ZERO NET ENERGY EMERGING CASE STUDY

GETTING TO zero | San Diego

To inspire the next generation of science leaders, Ocean Discovery Institute creates learning experiences for young people traditionally excluded from science due to race, income status, and educational opportunity.

Ocean Discovery Institute | City Heights, CA
Credit: Ocean Discovery Institute

Overview Facts

Building size: 12,000 sf

Location: City Heights, CA

Construction Type: New Construction

Building Type: Education

Construction Year: February 2016

Occupied Date: 2018

ASHRAE Climate Zone: 3B

California Climate Zone: 7

Predicted Energy Use Intensity (EUI): 23.6 kBtu/sf-yr

Predicted Renewable Energy Production Intensity: 24.2 kBtu/sf-yr

Predicted Net EUI: - 0.6 kBtu/sf-yr

Ocean Discovery Institute

The Ocean Discovery Institute Living Lab (the Lab) is a brightly colored seed planted on Manzanita Canyon's doorstep. The Lab aims to germinate and grow interest in scientific exploration and research for students from 14 San Diego Unified School District schools. Three years after opening, the non-profit supports 7,000 students annually with augmented school curriculums, after-school programs, and field trips at their zero net energy (ZNE) facility.

The Living Lab is a two-story, 12,000 square foot building located on a 28,000 square foot site in the City Heights neighborhood of San Diego. The U-shaped building has one wing that figuratively reaches toward nature, and the other stretches into the surrounding community, welcoming students.

Lessons Learned

1. Success is dependent on an advocate that aligns the team toward project sustainability goals from day one through operations.
2. Choose a design team that is committed and wants to work together.
3. The target EUI should be equal to or less than the available annual on-site renewable energy generation.
4. Energy end-use submetering is a fundamental requirement for ZNE buildings to have visibility into the energy consumption and fine-tune excess energy during operation.
5. A robust commissioning plan ensures that the systems are correctly installed and that energy data is reliable.
6. Buildings should be created *by* the community instead of *for* the community to meet the actual needs over the assumed community needs.

Planning and Design Approach

In 2007, after a decade of providing science education in San Diego, it was time that the Institute had a permanent home in the community it served. The Executive Director of Ocean Discovery Institute, Shara Fisler, is an energy efficiency advocate who wanted their new building to be a model for the community. She knew that they needed a team that was also committed to their north star. The Institute staff interviewed many designers to find the right team in 2008. Together, they toured buildings to understand what they liked and didn't like. They also saw that success was linked to having a sustainability advocate on the team from the start through day-to-day operations.

Project Goals

From the beginning, the Institute knew that sustainability was essential and that the building would be a ZNE, LEED Platinum building. Fisler stated, "when we set out to design the Living Lab, achieving ZNE was an important goal. As an organization that promotes environmental stewardship with our students in City Heights, we wanted to 'walk the walk' and make sure our building was sustainable."

Since the lab component could be an energy-intensive program, the team committed to studying the energy efficiency opportunities in detail, down to specific equipment. The team was focused on only consuming as much energy as could be generated by on-site renewable energy over a year.

Stakeholder Engagement

Community engagement was another important goal for the Institute. A broad stakeholder group was assembled to ensure that the Lab would be authentic to the community's needs while driving scientific education. Among the 40 project advisors included a youth advisory council, City Council members, and other students. Additional stakeholders were engaged when the advisory team attended over 50 community meetings in English and Spanish and translated information into 30 languages; They also visited neighbors' homes, attended street fairs, spoke with other non-profits, and visited schools to talk with students and teachers alike to understand the needs of the community.

During the engagement process, community members shared many thoughts on the building and program needs and desires, even down to the color of the building. Local residents wanted bright colors to reflect the vibrancy of the community ensuring the building felt welcoming to all. In the end, sunny yellow sunflowers and red-orange California poppies inspired the final exterior building colors.

An advisory board and a diverse stakeholder group helped ensure that the building would be authentic to the community's needs while driving scientific education.

Project Team and Awards

Project Team Owner/s: San Diego Unified School District, Ocean Discovery Institute

Architect: Rob Wellington Quigley

Contractor: Soltek Pacific

Energy Consultant: Stōk

MEP Consultant: MA Engineers

Civil Engineer/Landscape: Spurlock Landscape Architects

Commissioning Agent: MBO

Awards: LEED 2009 Platinum, 2019 SDG&E Energy Champion Awards

Facility

The facility includes:

- Dry and wet labs
- Offices
- Meeting rooms
- Commercial kitchen
- Outdoor teaching spaces
- Gathering spaces for media presentations
- Artwork
- Nature play
- Stand-alone scientist in residence studio

Curriculum

The curriculum provides:

- Ocean and canyon science education and exploration
- Scientific research
- Environmental appreciation and stewardship

Feasibility Assessments

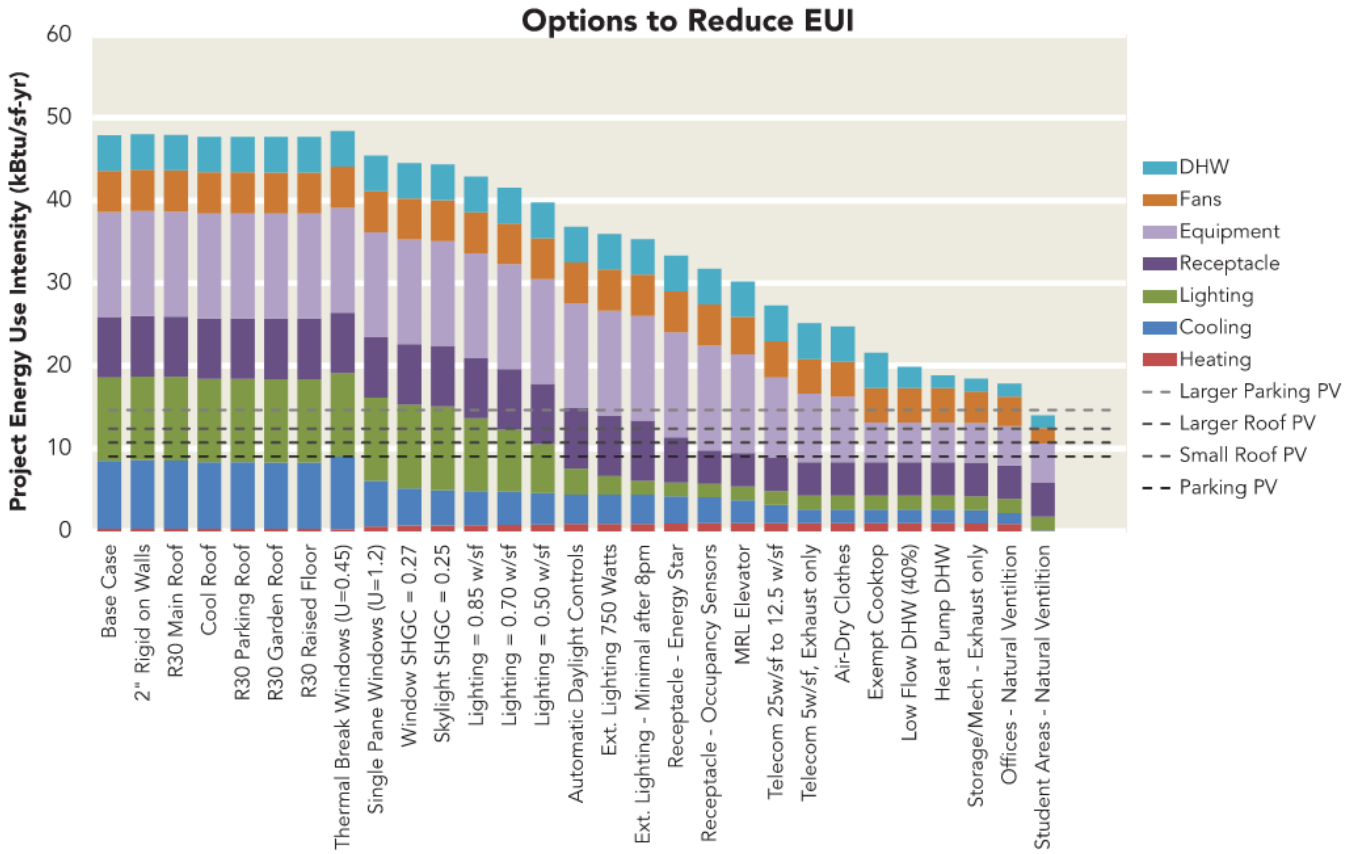
An energy consultant was brought onto the team early in the process to support the energy analysis. A prolonged design period allowed the science organization to install a weather station and collect five years of weather data. This hyper-local weather information helped the design the team understand the temperature, rainfall, sunny and cloudy days, wind speed, and direction. The data supported design decisions on the optimal envelope and the location of operable windows and renewable energy.

Energy modeling identified the main efficiency measures early, allowing the team to dive into the details and fine-tune the efficiency further as the design progressed. Daylight studies helped to identify window placement for daylighting. The results identified potential glare issues and the appropriate window overhang length. Computational fluid dynamic (CFD) modeling defined airflow patterns and supported the analysis of passive cooling options for the laboratory.

Early energy modeling and other analysis allowed the team to deliver a state-of-the-art science education building while meeting their budget-conscious ZNE goal.

Energy Modeling

The team studied over 30 building configurations to evaluate different efficiency measures, on-site photovoltaics (PV) siting, and how each iteration's efficiency and energy generation changed. In addition to assessing the energy consumption of the equipment needed on opening day, the team also evaluated different growth scenarios and how increased occupancy would change future energy demand.



Energy modeling analysis of different building systems.
Credit: Stōk

Financing Costs and Benefits

Public and private funding brought the Living Lab to life. $11.8 M of the $18 M budget came from San Diego Unified School District through Prop Z, a $2.8 B school bond approved by San Diego voters in 2012. Prop Z was intended to provide every neighborhood with a quality school by providing funds to repair, renovate and revitalize schools. Additional funding was raised through individual donations, foundational grants, the California State Parks, City of San Diego, and California Coastal Conservancy. San Diego Gas & Electric's (SDG&E's) Savings by Design incentives funded early energy analysis and offset costs associated with energy efficiency measures.

The Institute will continue a relationship with the school district for the next 40 years, offering tuition-free education for up to 10,000 students per year.

Energy Efficiency Strategies and Features

Building Envelope

The sloping site limited the building's orientation options. The team studied programming distribution between the two floors to maximize space and efficiency. The concrete masonry unit (CMU) and poured concrete exterior walls are nestled into the hillside, with the U-shaped building opening to the East and partially to the North as the site gently descends into the mouth of Manzanita Canyon.

Energy modeling confirmed that the building was cooling-dominated and that the envelope influenced heat loss/gain less than anticipated. This information allowed the team to optimize construction costs by not including more insulation than was needed. They also chose not to purchase triple-pane glazing since the modeled energy savings did not support the additional investment.

Lighting and Daylighting

Inside the Living Lab, daylight is optimized over electric light to reduce energy demand. The inside portion of the U-shaped perimeter is mainly glazing to light the interior. The windows are a mixture of single-pane glazing and insulated low emissivity glass, depending on the location. Low emissivity glass (also known as low-e glass), is coated with an ultra-thin transparent material that limits how much heat can radiate through a window, limiting solar heat gain. The project also includes skylights, solartubes, and motorized clerestory windows flooding the space with daylight. Modeling helped identify the depth of the deep overhangs that shade the glazing, lessening solar heat gain. The overhangs also reduce internal glare conditions.

Heating, Ventilation, and Air Conditioning (HVAC)

Foregoing mechanical air conditioning was the boldest energy reduction strategy implemented at the Living Lab. CFD modeling evaluated the airflow, focusing on the thermal comfort in critical spaces. The results showed that the areas would be out of the thermal comfort range on occasion, but this was a small price to pay for the energy reduction. The concern was that if mechanical air conditioning were provided, they would use more air conditioning than was designed. However, good design could address most of the thermal comfort factors to improve comfort. While air temperature, radiant (surface) temperature, and relative humidity, may be slightly out of range, air velocity, clothing factors, and metabolic heat are addressed through passive ventilation and fans, dress code, and activity level inside the lab.

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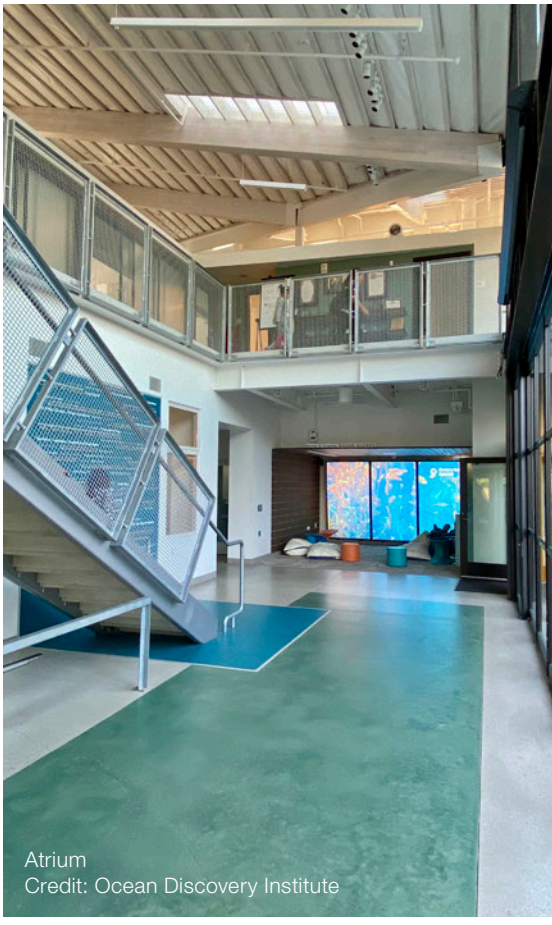
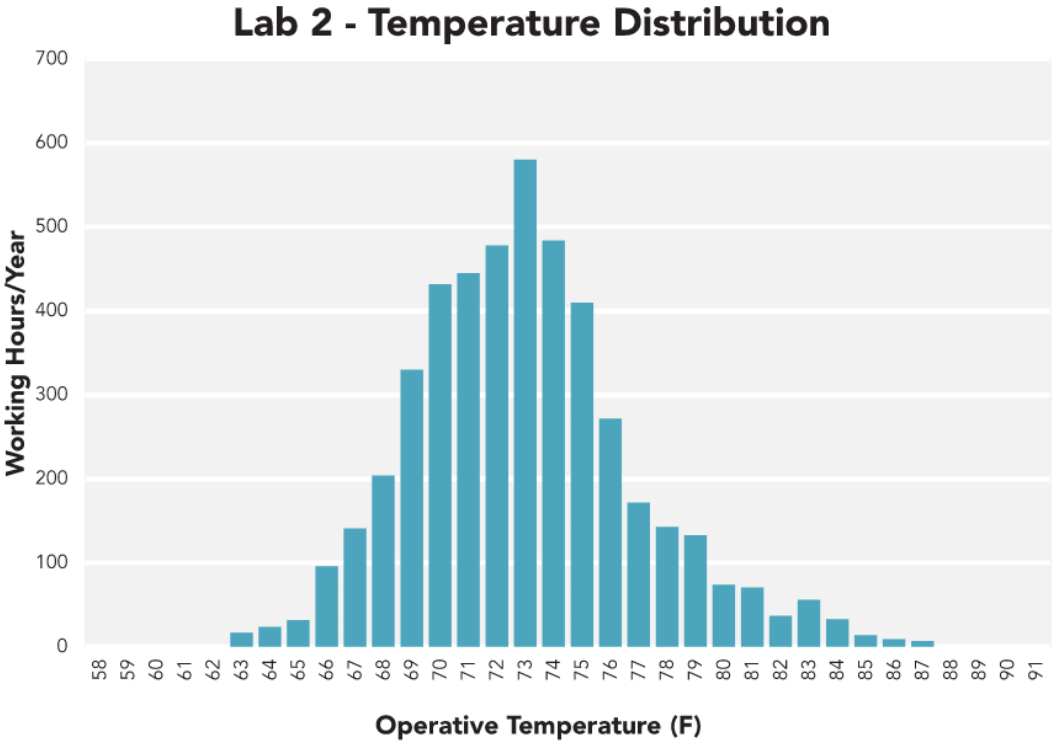
Shara Filer, Executive Director.



Atrium
Credit: Ocean Discovery Institute



The thermal comfort study evaluated the frequency (number of hours) of the internal building temperature. Traditional thermal comfort ranges from 67 and 82 °F, depending on airspeed, humidity, and other factors. Credit: Stōk

The Living Lab operates as a field station with a curriculum focused on exploration. As a result, students are frequently outside, experiencing the elements as working field scientists do. Knowing this, students are asked to dress accordingly and are prepared for warmer temperatures.

Operable windows bring in the cool morning air on temperate days. Students and staff are encouraged to use data to ensure a comfortable working and learning environment. They can check the site-specific weather from the on-site weather station through an app on their phone, or at the on-site weather station consuls and make decisions to open and close windows, turn on fans, close shades, etc.

Mechanical heating and cooling are provided in limited spaces. Specifically, three mini-split heat pump units are located in the server room, elevator machine room, and residential studio. In addition, a few spaces within the Lab utilize the gas boiler for fan coil heating units.

The school closes when the building cannot be passively cooled, or the outdoor temperature is extremely hot. After three years in operation, hot weather has only impacted three days of after-school programs.

The lab operates like a field station; the students are frequently outside, experiencing the elements as working field scientists.

Domestic Hot Water

A high efficiency gas boiler supports the relatively low domestic hot water needs in the kitchen, washrooms, and the wet lab. While reviewing the energy and water data post-construction, the team has continually fine-tuned the energy demand. For example, they recently identified that the boiler's temperature could be lowered from 140 degrees Fahrenheit (F) to 120 degrees F. The energy savings from this continuous fine-tuning suggests that buildings on a tight energy budget benefit from detailed energy submetering and require continuous commissioning and adjustment.

Sci-Tech Lab
Credit: Ocean Discovery Institute


David C. Copley Ocean Alcove
Credit: Ocean Discovery Institute


Dissections during COVID
Credit: Ocean Discovery Institute

Monitoring and Controls

The Living Lab is just that, an active lab where even the building is part of the curriculum. Due to the tight energy budget, the team wanted to understand their energy consumption to help them meet the ZNE goal. The energy associated with lighting, heating, cooling, plug loads, kitchen equipment, domestic hot water, and audiovisual systems are metered and compared against the design-phase energy model. The submeters also parsed the energy by floor level and room. The granular data provides insight and real-time information.

The submetering data allows staff to understand where unnecessary energy is consumed and how to modify their behavior. LEED Enhanced Commissioning helped to ensure the submeters were installed property and that the data could be trusted to provide accurate information. After opening, the Institute met with SDG&E to review the energy demand and discuss energy efficiency.

Staff and students alike can access energy consumption and renewable energy production through an interactive display in the atrium, allowing occupants to view the progress toward ZNE. In the future, they hope to have the energy data more automated and user-friendly.

To achieve ZNE, the project team identified the available annual on-site renewable energy generation and set the energy demand to be less than or equal to this value.

Renewable Energy Generation and Storage

Only so much energy can be produced on the small, urban lot. So the design team developed a solar budget by identifying the maximum annual on-site energy generation and set this as the maximum energy that the building could consume. As a mixed-fuel building, the system was designed to overproduce electricity to offset the gas consumption and electricity. The 50.4 kW solar array is comprised of two solar "trees" located in the parking lot. The trees provide shading for the parking lot, which keeps the surface cooler. These solar arrays generate all the energy the building consumes over a year.

Solar Tree
Credit: Ocean Discovery Institute

Occupant Engagement

The Living Lab incorporates building science into their education curriculum. Students learn about building design features with tours of the facility. In addition, an energy dashboard inside the building informs the occupants of the energy consumption and renewable energy production.

Other Sustainability Features:

In 2021, the building was awarded LEED v2009 Platinum status. Beyond the efforts to achieve ZNE, the Living Lab also has a greywater system that collects non-potable water to irrigate the drought-tolerant plants. In addition, the lab includes numerous recycled, reclaimed, and regional materials. Even the furniture reflects the environmental stewardship with bean bags made from recycled sails and stools made from plastic that once polluted the ocean.

Future Plans

The Living Lab creates learning experiences for young people traditionally excluded from science due to race, income status, and educational opportunity. With the Lab's premise, "If I know how the world works, I can make a difference," the hope and impact is that graduates are inspired by their discoveries and are better prepared for a science career where they can change the future. As the program grows, the staff has seen the need to accommodate more students. Therefore, in the future, the office will be converted into classrooms to make more room for more future scientists.

Landscape
Credit: Ocean Discovery Institute

For more ZNE resources,
visit gettingtozeroforum.org.

Living Roof
Credit: Ocean Discovery Institute

nbi new buildings institute

New Buildings Institute (NBI) is a non-profit organization driving better energy performance in commercial buildings. We work collaboratively with industry market players—governments, utilities, energy efficiency advocates, and building professionals—to promote advanced design practices, innovative technologies, public policies, and programs that improve energy efficiency. We also develop and offer guidance and tools to support the design and construction of energy efficient buildings.

This program is funded by California utility customers and administered by San Diego Gas & Electric® Company under the auspices of the California Public Utilities Commission.