

# Emerging Zero Net Energy School Retrofit Case Study



Credit: Tricia Casper, Auburn Journal



Credit: Newcastle Elementary School District

## OVERVIEW

**Location:** Newcastle, CA

**Size:** 31,536 SF

**Original Construction:** 1950s

**Retrofit:** 2017

**School District:**

Newcastle Elementary School District

**Number of Schools:** 4

**Newcastle Elementary School**

**Enrollment:** 148

**CA Climate Zone:** 12

### *Team/Owner Details*

**Owner:** Newcastle School District

**Architect:** DLR Group

**ZNE Pilot Design Consultant:**

Point Energy Innovations

**ZNE Pilot Monitoring Consultant:**

Frontier Energy, Inc.

**Civil Engineer:**

Warren Consulting Engineers, Inc.

**Energy Service Company:**

ABM Building Solutions

**nbi** new buildings  
institute

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[newbuildings.org/zero-energy](http://newbuildings.org/zero-energy)

## NEWCASTLE ELEMENTARY SCHOOL

With funding from California's Prop 39, the Newcastle Elementary School District (ESD) issued a request for proposal (RFP) to develop an Energy Expenditure Plan (EEP) for their district. With a long list of deferred maintenance issues and budget challenges, Newcastle ESD was inspired to look into additional project funding, including grants, rebates and third party financing.

One source of additional funding they found was the California Investor Owned Utility Prop 39 ZNE Pilot project managed locally through Pacific Gas and Electric. The Newcastle Elementary School was an ideal candidate because the building was already fairly efficient. Further energy reductions plus renewable systems meant Zero Net Energy (ZNE) performance was within reach. The site also housed two separate buildings on the same site, so by pooling existing Prop 39 funding for the two schools with ZNE pilot money, the district could target ZNE for the whole campus.

## Planning and Design Approach

### Stakeholder Engagement

In a small district such as Newcastle, the superintendent is a prime decision maker regarding facilities, yet the community, staff, and the school board all have important voices in the decision making process. Before the project, district leaders were not fully aware of the student educational outcomes, health benefits and cost savings associated with sustainable, zero energy schools. The team shared case studies of other ultra-low energy school projects to explain these benefits and convince decision makers to pursue aggressive energy goals.

Since up front funding was available, stakeholders were fairly easy to convince. However, the team found that they needed to be reminded of these important benefits and the ultra-low energy goal throughout the process when competing priorities arose.

“Energy will play a much greater role in the five-year facilities plan than it would have before Prop 39,”

-Denny Rush, Newcastle Elementary School District Superintendent



Credit: Newcastle Elementary School District

## Project Goals

ABM conducted several walkthroughs of the existing facilities to gain a better sense of energy saving priorities and opportunities. The district's ultimate goal was to create the best learning environment possible. This required glare-free daylighting, views to the outdoors, adequate outside air ventilation, and a thermally comfortable environment. Through interviews with district leaders and school occupants, ABM also learned that other district priorities included addressing deferred maintenance, reducing operating costs, and leveraging funding through rebates and incentives.

The only official energy target the project had to comply with was the SIR requirements of 1.10 required by the Prop 39 Program. Additionally, the Prop 39 ZNE Pilot recommends an EUI of 20 kBtu/sf/yr or lower. Using energy modeling analysis as a design tool, the team found a package of deep retrofit options that are expected to deliver an EUI of 14 kBtu/sf/yr. The other energy goal stewarded by the team was affordability of future utility bills, thus the school district had a preference for producing all electricity on site through renewable photovoltaic systems.

## Building Assessment

The team left no stone unturned during their on-site building assessments. They inspected systems and equipment including lighting and HVAC. They also focused attention on energy conservation opportunities such as insulation and air infiltration. Plug loads were also an area of investigation. The team discovered occupants played a huge role in plug load management. Importantly, the team interviewed occupants and operators during their visits to understand how spaces felt and were maintained. Some occupants didn't realize the importance of turning off equipment when not in use.

Teachers told them that existing HVAC units were loud and old which made them a key target for the retrofit. During the site assessment visits, the team learned that teachers sometimes turned off systems in the portables just so students could hear. With the HVAC system off, the room quickly became warm and stagnant.

Interior and exterior lighting was another opportunity for cost effective upgrades. Old electric lighting was dull and orange and in need of an upgrade. During the initial assessment, the design team discovered unique original daylighting features including clerestory windows and light shelves. They knew that daylighting had



been shown to improve student performance. However, the clerestory windows had been painted over to reduce glare and light shelves were low and extended several feet into the classrooms, which was a safety concern with children tempted to climb them.

### Energy Modeling

Extensive energy modeling helped the district achieve a balance between energy savings and cost-effectiveness. While ABM used its internal modeling software, Point Energy Innovations team simultaneously ran a detailed energy model through EnergyPro. The team also integrated daylighting modeling using Lightstanza to investigate daylighting scenarios.

The design team began with a base model and ran many iterations to find the most effective combination of efficiency measures. Energy engineers used data-loggers on existing facilities to find energy use patterns. They wanted to understand when teachers turned lights on and off and what HVAC schedule and temperature set points the teachers maintained in various spaces. This information improved the accuracy of energy conservation estimates and helped fine-tune the design to determine the level of efficiency needed to achieve energy goals.

## Energy Efficiency Strategies and Features

### Lighting and Daylighting

Electric lighting modifications covered both interior and exterior lighting. The district would have preferred to replace fixtures, but it ultimately decided against this because fixture replacement would have triggered the California Title 24 requirement for new lighting controls, as well as the high cost for new fixtures. Because the district could not afford the new controls, occupants would be responsible for turning off electric light when daylighting was sufficient, in lieu of automatic dimming controls. Instead of replacing the entire fixture, they opted to replace just fluorescent lamps with high quality LED lamps. During periods when electric lighting was needed the LED lamps would reap most of the energy savings of the fixture replacement.

Classrooms also needed to manage glare so teachers would not be tempted to disable the daylighting by closing blinds and turning on lights. Knowing that glare was the primary reason that clerestory windows had previously been painted over, the team used lighting simulation to investigate daylighting and perimeter glazing options. With the LEED standards in mind, the team compared various combinations of glazing translucency, light shelf length, and glare reduction in their analysis. They also confirmed that the school district's plans to raise the exterior awnings would still provide good daylighting and glare control. Simulations were helpful in showing decision makers daylighting conditions at specific times of the day.

Another important aspect of the daylighting design involved the integration of tubular skylights. The design team worked with the school district to fine-tune the design for aesthetic preferences, such as flush-mounted rather than dropped fixtures, and to accommodate a tighter joist spacing than expected. The end-result provided exceptional light to the room, more than the school district had expected.

“When the Newcastle Bard units were replaced with quiet, efficient new ones, those classrooms became the envy of the school—you couldn’t even tell the units were running while teachers were teaching, and the rooms were both comfortable and properly ventilated.”

-John Burdette, Director of Bundled Energy Solutions at ABM Building Solutions



Credit: Newcastle Elementary School District

## HVAC

Acoustics in portable classrooms suffered due to loud, wall-mounted HVAC units. Teachers sometimes turned old SEER-8.7 units off during lessons just so students could hear. The team replaced these old units with higher efficiency (SEER-14.7) units, which only slightly exceeded code but provided significant acoustical benefits. Caulking and sealing of the envelope also improved the system performance. Now, the units are quiet enough to run at all times of the school day and occupants are more comfortable, while saving energy.

The primary school HVAC system was another target for replacement. Two types of HVAC units were installed to replace the aging systems. Five new high-efficiency Bard wall hung units were installed at five of the portable classrooms. Additionally, a high-efficiency Trane rooftop unit was installed on the multi-purpose room. The weight of the new unit exceeded what was allowed by code, so the team worked with the manufacturer to customize the unit with lighter weight aluminum components so the overall weight would be acceptable.

A building management system upgrade tracks and controls all HVAC units. The software tracking features enable the district facilities manager to easily identify malfunctions in the system, saving time in daily operations and enabling quick correction of problems that arise.

## Renewable Energy Generation

The team determined that a 108 kW photovoltaic (PV) array would generate 150,400 kWh/year and enable them to meet their ZNE goal with a 20% safety factor. With the goal to reduce operating costs in mind, the school district made the decision to produce all of their electricity on site. Due to the challenge of adding weight to the roof, the PV system was ground mounted and fenced-in on the recently acquired lower campus.

“The ultimate goal is a learning environment that’s the best that we can possibly get.”

-Sue Wesselius, Facilities Consultant for Newcastle ESD



Credit: Newcastle Elementary School District

### Occupant Engagement

Training teachers and students on how to use the lighting and daylighting system was critical to ensure optimal performance. The team also developed a controls and equipment manual and trained facilities managers on efficient building operation and the proper use of controls.

### Future Plans

A five-year district fiscal plan includes a budget for facilities improvements. Prop 39 and the ZNE pilot has increased awareness that measures to enhance energy efficiency can also enhance student performance and well-being. Moving forward, the district intends to be more proactive with facilities issues. Future school improvement plans include interior finish replacements in the existing facilities as well as retrofit of a new site with three small existing buildings. Thanks to a successful ZNE retrofit, energy efficiency and student performance will be top considerations.

Through this project, the district also discovered that lease-leaseback is an efficient financing strategy for retrofits. Lease-leaseback allows school districts to lease real property from a contractor who builds on district property. Districts may enter agreements based on qualifications, value and total guaranteed maximum price. Lease-leaseback offers districts flexibility on financing because costs are paid back over several years. This allowed the district flexibility in contractor selection, and it guarantees the district can conduct concurrent projects without the risk of losing funding for any one of them.

## Lessons Learned

- When targeting zero net energy, even small design moves matter. The team for a ZNE school retrofit needs to have a high awareness during on-site assessments to identify cost-effective strategies.
- Preliminary analysis determined the efficiency measures with the highest return on investment were lighting and HVAC, yet the comprehensive nature of the project allowed the district to bundle efficiency measures, combining measures with long and short-term paybacks.
- The project team encountered several regulations that served as roadblocks to achieving ZNE. Instead of new fixtures, the team settled for LED lamp replacement, gaining some, but not all of the efficiency potential of a lighting upgrade. The team also had to work with manufacturers to re-engineer new equipment to address increased weight, which added to the project cost.
- Other concurrent projects in the district presented challenges for the ZNE team. Engineers were continually forced to respond to unexpected changes in the existing buildings due to competing goals of projects unrelated to the ZNE retrofit.
- As challenges arise in retrofit construction projects, the design team must continually reevaluate the design. Lead paint and asbestos are often found in old schools, and the team found both during the installation of Solatube skylights. Early materials testing and identification or anticipation of these challenges can help manage project costs.
- Summers-only construction schedule for schools is a challenge, especially when unexpected things like an unfavorable ruling from the state architect or local code official can delay the project. Thorough and proactive investigation, planning and design review can pave the way for a smooth project.

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

