] system worked to how the building was scheduled,” said Project Architect Wyck Knox of VMDO Architects. “Then, as we examined each system, we asked ‘How can we make little tweaks to save a little bit of energy?’”

Every decision (for Discovery)...was viewed through the lens of how that decision would affect energy use.

The architect worked through the design in close consultation with the district, educators, and the community. Every decision—from building orientation and massing to construction details for the building envelope to choosing lighting and HVAC systems—was viewed through the lens of how that decision would affect energy use.

Why Zero Energy?

Discovery Elementary School isn't a one-off. Some of the data are preliminary, but more than 50 schools in the United States are believed to be operating at or near ZE as of mid-2017 (see *Zero Energy Building Databases* in Helpful Resources).

As more ZE schools are built and their performance is measured and verified, the benefits that accrue to school districts, students, and educators are becoming better understood. Clearly articulating these benefits can help architects make the case to school districts that they can deliver a superior school building, meet the educational needs of teachers and students, and reduce operating costs over the life of the building—all within a conventional school construction budget.

Here are some specific benefits architects can use to sell the concept of ZE schools to school districts and educators.



Discovery Elementary School students enjoy interacting with the real-time data displayed on the energy dashboard and learning about their school's solar system. *Photo from VMDO Architects/@Lincoln Barbour*

ZE school(s) can be designed and built within a typical school construction budget using conventional materials, equipment, and tradespeople.

School District Benefits

- Competitive first costs as a ZE school can be designed and built within a typical school construction budget using conventional materials, equipment, and tradespeople.
- Reduced operating costs free up additional money for classroom and other educational needs. Discovery, for example, is saving more than \$100,000 annually in avoided energy costs.
- Reduced life cycle costs decrease the school district's fixed costs for decades to come.
- Higher confidence when planning for future energy costs because the school generates its own energy from an energy source with no fuel costs.

Teacher and Student Benefits

- Healthier indoor environment, reduced absenteeism, and improved academic performance (see *Improved Academic Performance* in Helpful Resources).
 - Better indoor air quality
 - Bright, welcoming, comfortable spaces
- Enhanced learning environment
 - The school becomes a hands-on, living lab for science, energy, and technology learning as students see the workings of a ZE building up close every day
 - The building is a teaching tool and could include features such as exposed walls sections, extensive signage, and prominent and interactive energy dashboards
- Improved teacher retention (see *Improved Academic Performance* in Helpful Resources)
- Pride in their beautiful and innovative school.

In addition, architects who design successful ZE schools receive recognition as innovators, thought leaders, and early adopters. Zero energy schools are a "good news" story for the local and national press, and education is a hot topic that is garnering considerable media attention.

The Importance of Teamwork

It takes more than architects to complete a complex building project. And, in the case of a school, the process involves multiple stakeholders and educational as well as energy goals. Ideally, educators, administrators, and the entire design and construction team are on board from the beginning, committed to the energy goal, and comfortable with an iterative, collaborative process.

It's hard to overemphasize the importance of assembling the right team. The architect, for example, can make or break a project with a firm energy goal. In the case of Discovery Elementary School, the architect embraced the challenges posed by the energy goal without sacrificing aesthetics. The result is a beautiful and functional ZE school building.

To maintain its ZE status, the building must be operated properly after completion. For that reason, the team should also include

commissioning agents, facility managers, and operations and maintenance staff or vendors.

Although architects cannot ensure proper operation, they can design with operational simplicity in mind. At Discovery Elementary School, the architect incorporated passive design elements that improve comfort but do not require regular maintenance. For example, the building orientation and shading maximize daylighting while minimizing heat gain.

Toward Zero Energy

While ZE schools are still the exception, their numbers are growing. They are affordable, practical, and a boon to school districts, students, teachers, and communities. The knowledge base that will make ZE schools commonplace continues to grow, and it's often architects who are leading the way.

Zero Energy School Best Practices for Architects

As a key member of the team, the project architect is involved in—and often guides—critical decisions from the outset of the school design and construction process. As more ZE schools come online, best practices are emerging that can help ensure the success of future ZE school projects:

- Assemble a skilled, experienced team committed to the energy and educational goals and the collaborative process.
- Involve key players and stakeholders—including students, parents, teachers, elected officials, school district administrators, facility and energy managers, community leaders, and members of the larger community who will use the school from time to time—from the beginning and solicit their input as the process unfolds.
- Establish a firm and specific energy goal at the beginning of the process, such as an energy use intensity of less than or equal to 25 kBtu/ft²-yr (see *Technical Feasibility Study for Zero Energy K-12 Schools* in Helpful Resources).
- Use the energy goal as a filter for every design decision.
- Include the energy goal as a contractual obligation with vendors and team members to align and focus the team.
- Emphasize energy efficiency strategies to minimize the size of the renewable energy system.
- Help ensure the school will be operated properly to maintain its ZE status by including commissioning agents, vendors, facility managers, and operations and maintenance staff in the conversation during the design process.
- Challenge the engineer to focus on the design of the thermal envelope, lighting system, and plug loads, which can make it possible to reduce the size of mechanical equipment by 50% compared to a conventional school building.



Zero energy schools are designed to meet educational as well as energy goals. For example, Discovery Elementary School in Arlington, Virginia, has a rooftop solar laboratory. *Photo from VMDO Architects/©Lincoln Barbour*

- Check with the local utility early in the process to determine how they handle the process of interconnecting the renewable energy system to the grid, what fees are involved, and what their net-metering guidelines are. In some areas, utilities do not allow renewable energy systems to be interconnected to the grid or limit the capacity of interconnected systems. If this is the case, design the building to be renewable energy ready.
- Monitor construction and commissioning closely to ensure that energy and educational goals are met.
- Conduct post-occupancy evaluations and engage with school staff and vendors to ensure that ZE goals are met through operations and maintenance.
- Document the project to help other owners, designers, school districts, and building professionals replicate the ZE process.

Helpful Resources

Zero Energy School Resources for Architects

<https://buildingdata.energy.gov/cbrd/search/resources/>

Feasibility Study

Technical Feasibility Study for Zero Energy K-12 Schools

<https://buildingdata.energy.gov/cbrd/resource/1981>

Design Guide

*Advanced Energy Design Guide for K-12 School Buildings:
Achieving 50% Energy Savings*

<https://buildingdata.energy.gov/cbrd/resource/1100>

An advanced energy design guide for zero energy schools is under development

www.ashrae.org/aedg

Case Studies

Discovery Elementary School

<https://betterbuildingssolutioncenter.energy.gov/showcase-projects/discovery-elementary-school>

Arlington [Virginia] Public Schools

“A Building That Teaches: Hood River Middle School Music and Science Building”

<http://www.hpbmagazine.org/attachments/article/11945/13W-Hood-River-Middle-School-Music-and-Science-Building-Hood-River-OR.pdf>

High Performing Buildings magazine

“Stevens Library at Sacred Heart Schools”

<http://www.hpbmagazine.org/Web-Exclusive-Stevens-Library-at-Sacred-Heart-Schools-Atherton-Calif/>

High Performing Buildings magazine

“Achieving Net Zero: Richardsville Elementary School”

<http://www.hpbmagazine.org/attachments/article/11817/12F-Richardsville-Elementary-School-Richardsville-KY.pdf>

High Performing Buildings magazine

Friends School of Portland: Zero Energy with an Affordable Price Tag

National Renewable Energy Laboratory

Odyssey Elementary: A Zero Energy Building Pays for Itself

National Renewable Energy Laboratory

Discovery Elementary: Zero Energy Is an A+ for Education

National Renewable Energy Laboratory



At Discovery Elementary School, building orientation and shading maximize daylighting while minimizing heat gain.

Photo from VMDO Architects/©Lincoln Barbour

Zero Energy Definitions

A Common Definition for Zero Energy Buildings

<https://buildingdata.energy.gov/cbrd/resource/1938>

Improved Academic Performance

Evidence from Scientific Literature about Improved Academic Performance

<https://www.epa.gov/iaq-schools/evidence-scientific-literature-about-improved-academic-performance>

U.S. Environmental Protection Agency

Zero Energy Building Databases

Getting to Zero Database

<http://newbuildings.org/resource/getting-to-zero-database/>

New Buildings Institute

High Performance Buildings Database

<https://buildingdata.energy.gov/>

U.S. Department of Energy ■