

# Emerging Zero Net Energy School Retrofit Case Study



Ralston Intermediate



Santiago High School Science Building

## OVERVIEW

**Location:** Garden Grove, CA  
**District Size:** 45,000 Students  
**Number of Campuses in District:** 72

### School Size

**Santiago High:** 169,358 SF  
**ZNE Project Size:** 8,069 SF  
**Ralston Intermediate:** 75,123 SF  
**ZNE Project Size:** 6,954 SF

### Original Construction

**Santiago High:** 1961  
**Ralston Intermediate:** 1952  
**Retrofit:** 2017  
**School District:** Garden Grove Unified School District

### School Enrollment

**Santiago High School:** 2,214  
**Ralston Intermediate:** 643  
**CA Climate Zone:** 8

## GARDEN GROVE SCHOOL DISTRICT

### Santiago High School Science Building & Ralston Intermediate Building K: Multipurpose Room & Kitchen

Garden Grove Unified School District (GGUSD) is a large, low-income school district that has recently become a regional leader in Zero Net Energy (ZNE). Seventy percent of GGUSD's students are eligible for Free & Reduced Price Meals (FRPM). Among California's 140 school districts with greater than 65% FRPM, GGUSD was the highest-performing district for both Math and English Language Arts on the state's 2017 Smarter Balanced Assessment Consortium (SBAC) test.

Historically the district has prioritized investment of scarce resources into its students, rather than into its facilities. However, an estimated \$11.5 million allocation from the state funded Proposition 39 Clean Energy and Jobs Act ("Prop 39") allowed the district to think beyond maintaining and repairing existing building systems, to replacing systems with more environmentally sustainable alternatives. The district was able to leverage its Prop 39 funds with approximately \$130 million in one-time capital facilities funds and \$858 million in bond money that the district had issued for its first modernization program in decades. In addition, the Proposition 39 ZNE School Retrofit Pilot program, administered locally by Southern California Edison (SCE) and SoCalGas, provided funding to further enhance the project to capture measures that support ultra-low energy and ZNE performance.

GGUSD proposed two different ZNE retrofit projects. The Santiago High School project is a high school science building which will become a living laboratory for students. The other is Ralston Intermediate School's multi-purpose room and kitchen referred to as "Building K", which includes a central kitchen that serves 5,500 meals each day.

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

## Team

**Owner:** Garden Grove Unified  
School District

**ZNE Pilot Consultant:**  
Climate Resolve

### *Santiago High School Project*

**Architect:** WLC Architects, Inc.

**Engineer:** P2S Engineering, Inc.

**Structural Engineer:**  
KNA Consulting Engineers

**Main Design Report Consultant:**  
DNVGL

**M&V and Final Report Consultant:**  
Lincus, Inc.

### *Ralston Intermediate School Project*

**Architect:** WestGroup Designs

**Engineer:** P2S, Engineering Inc.

**Structural Engineer:**  
KNA Consulting Engineers

**Main Design Report Consultant:**  
NORESKO

**M&V and Final Report Consultant:**  
Lincus, Inc.

## Planning + Design Approach

### Stakeholder Engagement

Like many school districts, GGUSD has maintained facilities in the district to the highest standard possible with limited budgets and a culture of frugality. Their Director of Facilities was widely respected within the district for her efforts. She became the champion within the district and convinced stakeholders and decision makers that the retrofit to ZNE was a wise decision for the district.

The ZNE project team meets weekly with key stakeholders, including the Facilities Director and Project Managers who are developing an understanding of ZNE that is quickly becoming part of the district's institutional knowledge. The team brings others into the project workflow early and then when necessary during the process. For example, the district's Food Services Office is a key participant in the retrofit of Ralston's kitchen to reduce energy consumption. Additionally, at Santiago High School a student sustainability council has been working with the project team as they conduct research into the behavior of the building occupants.

### Project Goals

The Santiago project science classroom will serve as a hub for the school's environmental student groups where students are provided with energy use data to use for hands-on learning opportunities and STEM educational practices. In addition to this direct link to the curriculum, another goal in the project was regarding energy targets. Projects in the ZNE retrofit pilot aim to achieve a site Energy Use Intensity (EUI) between 18-24 kBtu/sf/yr. At the Santiago Campus, the project team is aiming for an EUI of 24.7 kBtu/sf/yr and with added renewable generation on site. To generate significant onsite energy needed to achieve ZNE, GGUSD plans to fund the installation of PV carports in an adjacent teachers' parking lot.

The goal of the kitchen retrofit at the Ralston Intermediate School is to demonstrate best practices that can be replicated across the district. The team realizes that achieving ZNE for a kitchen with high process load energy use will be a challenge therefore they intend to take a phased approach to energy conservation measures with an ultimate goal of ZNE. GGUSD plans to fund PV carports in an adjacent teachers' parking lot, and may also install PV canopies to provide shade for the students' outdoor lunch benches next to the kitchen.

### Building Assessment

The team investigated all opportunities for improvements during building assessments. Lighting upgrades are an obvious opportunity for energy savings. Beyond that, the team conducted walkthrough inspections of building envelope and energy-using equipment to further determine building energy usage and energy conservation opportunities. The savings-to-investment ratio (SIR) analysis required for the Prop 39 program gave GGUSD visibility into projected cost savings associated with investing in advanced Energy Conservation Measures (ECM).

## Energy Modeling

Extensive energy modeling helped the district achieve a balance between energy savings and cost-effectiveness. The team used eQuest to run various energy conservation package options. At the Santiago site, the team used EnergyPlus software to assess the ECM's. The approach the team used was a combination of assumptions such as estimating gas use in ovens at Ralston based on operating schedule for the site and using data loggers to adjust the model assumptions. They also integrated daylighting modeling using Lightstanza to investigate daylighting scenarios.

Teachers at Santiago collected information to get a better understanding of when they turned lights on and off and what HVAC schedule and temperature set points they maintained in various spaces. This information improved the accuracy of energy conservation estimates in the model 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

Lighting and daylighting retrofits focused on improving lighting quality and reducing the need for electric lighting. The team pursued high quality LED fixture replacements and occupancy sensors in classrooms and common areas. Each classroom now has two to three tubular skylights with integrated daylighting controls to encourage occupants to open blinds and to encourage natural light as the primary source of illumination in spaces. At Santiago, the team performed a daylight autonomy which informed the correct placement of Solatubes for the classrooms. This study also indicated that the only glare condition existed in the winter time when the sun is at a lower profile in the sky after 4:00 PM when classrooms were unoccupied.

Part of the overall retrofit included an upgrade of the lighting in the Ralston kitchen. They had old, linear fluorescent lighting throughout the cooking spaces and walk-in coolers which was upgraded to the latest LED technology during the summer of 2017. This reduced the kitchen lighting load by approximately 50% and improved the light quality in the space.



Credit: NORESCO

*Ralston Intermediate Lighting Before Retrofit*



Credit: NORESCO

*Ralston Intermediate Lighting After Retrofit*

### HVAC

Classroom temperatures in Garden Grove have exceeded 100 degrees Fahrenheit at certain times of the year so the district is installing air conditioning in all facilities, up from 15% of facilities just three years ago. HVAC systems were upgraded to a higher performing DX Cooling (4 ton @ 16.4 SEER; 6 ton @ 13 EER/20.3 IEER) with improved heating efficiency (82%) with a differential dry bulb economizer. For the Santiago ZNE project, GGUSD realized that the new air conditioning systems could cause its energy costs to spike without additional energy efficiency measures.

New HVAC is being installed at all campuses as part of the district’s modernization plan. After the first phase of modernization, the Facilities Department discovered that new HVAC units were on while doors and windows were left open; occupants were still behaving as they had when there was no HVAC, and were consequently wasting energy. The district recognizes that a technological interface with human behavior may improve the energy efficiency of the Santiago ZNE project. The district is planning to install technology to notify occupants in order to optimize the use of natural ventilation instead of HVAC, and conversely to ensure that HVAC is not operating when windows are open.

	NO AC (Heating Mode)	Fan Only (Economizer Mode)	AC (Cooling Mode)
Windows Closed	 <b>Window Closed (Heating Mode)</b> Interior High Temp: NA Exterior High Temp: NA Interior Low Temp: 68°F	 <b>Fan Only (Economizer) Window Closed</b> Interior High Temp: 78°F Exterior High Temp: 75°F Interior Low Temp: 68°F	 <b>AC Running with Compressor Window Closed</b> Interior High Temp: 78°F Exterior High Temp: NA Interior Low Temp: NA
Windows Open	 <b>Window OPEN (only)</b> Interior High Temp: 82°F Exterior High Temp: 78°F Interior Low Temp: 68°F	 <b>Fan Only (Economizer) Window OPEN</b> Interior High Temp: 78°F Exterior High Temp: 75°F Interior Low Temp: 68°F	<b>Not applicable: AC does not run when Windows are OPEN</b>

Modeled Santiago High School HVAC System Set Points

Credit: DNV GL

The Ralston site originally had poor ventilation in the kitchen due to outdated systems. Kitchen refrigeration equipment upgrades suggested by the ZNE pilot program team included ECM motors, smart controls, low global warming potential (low-GWP) refrigerant, and high-efficiency coils. The team also decided to upgrade all four compressor/condenser units and evaporator units with high-efficiency equipment.



*Santiago High School Windows*

“GGUSD has made an investment in the Ralston pilot project so they can transfer best practices to reduce energy consumption and operating costs at their other central kitchens.”

– Seth Jacobson, Climate Resolve

## Envelope

Envelope sealing and improvements at Santiago High School were integrated into overall plans for building improvements. Window replacement is expected to create a more comfortable learning environment by improving thermal performance and natural ventilation. As part of the roof replacement, the team upgraded insulation to R-30 and added a reflective surfacing with a solar reflectance index (SRI) of 112

After deep analysis at the Ralston site, the team determined that the envelope improvements would not have a reasonable payback and were not included in this retrofit.

## Renewable Energy Generation

To generate significant onsite energy needed to achieve ZNE, GGUSD plans to fund the installation of photovoltaic (PV) carports in adjacent teachers' parking lots at both sites and PV canopies at the Santiago site. GGUSD currently plans to install a 36 kW PV system at Santiago and a 77 kW PV system at Ralston. These system sizes may be refined based on the results of building-level metering.

## Occupant Engagement

At Santiago High School, a software dashboard will track and display real-time energy data from the campus electricity meter and from dozens of monitoring touchpoints throughout the ZNE project in the school's Science Building. Students, teachers, and staff will be able to access the dashboards to view real-time energy consumption and savings due to behavioral change.

The behavioral program will train student leaders within the school's Student Sustainability Council to engage other students, teachers, and staff on actions to reduce energy consumption on campus each day. Students, teachers, and staff will compete to reduce their energy consumption for prizes and recognition. Sub-meters at Santiago's Science Building will allow the six classrooms within the building to compete against each other; the software dashboard will track and display real-time energy consumption by each classroom.

## Future Plans

These deep energy retrofits and renewable energy projects serve as examples that can be replicated across the district. Many ECMs including solar tubular daylighting devices, lighting controls and automatic dimming will further reduce the lighting load to almost zero during daytime hours which account for most operating hours annually. The Food Services Office is so pleased with the impacts of these ZNE-related improvements that it recently announced that it is planning to implement the same measures at five other central kitchens in the district.

Commissioning is planned at both campuses and the energy dashboard will yield results that both the design team and the occupants can use to inform their ZNE operations. Detailed monitoring and verification was designed into the project early so that it could easily track multiple touch points throughout both of the buildings.

“Zero net energy projects make a difference by protecting the environment, saving money, and serving as a living laboratory for students.”

– Margie Brown, Director of Facilities

## Lessons Learned

- GGUSD is a low-income district with a culture of frugality. It did not change its values to invest in ZNE retrofit projects. Instead, its emphasis on financial thrift led it toward ZNE solutions. GGUSD’s leadership shows that under the right conditions, ZNE can make financial sense for any school district.
- Understanding occupancy and use patterns provides energy modelers with detailed information that can be used to most accurately calibrate energy model predictions.
- Every ultra-low energy retrofit measure at Santiago and Ralston needed to fit a normal budget without any “gold plating.”
- All pilot energy efficiency measures can be replicated across the district.
- Engaging stakeholders is an investment in cultural change regarding energy efficiency. This has been seen to be essential to achieving ZNE that over the long term. GGUSD believes that fostering this cultural shift among students, teachers, and staff may turn out to be the most cost-effective investment of funds toward achieving ZNE across the district.
- The central kitchen at the Ralston presented interesting challenges regarding ZNE. During the Ralston evaluation, the team identified six ECMs to implement in the Ralston building. Currently, the ECM’s that have moved forward are the kitchen lighting retrofit, walk-in refrigeration equipment replacement, installation of Solatubes and light sensors. The additional ECMs will be installed at a later date as part of the pilot program and include replacement of hood exhaust fans, a modified exhaust hood design and a make-up air unit with demand controls to improve ventilation and reduce uncomfortable kitchen temperatures. The team has separately sub-metered the Ralston kitchen so they can continually work to reduce energy loads and provide the best case for the installation of the additional ECMs.

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

