Zero Energy Building Pays for Itself: Odyssey Elementary

Project:

Odyssey Elementary
Woods Cross, Utah
Davis School District

Project Data:

Grade levels: Pre-K through sixth
Occupancy: 180 instructional days plus summer camps
Gross Area: 84,758 ft^2
Site area: 12 acres
Context: Suburban
Number of floors: Two
Number of occupants: 650 students, 75 staff
Date completed: August 2014
Year certified: LEED Gold 2016
Cost: $19,609,700
- Site development: $4,788,100
- Building Construction: $13,021,600
- Fixed Equipment: $1,800,000

Team:

Architect: VCBO Architecture
Engineers: Bsumek Mu and Associates, Ensign Engineering and Land Surveying, Van Boerum & Frank Associates, Envision Engineering
Contractor: Hughes General Contractors

Introduction

Odyssey Elementary is a large public school in an area of Utah with a growing population. Created as a prototype for the Davis School District, Odyssey is a zero energy building whose design has already been copied for two other new schools, both of which are targeting zero energy. It has a unique design with four "houses" (or classroom wings) featuring generously daylit classrooms. This design contributes to the school's energy efficiency.

In a post-occupancy survey of parents, students, and teachers, more than 87% were satisfied with the building overall.

Motivation

For more than a decade, the school district has been working on slashing its energy use. The prior prototype, also designed by VCBO, is operating at 25 kBtu/ft^2·yr. Efficient new construction and an ongoing focus on existing buildings paid off: From 2007 to 2014, the Davis School District added 1.4 million square feet yet *reduced* its total energy use.

The school district chose to purchase PV to offset the very low energy use. *Photo courtesy VCBO Architecture, photography by Dana Sohm*

Energy Data: August 2015–July 2016

	Site EUI (kBtu/ft^2·yr)	Source EUI (kBtu/ft^2·yr)	Energy Cost/ft^2	Net EUI (kBtu/ft^2·yr)
Energy Model Baseline	43.8	N/A	$0.77	N/A
Energy Model: Design Building	21.8	N/A	$0.48	N/A
Actual Usage	15.0	36.6	$0.23	-16.2

Despite this, no one was certain at first that the district would make the leap to zero energy. "When we were first asked to do it, we didn't think it was actually going to happen," admitted John Oderda, AIA, associate principal at VCBO Architecture; they were designing it to be zero energy ready. But if the design energy use intensity (EUI) could be brought down low enough—the team was shooting for 22—"it might be possible to do PV."

In the end, it wasn't a hard decision. "We didn't have to push it," Oderda remarked, because "reducing the amount of energy consumed means they can spend more money on the students."

Reducing the amount of energy consumed means the school district can spend more money on the students.

A theme of "Bodies in Motion" is integrated into the design of the classroom wings. *Photo courtesy VCBO Architecture, photography by Dana Sohm*

Design and Construction Process

Odyssey and two other schools were financed through a 2009 bond, long before discussions of zero energy began. The purchase of photovoltaics received widespread support from the school board and the public—and was possible for all three schools without requiring additional bonds.

In addition to a dedicated building committee, the design process involved administrators and teachers. Even students participated at times—mainly to help shape the "bodies in motion" theme, which was incorporated into each house in different ways to integrate positive messages about fitness into the learning environment. Other major stakeholders included the school board and a district-wide energy committee that monitors use across the district and makes recommendations about building-level use.

The integrative process and the interwoven expertise of various members of the design team really helped the project succeed at its energy goals, according to Odera, and their collaboration resulted in increased energy savings. In addition to a number of automated systems—everything from the air handling units and lighting to the drinking fountains and vending machines—certain electrical engineering decisions "let us reduce the size of the equipment," and "small things added up." Being able to specify a small transformer contributed to lower first costs for the electrical system. In addition, the school district decided to purchase photovoltaics to offset the building's very low energy use.

The network of sensors did not at first play well with the district's building automation system. However, the team was committed to a robust commissioning process (see "Lessons Learned"), in part because the school was targeting LEED certification. Odyssey is the first LEED Gold school in the state, according to U.S. Green Building Council.

Integration with the mechanical engineering firm also contributed to success, Oderda said, especially because of the important role that demand-controlled displacement ventilation played in the project—both for energy efficiency and for indoor air quality. The CO_2 sensors in each occupied space trigger the main air-handling unit to supply preconditioned fresh air to the space. "You're supplying good, fresh air down low where the students are, as opposed to trying to push it down through the naturally rising, dirty air," he explained. The team also leveraged the dry climate to its advantage—choosing two-stage evaporative cooling over other options.

Another aspect of successful zero energy design includes proper siting; however, the team had to think ahead since Odyssey was a prototype. "There are not as many wide-open sites" as there used to be, Oderda noted, so "we designed it to fit on any site and still utilize daylight. It can be flipped and have entries on two different sides, so it can go on any site and still have the classroom wings oriented properly."

It will take 10 to 13 years to earn back the money put into making Odyssey a zero energy building, according to Doug Anderson, director of utility services with the Davis School District. (That payback time is separate from that of the solar panels, which will take about 20 years.) Anderson said that, based on the age of other buildings in its portfolio, the district plans to inhabit the building for 50 to 60 years. Because the energy features completely pay for themselves in just over a decade, he added, the decision was "a no-brainer."

Technologies

Glazing	Double glazed, U-factor of 0.27 and solar heat gain coefficient of 0.25
Envelope	R-30 roof and R-20 walls with three inches of continuous exterior polyisocyanurate insulation
Heating, Ventilation, and Air Conditioning	Ground-source heat exchange loops, two-stage evaporative cooling, water-to-water heat pumps, gas boiler, thermal displacement ventilation
Renewable Energy System	1,100 solar panels, 320 kW of peak output

Ample daylight helped the design achieve ultra-low energy use. *Photo courtesy VCBO Architecture, photography by Dana Sohm*

In fact, rising energy prices were a big part of the district's decision to pursue zero energy for its next generation of buildings. "We wanted to help curb demand costs because those are getting really expensive," stated Anderson. "That is why we have gas at Odyssey—to supplement during times when we don't have any PV power but we need to heat the building up at night."

Anderson estimates Odyssey costs $25,000 a year to operate—about $0.29/ft^2. The school built most recently before Odyssey costs $0.66/ft^2.

Costs

	Typical Elementary School in Davis School District	Odyssey Elementary
Building construction	$144.05/ft^2	$153.63/ft^2
Mechanical and plumbing	$25.50/ft^2	$35.40/ft^2
Electrical system	$18.10/ft^2	$21.80/ft^2

Lessons Learned

The district has an Energy Committee that has been around for 14 years, which reports to the local Department of Education. From an energy perspective, it made sense to operate just four buildings for all summer activities—and Odyssey is one of them.

"We funnel all summer activities to Odyssey because the building is so cheap to run," explained Anderson. In some zero energy buildings, extra programming might jeopardize zero energy operations, but at Odyssey, the building is functioning as energy positive, so it has power to spare. Most buildings can use ground-source loops for cooling for a certain amount of time, but they eventually have to shift to a cooling tower. Odyssey's system has one large ground loop that sends chilled water to air handling units, which supply preconditioned fresh air, and it doesn't need the cooling tower for most of the year. "It was cheaper to use the ground wells," Anderson said. "We found that we could use those longer if we set the temperature setpoints to 75°F [in summer] and 65°F [in winter]."

It wasn't easy to get everything operating smoothly, though. The zero energy design relies heavily on automated systems that had to be put through their paces meticulously during a long commissioning process. "We went beyond having a commissioning agent," said Anderson. "After the building was built, we sat down with the engineer who designed the automation system and reviewed every sequence. We found a lot of problems: there are always going to be places where the guy programming the system is interpreting the directions differently than what the engineer intended."

Anderson agrees that the operations side is just as important as a robust design—if not more so—and that training across the district is paramount. Automation isn't always as automatic as it seems. The lighting system, for example, requires some training even for teachers. Automatic dimmers keep the lighting level appropriate throughout the day, while vacancy sensors turn lights

In common areas, the "Bodies in Motion" theme continues, with larger-than-life artwork showing people running, swimming, jumping, and flying. *Photo courtesy VCBO Architecture, photography by Dana Sohm*

Students can move around more freely during group activities in flexible classroom spaces. *Photo courtesy VCBO Architecture, photography by Dana Sohm*

off completely when no one is the room. Lights must be manually turned on—but according to Oderda, most teachers don't bother. "Anecdotally, we have talked to several teachers who prefer the lights off for most of the day," contributing further to Odyssey's impressive energy savings.

As for the more complex systems monitored and managed at the district level, "we have the people who have the knowledge to keep those kinds of things running," Anderson said. "You need to have someone on staff who understands the vision."

Resources

Zero Energy Buildings Resource Hub (zeroenergy.org)

Net Zero Building Commissioning

Zero Net Energy Building Controls: Characteristics, Energy Impacts and Lessons

Daylighting Schools ■

Decorative features on the exterior echo the theme of "Bodies in Motion." *Photo courtesy VCBO Architecture, photography by Dana Sohm*

A small amount of awning-integrated PV supplements the rooftop system. *Photo courtesy VCBO Architecture, photography by Dana Sohm*

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For more information, visit: www.zeroenergy.org

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