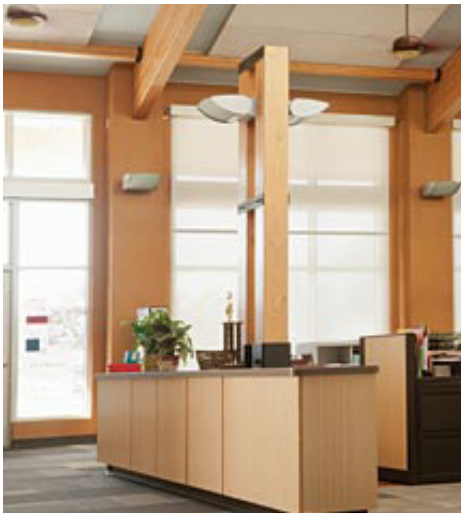
Emerging Zero Net Energy School Case Study



Photos: KaraGeorge Studios

OVERVIEW

Building Size: 9,200 SF

Location: San Jose, CA

Construction Type: New Construction

Completion Date: 2011

Building Type: Education

CA Climate Zone: 8

Energy Use: Electric

Construction Cost: $5.85 Million

Measured Energy Stats

34	-	25	=	9
BUILDING'S TOTAL EUI		RENEWABLE PRODUCTION RPI		BUILDING'S NET EUI

Site Energy Use Index (EUI) kBtu/SF/year

The Energy Equation: **the building energy use** *minus* **the renewables production** *equals* **the net energy of the building**. Buildings may be 'Getting to Zero' and have a net EUI above zero. If renewable production exceeds energy use its net EUI is below zero (negative) and it is creating surplus energy.

nbi new buildings institute

For more information:
newbuildings.org/zero-energy

LEYVA MIDDLE SCHOOL ADMINISTRATION BUILDING

The George V. LeyVa Middle School Administration Building was designed to be one of the first zero net energy (ZNE) public school buildings in California as well as the first zero net emissions public school building in California. This leading building was completed in 2011 and has helped demonstrate the financial feasibility of ZNE. A strong fundamental design for low-energy use can cost effectively set up a building to reach zero net energy with minimal onsite renewables. This 9,200-square-foot administration building for the school spent less than 4% of the project budget on solar panels to reach ZNE.

Planning & Design Approach

The design team didn't initially set out to create a zero net energy building. According to John Diffenderfer, Principal at Aedis Architects, the designers "realized that the building was taking on a shape and orientation that lends itself to real sustainable design." From there, the designers approached the school district to study the performance potential of the building design while keeping cost increases to a minimum. As a result of the study, the designers realized the LeyVa School could cost effectively reach ZNE. The final energy target of the building was 41% energy savings over the Title 24 energy code.

Policy

The eventual high efficiency goal for the LeyVa School Building design did not stem from a district policy. Rather, the ambitious design came from Aedis Architecture, which was pursuing the national trend toward energy-efficient buildings, and taking it further to achieve ZNE. Aedis has been an advocate for energy efficiency, and has encouraged the rest of the school district to follow the example set by the LeyVa Administration building.

Team/Owner Details

Owner: Evergreen School District

Architect: Aedis Architects

Civil Engineer: Carroll Engineering, Inc.

Structural Engineer: Thornton Tomasetti

Mechanical Engineer: Capital Engineering Consultants, Inc. (CECI)

Electrical Engineer: Integrated Design Associates, Inc. (IDeAs)

Landscape Architect: Landarc Associates, Inc.

Integrated Design Process

The design process was fully integrated from the start. The electrical, mechanical, and plumbing teams were involved in the design process as early as the building program development stage. The overarching question the team was looking to solve was, "How do we make this work?" Working together on the energy model, the team quickly realized that they could produce a highly efficient building that not only consumes very little energy, but also generates as much energy as it consumes. Much of the success of this project is attributable to the valuable input that each party in the design team was able to contribute early on to ensure the different building systems efficiently function together.

The energy model for the building was intentionally conservative. The weather conditions for the photovoltaic generation were less favorable than average, and plug load management wasn't assumed to be put in place, thereby creating a worst-case scenario to model energy consumption that would help ensure the ZNE target would be met.

Financing & Cost

The total cost of the middle school building was $5.85 million. This equates to a total cost of approximately $640 per square foot. Of that total cost, the incremental cost of the solar panels, after taking advantage of the available utility rebates from Pacific Gas & Electric (PG&E), was $215,000, or approximately $24 per square foot. Throughout the life of the building, the additional incremental costs of the solar panels will be recovered by the school district through avoided energy costs.

Energy Efficiency Strategies and Features

The LeyVa Middle School employs a variety of energy efficiency approaches, including passive design, and active strategies in the operation of the building.

Lighting and Daylighting

The office spaces in the LeyVa Admin building are 100% naturally daylit, drastically reducing the energy use for electric lighting required by the occupants in the space. The daylighting is accomplished by purposefully placed windows and skylights to illuminate the occupied spaces. Aside from daylighting, high efficiency lighting fixture are installed throughout the building to keep energy costs down whenever supplemental lighting is needed.

Envelope

The high performance envelope of the school building was an important first step in reducing heating and cooling loads in the building. The temperate climate of San Jose, combined with a high performance envelope, completely eliminates the need for heating and cooling on most days. This high performance envelope includes energy-efficient windows and a cool roof. The high reflectivity serves to prevent energy from entering the roof in the form of heat in the first place. The 70% design reflectivity prevents a substantial amount of heat absorption into the roof. The other component to the cool roof, the high emissivity, serves to reject the heat that the roof does absorb. The 90% emissivity translates to a very effective radiation of heat from the roof out to the cooler surroundings.

Photos: KaraGeorge Studios

"The business case for making the building net zero energy is that it will not just lower our energy bill, but it also will allow us to put those savings straight back to the top line of our operations budget for maintaining programs for kids."

-Assistant Superintendent Kathy Gomez

HVAC

The primary HVAC system for the LeyVa Administration Building is a variable refrigerant flow (VRF) heat pump system. The mild climate of California, combined with the high performance building envelope do much to mitigate heating and cooling loads, which requires the HVAC system to operate at low and average load conditions. VRF systems typically have higher efficiencies than packaged rooftop units, particularly during part-load conditions, which make up the vast majority of operating hours.

The building includes tankless water heaters, which consume less energy than traditional storage tank style water heaters by mitigating heat loss associated with the stored hot water. Further, these point-of-use heaters also take up less space in the mechanical room, which helps reduce space requirements.

Controls

Occupancy sensors along with daylighting controls automatically reduce lighting loads in the building. The controls are able to sense the level of daylight coming into the space and decide whether to turn on the artificial lighting to maintain sufficient task-level lighting for the occupants. Occupants also have the capability to override the controls, manually turning on the lights in the event that additional lighting is needed.

Photos: KaraGeorge Studios

The VRF mechanical system, pictured above, offers advanced zoning control. In an office environment, this an important benefit as it prevents competing zone set points from driving up energy consumption, which often occurs as simultaneous heating and cooling. Rather, the VRF system uses heat recovery within the refrigerant flows to effectively redistribute heat from one zone to the other. The variable flow capacity allows for finer control of the zone temperatures with the help of variable capacity compressors.

Some natural ventilation capabilities are also built into the design. Relief openings with motorized dampers installed high on the walls encourage natural ventilation, which can address the cooling needs of the space under favorable outdoor air conditions, thereby reducing the run-hours of the mechanical cooling system.

Renewable Energy Generation and Storage

The building has a 36-kW rooftop solar panel arrays. These arrays were designed to meet 108% of the anticipated buildings needs over the course of a year. The additional 8% capacity was intended to serve two purposes. First, it will serve as a buffer to maintain zero net energy performance in case the energy models are too optimistic, or if the weather in a given year is particularly unfavorable for solar generation.

"In the initial stages, we realized the building was taking on a shape and orientation lends itself to real sustainable design, so we approached the District to study just how far we could push the building's performance without significantly increasing its cost."

- John Diffenderfer, Aedis Architects

Post Occupancy

Commissioning

The building underwent basic commissioning, however the commissioning scope was reduced so HVAC systems monitoring and integration of controls were excluded. This reduced scope of the commissioning to eliminate monitoring and feedback systems was a result of value engineering and seems to have resulted in negative effects. Actual measured energy performance hasn't met expectations, in part because control systems do not appear to be optimized. Retro-commissioning and reprogramming is underway and monitoring systems will be reprogrammed as well.

Monitoring

A building monitoring system is in place to verify the performance and energy consumption as well as generation of the mechanical and solar systems. On a larger scale, a school-wide energy management system will monitor energy consumption of each building on the school campus. By keeping track of how each building is using energy and at what times, the management system can then adjust the scheduling of HVAC systems, as well as exterior lighting systems, to effectively reduce energy demand. Seperating energy consumption by major end use also allows building operators to quickly spot any suspicious energy consumption trends which may signify improper scheduling, HVAC system or equipment failures, or general maintenance issues.

Behavior

In the communications hub of the LeyVa Administration building, the real-time energy generation and consumption of the building is on display in the lobby. A large flat screen TV shows the historical performance of the building as well. This kiosk serves to increase awareness of energy consumption for the occupants and visitors. Further, the kiosk will be able to serve as a teaching tool for students to see the real benefits of the solar system on the energy budget both of the building and the campus as a whole.

Successes

The Evergreen School District has been working to reduce its energy costs, which had been one of the larger line items in its budget for many years. It is often difficult for owners to invest the additional up-front incremental costs for energy efficiency. However, the school district has incorporated investments in energy-saving measures into its cost-reduction strategy and it is estimated they will be saving close to $9,000 annually in energy costs from this campus alone.

The LeyVa School Administration building has helped to shift the focus of future projects towards energy efficiency and renewable energy by demonstrating that it can be done cost effectively and bring forth significant energy savings for the school district in the form of avoided energy costs. These savings have helped inspire the entire LeyVa middle school modernization to add additional solar investments in the school and the district.

The occupants of the building have expressed very positive reviews of the building. The staff have appreciated the daylight in the spaces which has created a more enjoyable work environment. They have also praised the comfort and indoor air quality of the space, which is largely attributable to the natural ventilation, dedicated outside air system, ceiling fans, and improved zoning capabilities of the VRF system.

> “This system’s technology has contributed to saving us thousands of dollars this past year. And because of its exceptional zoning capabilities, there are no more zoning wars, and each office has its own temperature setting. But, I think its greatest benefit is the indoor comfort it brings our students.”
>
> *- Rob Smiley, Evergreen School District Director of Operations*

Illustration: Aedis Architecture

Lessons Learned

- Designing and building a ZNE building poses many technical challenges. Using-off-the shelf mechanical equipment, the designers put forth a strong design for this project. Unfortunately, predictions of the energy models have not been fully realized in the operation of the building.
- The relatively low cost of commissioning relative to the total cost of the project makes it a very good investment. Removing the monitoring systems from the commissioning scope resulted in reduced performance. For ZNE projects, having a commissioning agent present to ensure all systems are properly commissioned, installations were done according to specifications, that schedules for the HVAC system were properly set, and other systems were properly tuned helped set the project up for success at occupancy.
- The LeyVa Administration building staff are continuing to work toward achieving zero net energy while recognizing that it is common for many projects to have a longer timeframe of adjusting system operations to get to zero. For this reason, we have classified this project as “emerging” zero net energy at this time. The building is now very close to achieving the original design goals and it is probable that retro-commissioning will help the school to find potential improvements to reduce the energy consumption and achieve the building’s ZNE performance target.

Resources for More Information

- Local Government Commission: First Net Zero Energy Public School in California: http://lgc.org/wordpress/docs/freepub/newsletter/fall2011/page03.html
- Vista Solar: George LeyVa Middle School: http://www.vista-solar.com/projects/george-leyva-middle-school/
- HPAC Engineering: VRF Zoning Helps School District Achieve Energy and Cost Saving Goals: http://hpac.com/air-conditioning/vrf-zoning-helps-school-district-achieve-energy-and-cost-saving-goals
- The News, “Net-Zero Schools Lead the Green Pack.” http://www.achrnews.com/articles/123978-net-zero-schools-lead-the-green-pack

Brought to you by the California Investor Owned Utilities’ Proposition 39 Zero Net Energy (ZNE) School Pilot Program.

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