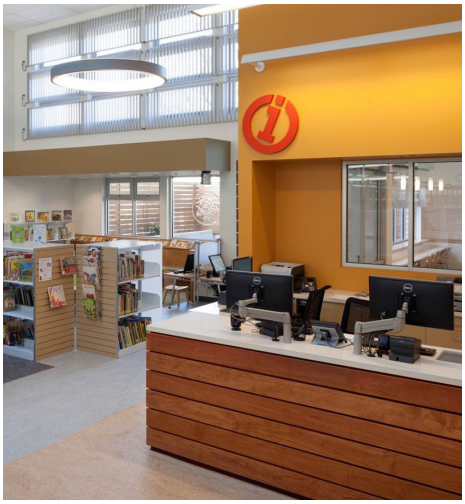
Zero Net Energy Case Study



Photos ®Mark Luthringer Photography

OVERVIEW

Building Size: 9,400 SF

Location: Berkeley, CA

Construction Type: New Construction

Completion Date: December 2013

Building Type: Public Assembly

CA Climate Zone: 3

Energy Use: Electric

Construction Cost: $5.5 Million

Measured Energy Stats

23 - 28 = -5

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

WEST BERKELEY PUBLIC LIBRARY

The West Berkeley Public Library is the first verified zero net energy (ZNE) public library in California. Completed in late 2013, the 9,400-square-foot library produces as much or more energy than it consumes on an annual basis. To reach its zero net energy goals, designers used a variety of innovative technologies and passive strategies. To ensure the proper integration of all the systems, the project's design team partnered with Pacific Gas & Electric (PG&E) to access resources from the statewide Savings by Design program that provided funding for simulations which were key to the design's success. The library is also one of the first projects to take part in the PG&E ZNE Pilot Program.

Planning & Design Approach

When the city issued a Request for Proposals (RFP) on the West Berkeley Library, Harley Ellis Devereaux (HED) was the only firm that proposed a zero net energy library facility. This garnered the attention of the planning team and ultimately helped win the firm the project, especially given this was proposed at no additional cost. To achieve this ambitious ZNE goal, the design team invested in a thorough suite of simulations to optimize the building performance within the tight urban environment. By focusing on passive strategies first, the design team was able to drive down the anticipated energy consumption of the building, which then made the task of generating enough energy to cover the consumption much more cost-effective and achievable.

The design of the library fully embraces both passive strategies and a "high tech" approach to building operation. The control system integrates the electric and thermal solar energy generation with the demand control ventilation, radiant heating and cooling, and lighting systems. The suite of modeling work included: climate, solar, daylighting, energy, and computational fluid dynamics. To offset the energy consumption, solar photovoltaics and solar thermal collection systems cover the roof of the building, along with a series of interspersed skylights. The complexity of the building was well designed and executed, and the result is a net-positive, energy-producing building.

Team/Owner Details

Architect: Harley Ellis Devereaux

Civil Engineering: Moran Engineering

Structural Engineer: Tipping Mar

Mechanical, Electrical, Plumbing Design Engineer: Timmons Design/Harley Ellis Devereaux

Landscape Architect: John North Roberts

Sustainability Consultant: Harley Ellis Devereaux

Audio Visual: Smith, Fause & McDonald Inc

Photography: Mark Luthringer Photography

Awards

AIA COTE Top Ten Award, 2016

LEED Platinum, 2016

Living Building Challenge Net Zero Energy Certified; International Living Futures Institute, 2015

East Bay Annual Design Awards, American Institute of Architects, 2015

Gold Nugget Award, Pacific Coast Builders Collaborative (PCBC), 2015

IES Illumination Award, Illuminating Engineering Society (IES), 2015

Photo®Mark Luthringer Photography

Policy

In 2009, the City of Berkeley came forward with a bold Climate Action Plan with a goal of driving down greenhouse gas emissions to 33% below year 2000 levels by 2020. City buildings in Berkeley are required to be LEED Silver, which helped steer the design team towards a high efficiency and low-carbon building. Additionally, the city recognized that achievement of their Climate Action Plan (CAP) goals required a very aggressive approach such that all new buildings should be on par with zero net energy performance. In 2008, the city passed a measure to help fund four new public libraries. These resources provided an opportunity to leverage new community funding and CAP goals to achieve the ZNE project.

Integrated Design Process

The project team worked closely with the City of Berkeley and library staff throughout the project. The design was highly responsive to the climate and site context and used complex modeling to ensure the building could take full advantage of these local conditions to minimize energy usage. Involving mechanical and electrical engineers in early design sessions allowed the team to explore strategies reflective of local climate and building type and fostered a truly integrated design process.

Financing

The project is the first publicly funded ZNE library in California. With a $5.5 million construction cost (including all change orders), the cost per square foot is comparable to that of similar library buildings in the same area that were built in the same time period but without the zero net energy performance attribute.

The additional incremental costs of $43,000 for modeling work to properly design the natural ventilation, solar renewable system, and other complexities were completely offset by a grant from the PG&E Savings by Design program. The project also received a standard Savings by Design incentive that went directly to the owner.

Energy Efficiency Strategies and Features

Lighting and Daylighting

The library takes full advantage of the natural sunlight with a series of skylights and a large glass facade designed to eliminate the need for artificial lighting during the day. Given the operating hours of the library, this reduces lighting energy to near zero. Electrical lighting is tied to daylight sensors, which is used to supplement the daylight on cloudy or darker days.

Envelope

The library envelope provides excellent thermal and acoustic insulation, maximizing energy performance and comfort for occupants. A triple-paned, store-front glazing system along noisy University Avenue helps manage acoustic performance. The vestibule at the entrance maintains pressurization in the building, and prevents warm or cool air from escaping.The envelope also included a cool roof with an R40 insulation value, R31 walls when considering the thermal bridging at the microlam studs. Further, the building was built on a 12” structural slab, with a single layer of rigid insulation between the 4” radiant slap and the 18” mat slap. All conduit was run beneath the mat slab.

Photo©Mark Luthringer Photography

"In 2009, the City of Berkeley adopted their climate action plan with an aggressive goal: reduce greenhouse gas emissions by 33% (below 2000 levels) by 2020 and by 80% by 2050. To reach their target, the city realized they would need every new building to operate at net zero energy."

—ILFI W. Berkeley Library Net Zero Case Study

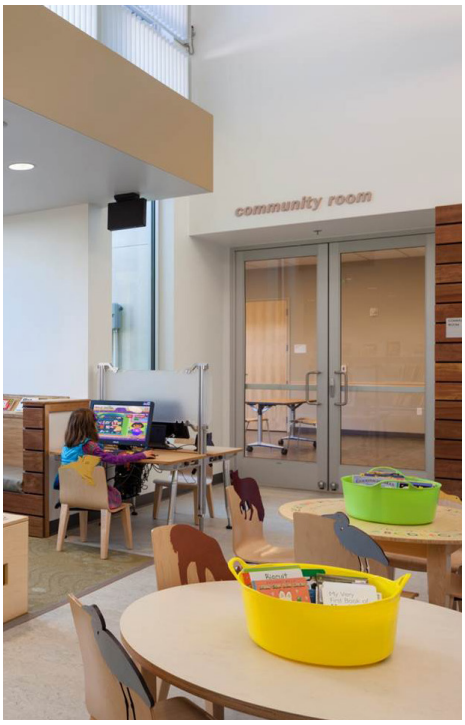
HVAC

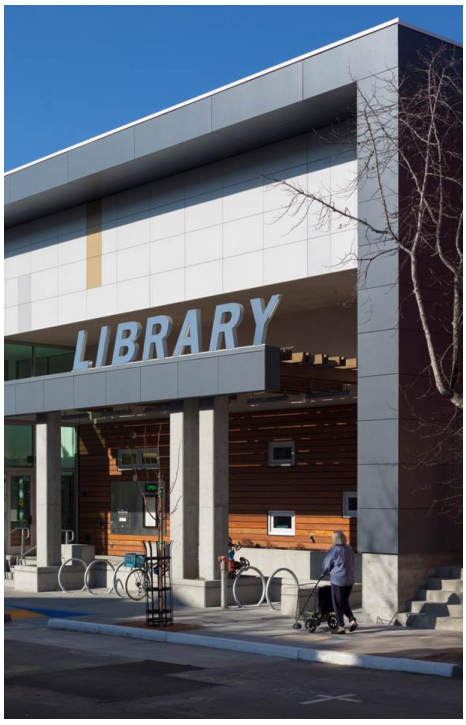
The library's primary mechanical system is a hydronic radiant slab used for both heating and cooling. The radiant system is only used during peak loads when comfort conditions can't be met by purely natural or assisted natural ventilation alone. To supply the radiant system, the solar thermal collector and heat pump operate in a primary-secondary function, with the heat pump supplementing the solar collector as needed to meet water temperature set points.

Natural ventilation is an important part of the design. Manually operable windows are in a position where patrons and staff can easily use them. Automatically controlled windows are located high in the space and have preheating hydronic convectors at the openings to prevent cold drafts caused by cold air entering the space in winter.

Plug Loads

Since this building was replacing the library's old location, they had the opportunity to study the existing plug loads to have a more accurate input for the energy model. Laptops are charged by staff and checked out to users to help limit plug loads and allow the staff to keep track of the energy consumed by the computers. Public electric outlets are provided at reading tables in the stack area and in wall outlets in the meeting room for patrons to use.





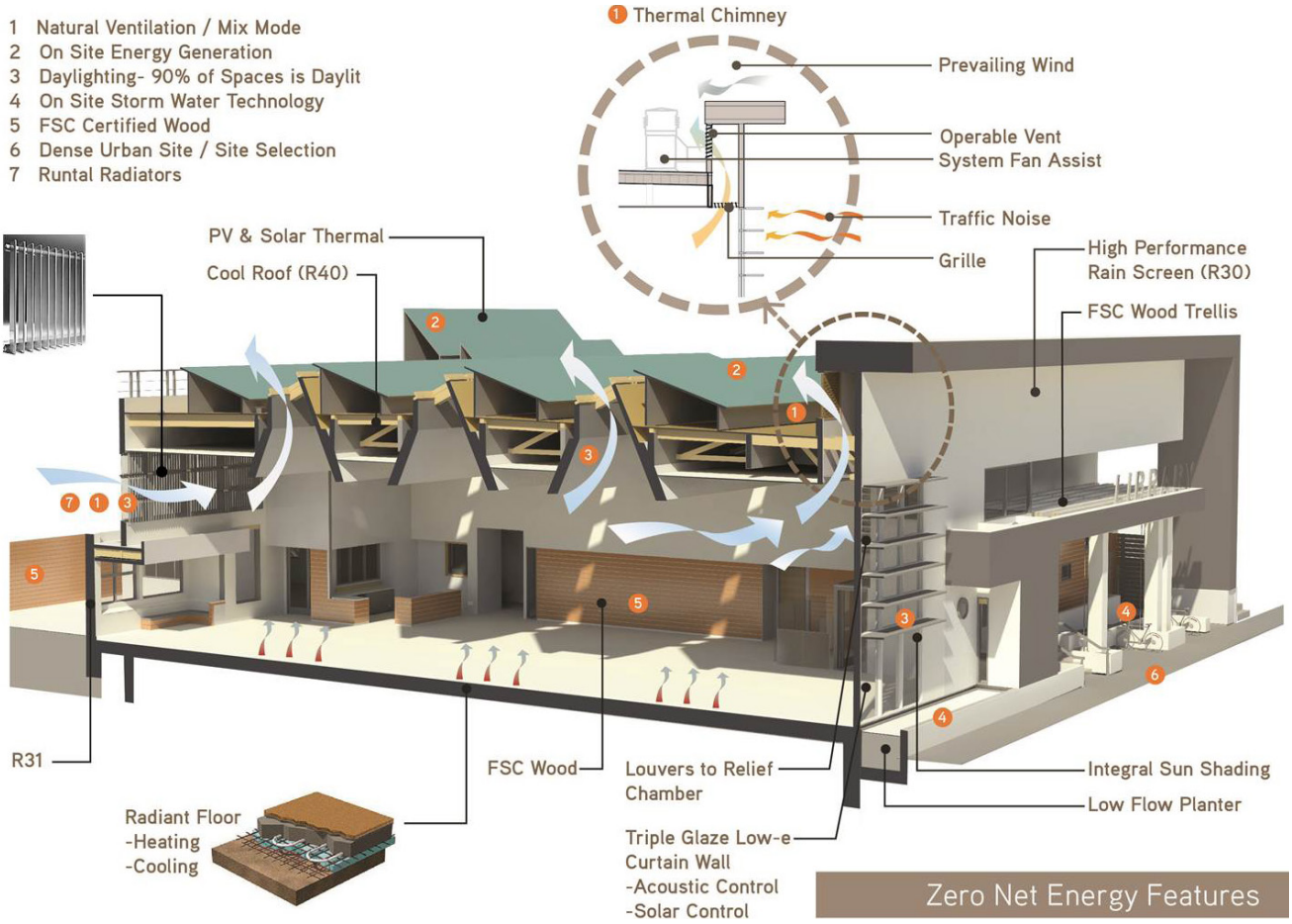
All Photos ®Mark Luthringer Photography

Controls

An integrated building automation system (BAS) controls the photovoltaic system, lighting, radiant heating and cooling. The HVAC system is controlled using several modes of heating and cooling, with various levels of natural ventilation, fan-assisted ventilation, and radiant heating and cooling. The systems are optimized for energy consumption and the lowest energy operating mode is used to satisfy the heating, cooling, and ventilation loads. If loads can't be met, the system incrementally incorporates fans and eventually the heat pump as needed to meet the loads with minimal energy use.

Renewable Energy Generation and Storage

Designing the solar panel configuration was one of the great challenges for this project. Given the tight urban density and nearby buildings shading the library, the design team used extensive modeling to optimize the solar design for the site, all while incorporating skylights to nearly eliminate the lighting loads. The project includes four photovoltaic (PV) arrays arranged between three rows of skylights, for a total of 120 panels. The library also has 16 solar thermal panels, which are arranged into two arrays in the northeast corner of the roof. New Buildings Institute (NBI) has evaluated the library's 2014 calendar year's performance and verified that the library is a zero energy building, with renewable energy production of 27.6 kBtu/SF/yr, and consumption of only 24.7 kBtu/SF/yr. With a small amount of overproduction, the project has achieved a verified net positive energy performance.



Post Occupancy

Commissioning

The project process included both LEED-enhanced commissioning and ZNE commissioning to ensure the basis of design was met. Commissioning staff participated throughout the process from monthly meetings early in the design phase and into construction, then weekly meetings were needed as mechanical systems were being installed. Further involvement of the commissioning agent included training of staff and operators at occupancy and then continued tweaking and tuning to ensure systems were properly operating.

> "A lot of care went into this building, almost everything you see isn't just for looks. It has a specific function."
>
> —*Gerard Lee*
> *Project Architect, Harley Ellis Devereaux*

Monitoring

In order to track and maintain the performance of the building, the energy consumption and generation are logged in the building management system. This allows the building operators to continuously monitor the building systems, tracking progress towards the goal of reaching net zero energy.

Behavior

The building has an energy dashboard at the entrance which shows the sustainable design features and current energy balance of the electrical loads and PV generation. Keeping the energy use of the building visible to staff and occupants helps raise awareness of energy consumption, which in turn leads to lower occupant-driven energy loads, such as plug loads. Library staff have educational materials to help inform both staff and public understanding of the building and staff routinely host public tours about the building's design and operations.

Photo©Mark Luthringer Photography

Lessons Learned

- An integrated design and procurement process can be helpful for a ZNE building. When competitive procurement policies and regulations prevent this, ZNE goals and energy targets must be clearly specified to ensure that the low bid does not remove the high performance and renewable energy components from the building when constructed.
- The early involvement of the engineers in design decisions, the use of computer modeling to set the parameters of the design and the testing of assumptions to confirm design choices were all critical to achievement of the project's performance goals.
- Be "ZNE aware" in decision making as integrated designs are often not friendly towards field changes. Commissioning contracts should also extend two years from occupancy to ensure longer tuning times needed in ZNE buildings.
- Computational Fluid Dynamics (CFD) studies paid off. The library has minimal comfort issues, which is largely attributable to the success of the natural ventilation system. In addition, the ventilation stack was lined with acoustic boards to keep the building quiet. For the 2014 calendar year, the library was net positive by approximately 3 kBTU/sf/year. This represents a renewable energy production excess of nearly 12%, making the project net positive.

Resources for More Information

- International Living Future Institute West Berkeley Library Case Study: http://living-future.org/case-study/berkeley
- Green Architecture and Building Report Case Study: http://www.gabreport.com/2014/05/californias-first-net-zero-energy-library

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

Pacific Gas and Electric Company

Southern California Edison
An Edison International Company

SDGE
A Sempra Energy utility

SoCalGas
A Sempra Energy utility