

Zero Energy Is an A+ for Education: Discovery Elementary

Project:

Discovery Elementary
Arlington, Virginia
Arlington Public Schools District

Project Data:

Grade levels: Pre-K through fifth
Gross Area: 98,000 ft²
Site area: 15 acres (including playing fields and parking)
Context: Suburban
Number of floors: Two
Occupancy: Extended day program goes from 7 a.m. to 6 p.m. Also occupied for weekend meetings and summer camps.
Number of occupants: 630 students, 715 total
Date completed: August 2016
Cost: \$32,305,800
 Building only: \$26,690,000
 PV: \$1,510,000
 Sitework: \$4,106,000

Team:

Architect: VMDO Architects
Engineers: CMTA Consulting Engineers, 2rw Consultants, Fox + Associates, Bowman Consulting Group
Contractor: Sigal Construction Corporation
Construction Manager: Heery International

Introduction

Currently experiencing a population boom, Arlington County, Virginia is facing massive growth in the next decade and is seeking to add half a million square feet in educational facilities. During competitive design procurement, one of the teams suggested a zero energy goal could be accomplished within the given budget. Proponents at the district level who had been championing energy efficiency were receptive because sustainability was a core value of the project from the start. However, they were skeptical that it could be done within the budget aimed at Leadership in Energy and Environmental Design (LEED) Silver certification. Not only did the project end up coming in under budget, including the solar array, but the building is more efficient than originally predicted. Now Discovery saves \$100,000 per year in utility costs, enough to cover the salaries of two teachers.



Discovery Elementary School in Arlington, Virginia, integrates zero energy performance with the curriculum across grades.

Photo ©Alan Karchmer

Energy Data: August 2015–July 2016

	Site EUI (kBtu/ft ² .yr)	Energy Cost/ft ²	Net EUI (kBtu/ft ² .yr)
Typical School in District	69.0	\$1.21	69.0
Energy Model: Design Building	21.2	NA	-0.85
Actual Usage	16.2	\$0.18	-0.65

Motivation

At a fundamental level, Arlington County district officials believed that integrating environmental stewardship with learning environments would give their schools a competitive edge. The district’s strategic plan was centered around creating optimal learning environments while meeting the needs of the whole child—a directive that was often linked to healthy classrooms and an ethic of sustainability. So as the district began to think about building Discovery Elementary, officials looked around for other models.

One project caught their attention: a LEED Gold, highly efficient elementary school in nearby Manassas Park. So as the District issued a call for proposals, it reached out to the Manassas Park architect with a challenge: “Give us one of those, but make it better.”

The children naturally embrace their own sense of stewardship.



The zero energy design was accomplished within the original budget for the school. *Top photo ©AirPhotosLive; Bottom photo ©Lincoln Barbour*

remembers Wyck Knox, American Institute of Architects, associate principal at VMDO Architects.

Knox and his team proposed zero energy. Furthermore, they proposed it at the same price as the original budget, which was established for LEED Silver. “We were still coming out of the construction recession, and the cost of photovoltaics (PV) had really gone down. It seemed like the perfect opportunity to try out something big,” Knox said.

The school board was interested in the concept but assumed that purchasing the solar panels would be too expensive. They decided to go forward with the project and design for a zero energy ready building and then bid the renewable energy system as an alternate. When the bids came in, however, the zero energy version was still \$1 million less than the original budget.

John Chadwick, assistant superintendent of facilities and operation at Arlington County Public Schools, remembers asking the school board if they wanted to go forward with purchasing the panels. “You don’t have to do this. We’ll still have the most energy-efficient building in the system,” he told them. But they said, “Yes, it’s within budget. We would like to do it,” according to Chadwick.

Design and Construction Process

Discovery was built adjacent to an existing middle school on a portion of the site that was previously considered unusable because of a sloped hillside. Even with those constraints, the design team experimented with various shapes and orientations for the new 630-student school. Every version was analyzed for energy efficiency and described in terms of how many solar panels it would take to offset the energy load.

The model that performed best was actually rejected. It was too compact and did not have enough sun exposure for daylighting. “It had to be a great school first,” Knox said. Community leaders also expressed a desire for the school to fit the size and scale of the neighborhood. The team settled on a north-south orientation, which was ideal for daylighting and solar gain, and decided to terrace the school’s three levels into the hillside in order to blend into the neighborhood.

An engineering firm that had successfully designed several zero energy schools in Kentucky was brought onto the team. The firm had experience with designing and modeling exterior wall assemblies constructed with insulated concrete forms—a construction technique that is rarely used in Virginia but that offers high insulation efficiency (R-value), high thermal mass, and good air sealing. Add LED lighting and geothermal wells for a ground-source heat pump system, and they had the main ingredients for a highly efficient school, Knox said.

Knox can make it sound easy, but Chadwick points to how conscientiously Knox’s team designed each aspect of the building. “The roofscape of the building had to be designed very carefully,” he said. The mechanical equipment had to be located on the inside of the building so that it “wouldn’t take up room on the roof or cast any shade that might limit the output of the panels.” (Keep in mind that the solar panels were bid as an alternate, so the design team didn’t actually know whether they would be installed or not.)

The team’s hard work paid off. In Discovery’s first year of operation, the school achieved a site energy use intensity (EUI) of 16 kBtu/ft²·yr, which is 76% more efficient than the national

Technologies

Windows	Double paned
Envelope	Insulated concrete forms (8 in. concrete core and 4 in. polystyrene)
Heating, Ventilating, and Air Conditioning	Geothermal wells and small, distributed floor-mounted heat pumps; demand-control ventilation
Renewable Energy System	1,700 photovoltaic panels, 496 kW

Costs

(Breakout reflects average bid results, not final costs)

Total cost	\$342.16/ft ²
Building cost (including PV)	\$289.97/ft ²
Concrete	\$24.51/ft ²
Metals	\$23.33/ft ²
Thermal and moisture	\$17.25/ft ²
Finishes	\$22.27/ft ²
Plumbing	\$8.54/ft ²
Heating, Ventilating and Air Conditioning	\$52.23/ft ²
Electrical System	\$60.63/ft ²

average for a comparably-sized school.¹ Actual energy use was slightly lower than what was predicted from the energy model used for design.

“The building performed incredibly well this year, and we’re very proud of that,” Chadwick said. “EUI is weather dependent, so if we have a mild year, we will do better, and if we don’t have a mild year, then we will do worse. But we think we have plenty of margin to still be zero energy in a bad [weather] year.”

The cost of Discovery Elementary might seem very high compared to most districts, but it falls within range of other schools in the area. Final construction costs for Discovery amounted to \$331.04/ft². A comparable school built in Prince George’s County, Maryland in 2014 cost \$293.97/ft².

A portion of the difference in cost between similar schools and Discovery wasn’t related to the zero energy goal. Several upgrades were added to the school in order to provide community amenities. Arlington County approved a total of 34 upgrades, such as added turf fields, increased gym size, and more restroom facilities, which amounted to \$3 million—or \$30.61/ft²—the costs of which were shared by the school district and the County.

Attempts to isolate costs related to the zero energy goal are complicated, but the team points to the bid day results that were broken up by class division to argue the zero energy design (without the solar panels) did not actually cost any more than a conventional school. “When you look at the percentage of the budget that the mechanical, electrical, and lighting equipment represent, it was around 30% of the overall budget,” Knox said (see cost table). “That’s around what you would expect, so we didn’t really pay more for the high-performance mechanical systems.”

¹ Environmental Protection Agency’s Table 1: 2003 CBECS National Median Source Energy Use and Performance Comparisons by Building Type.

“So then you’re really just looking at the cost of the solar array,” Knox said. Simple payback on the photovoltaic system at Discovery is estimated to be 13 years, Knox said. However, because the PV system works in conjunction with an energy-efficient design, Discovery is saving approximately \$100,000 on energy costs per year, which more than makes up for the bond payment on the solar array.

As with Discovery, many school boards may be faced with the question, Why spend money on a solar array when that money could go to more square footage? Knox’s answer is that that is a very valid concern. “However, a bond event is a one-time event, while your ongoing expenses (which come out of property taxes) are there forever, Knox said. “A zero energy building allows us to leverage that one-time debt event and translate it to savings that go on and on and on.”

Lessons Learned

For the project team, the lessons learned from Discovery have been about tracking performance and understanding maintainability.

Most sustainability programs are based on predicted energy use. “The thing about zero energy is that you don’t get the medal until the building shows that it actually performs,” Knox said.

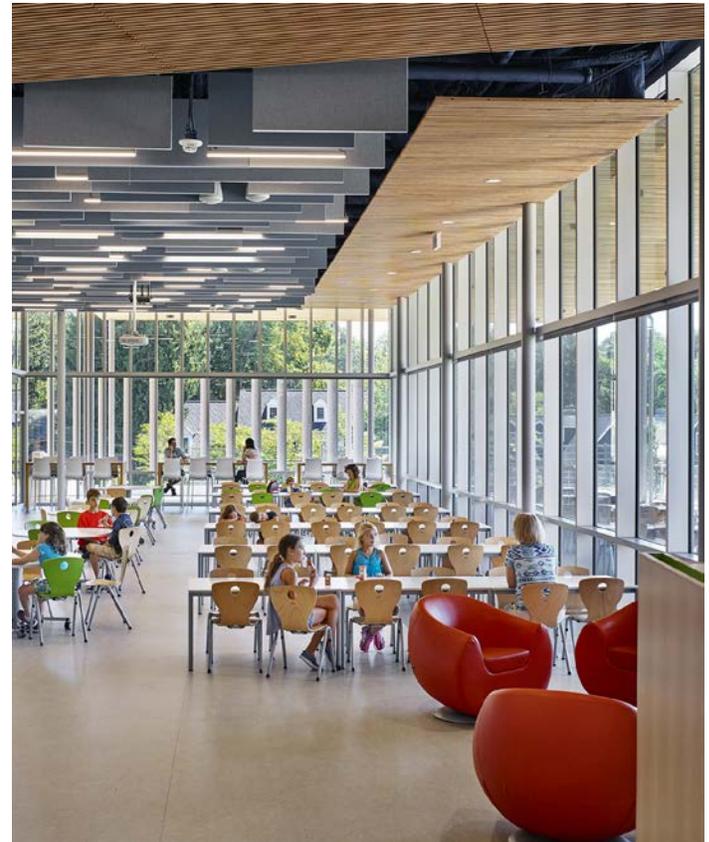


A careful daylighting plan helps the project save energy.

Photo ©Alan Karchmer



Knox met with students to jump-start the zero energy curriculum at Discovery Elementary. *Photo ©Lincoln Barbour*



The children naturally embrace their own sense of stewardship. *Top photo ©Lincoln Barbour; Bottom photo ©Alan Karchmer*

And part of tracking actual performance means the design team is more in touch with problems that crop up during operations.

Knox has learned that “the more you can make things simple to operate, the more energy savings you are going to get.” When the controls are too complicated, the facilities maintenance team just ends up turning them off, Knox said. It’s better to simplify by “having one high-quality occupancy sensor that triggers multiple systems.”

Actual performance also relies on each occupant—down to the youngest kindergartners—to do their part. After the firm did a few presentations to the students, and the teachers started utilizing the building in their class curriculum, Knox found that the children naturally embrace their own sense of stewardship.

“The students began to measure things: their trash, the number of kids who biked to school, how much cafeteria food was being donated to the food shelter,” Knox said. “Just by setting this big audacious goal, that culture begins to grow organically.”

Resources

[Zero Energy Buildings Resource Hub \(zeroenergy.org\)](http://zeroenergy.org)

[Reaching for Net Zero in School Design](#)

[National Action Plan for Educating for Sustainability](#)

[How to Green Existing Schools: Energy Management](#) ■

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For more information, visit: www.zeroenergy.org

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