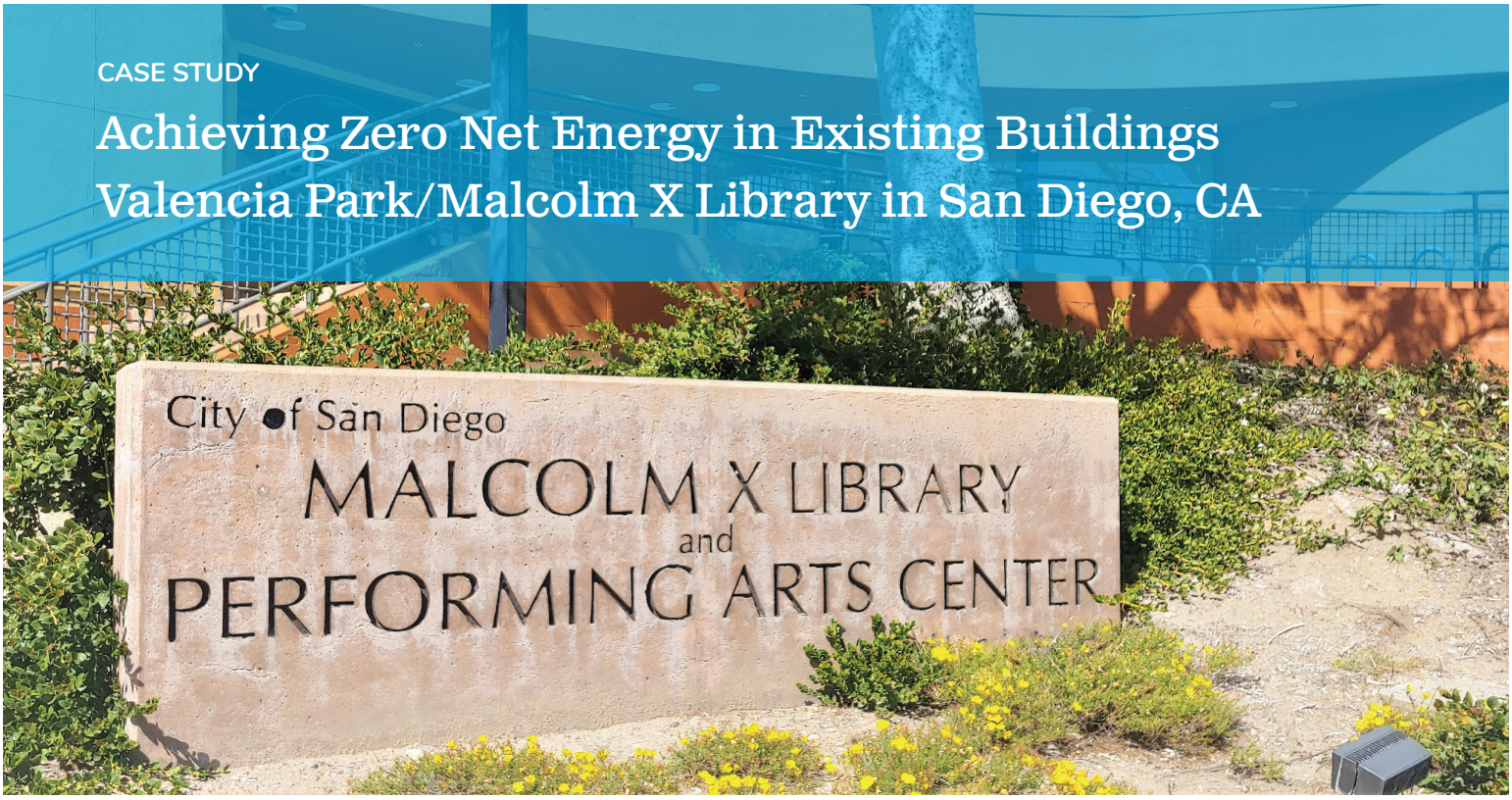
CASE STUDY

Achieving Zero Net Energy in Existing Buildings
Valencia Park/Malcolm X Library in San Diego, CA



California has aggressive goals to reduce energy use in residential, commercial and government facilities by developing and promoting zero net energy (ZNE) buildings that generate as much on-site renewable energy as they consume each year.

All new residential construction must be ZNE now, and by 2030, new commercial buildings must be ZNE. But the majority of California buildings already exist, so to be more effective, goals extend to requiring 50% of renovations of state buildings to be ZNE by 2025, and 50% of all existing commercial buildings must be ZNE by 2030. That means hundreds of thousands of buildings will need extensive energy upgrades over the next decade.

The San Diego Libraries ZNE and Integrated Demand Side Management (IDSM) Project, known as SD ZN3, was designed to establish a blueprint for maximizing energy efficiency and reducing the carbon footprint of municipal and small commercial buildings. With a $2.7 million grant from the California Energy Commission and in partnership with the City of San Diego, Mazzetti, Inc., M+NLB Construction Services, Inc., San Diego Green Building Council and San Diego Gas & Electric®, the Center for Sustainable Energy (CSE) conducted retrofit demonstrations at three existing San Diego branch libraries, including the Valencia Park/Malcolm X Library.

Energy Efficiency Measures and Solar

The library was outfitted with Energy Efficiency Measures (EEMs) and photovoltaic solar panels that together were evaluated for system performance, market viability, energy savings and capacity to participate in demand response.

Prior to the installation of energy efficiency measures and solar, the library consumed approximately 1,200 million British thermal unit (MMBtu) of energy annually consisting of more than 280,000 kilowatt (kWh)/year in

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electricity and approximately 190 MMBtu/year in natural gas. Electricity accounted for about 90% of the library's energy consumption, peaking in the summer months. After installation, electric use is estimated to be reduced by 28% and offset by 100% with solar generation.

System Design and Performance

Tridium Building Automation and HVAC Controls

A Tridium Niagara Version 4 (N4) building automation system (BAS) was installed at each library, and Viconics heating, ventilation and air conditioning (HVAC) controllers were installed at the Valencia Park/Malcolm X Library. The Tridium control system includes a supervisory-level control front-end system installed on a centralized City server along with a Java application control engine (JACE) with building automation and control network (BACnet) drivers and additional local operating network (LON) drivers to communicate to the existing Trane controls. The system manages all HVAC controls (new Viconics), on/off lighting controls and the smart plugs. It also reports real-time energy data from the energy monitoring devices installed at the libraries.

Solar photovoltaic

Solar photovoltaic (PV) systems, also referred to as solar electric systems, capture sunlight energy and convert it into electricity. PV systems were installed by the City of San Diego using Power Purchase Agreements (PPAs).

Energy End-use Monitoring Equipment

Energy end-use monitoring systems are measurement sensors that track energy consumption patterns of a building at a granular level. The installed sensors allow energy use to be broken down between HVAC, lighting, plug and other uses.

Lighting Retrofits and Controls

Light-emitting diode (LED lighting fixtures and/or lighting retrofit kits/lamps were installed and lighting control panels replaced with systems capable of BACnet communication for integration to the building automation systems and with additional local programming capabilities. The lighting controls integration allows for remote control of the lighting with on/off function of various zones preprogrammed and aligned for each library's operating hours. The local scheduling can be overridden after hours for a two-hour duration for the custodial staff. Overall lighting levels at all three libraries have significantly increased. Further, the new central lighting control systems and programmed lighting schedules ensure lights shut off to conserve energy, whereas before the retrofit, lights were left on after hours.

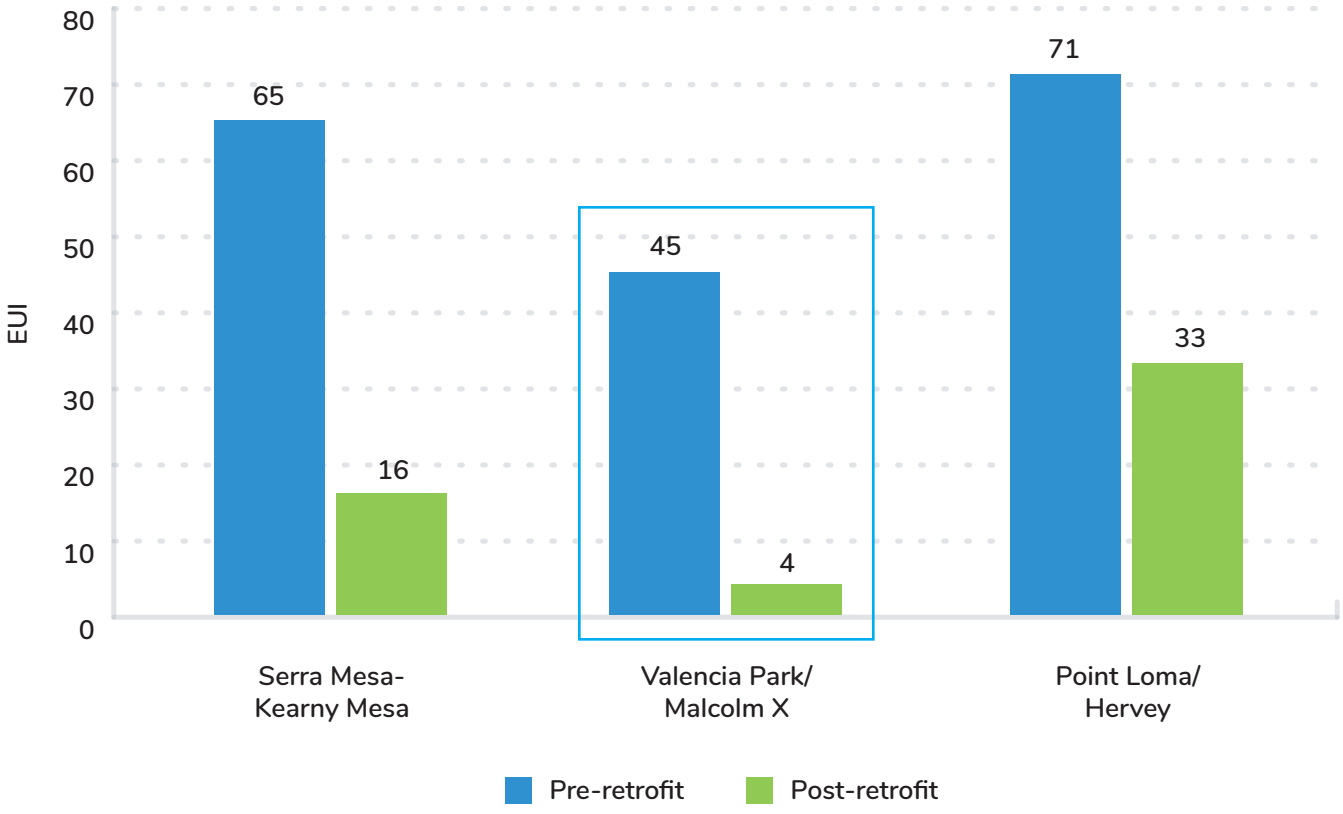
Plug Load Management

Plug load management devices, also known as smart plugs, control energy consumption for copiers, printers, kitchen appliances, vending machines, water coolers/heaters and small air conditioners or any other device that connects to an electrical outlet or wall receptacle. They were installed between the power cable for devices and the wall receptacle, and then connected to a Wi-Fi network to integrate on/off scheduling with the building automation systems. Smart plugs also have the capability to collect and report real-time interval energy consumption data.

Project Economics: Cost and Energy Savings

By installing energy efficiency retrofits, the library is projected to save $13,170 in energy costs per year, 32.8 kW in peak demand, 81,609 kWh and reduce greenhouse emissions by 57.7 metric tons, not including solar generation savings. The upfront cost of energy efficiency measures, installation and construction management was about $573, 000. Solar generation will produce about 230,283 kWh of renewable energy, and the Valencia Park/Malcolm X library is estimated to be near-ZNE status.

Energy Use Intensity (EUI)



Energy Dashboards

Valencia Park/Malcolm X's current energy use and current performance is available in near real-time on its energy dashboard available at energycenter.org/sdzn3.

Occupant Survey Results

To measure retrofit effects on employees and volunteers, surveys were conducted before and after the energy efficiency retrofits. There are several promising findings that show occupant behavior changes, building improvement and indicate further refinements that could help boost comfort and further increase behavior change.

The following are key findings from the pre- and post-retrofit surveys.

- **Awareness of energy efficiency measures:** Most respondents were aware of EEMs at their libraries.
- **Thermal Comfort:** After retrofits, most respondents reported an increase in thermal comfort at the front desk areas and workroom areas, which are areas staff reported spending a lot of time in, but they also still reported comfort levels varied between specific spaces at the three libraries.
- **Lighting brightness:** Respondents at Point Loma/Hervey and Valencia Park/Malcolm X staff seem satisfied with lighting brightness after the retrofits but it was noted lights should be replaced quickly if they burn out. Serra Mesa-Kearney Mesa reported the most dim or too bright areas.
- **Lighting sufficiency:** Lighting sufficiency varied in different workspaces at the libraries, but overall, respondents from all three libraries responded more positively about daylight and lighting sufficiency; brighter lights were still desired in some areas, while excessive direct sunlight was still reported in others.
- **Plug load management:** Responses were mixed on if the smart plugs were working properly. More education is needed on how to operate the installed smart plugs.
- **Behavior:** Half of all library respondents agreed their behaviors helped conserve energy after retrofits were complete. This was an increase from the pre-retrofit surveys, where more than half of respondents at all three libraries felt neutral.

LIBRARY TESTIMONIAL

> *"Returning colleagues and community members quickly notice and comment how much brighter the Valencia Park/Malcolm X Library appears. We enjoy telling them the lighting upgrades are also energy-wise and that combined with other improvements and our solar generation capabilities, the facility is approaching zero net energy use."*
>
> – Alan Bugg, Valencia Park, Malcolm X Library Manager

Conclusions

Key Successes

The SD ZN3 project estimates an overall reduction in electricity consumption at the three libraries to be approximately 239,704 kilowatt hours and 84 kilowatts, which amounts to savings of about $33,655 per year, not including solar generation savings.

Lessons Learned

The path to California's goal of ZNE in 50% of existing commercial buildings still has many opportunities for growth. The lessons and findings from this project can better inform future ZNE projects and the most relevant and applicable are the following.

- Identify the delta to ZNE (difference in building energy consumption and energy generation).
- Conduct pre-retrofit sub metered monitoring (measure building end uses separately: lighting, plug loads, HVAC, etc.).
- Isolate energy reductions by end use to achieve maximum savings (target energy efficiency measures that will reduce end uses with higher energy consumption first).
- Identify the right energy modeling tool for the project and perform additive modeling (many tools are available, but some are better at identifying savings for individual measures).
- Identify building cybersecurity and network requirements early on (these requirements vary and will impact install and material costs).
- Know the budget requirements (lighting upgrades and building controls are cost-effective ECMs for existing buildings but many emerging technologies are still too expensive).
- Plan for unanticipated repairs in existing buildings to bring systems into full operation (HVAC repairs may be needed to implement controls for example).
- Perform 12 months of post-retrofit monitoring (do not rely on "ZNE design" as there are many factors such as occupant behavior that impact a ZNE calculation).
- Develop plans for ongoing maintenance and retrocommissioning (additional budget will be required post-retrofit to maintain equipment and operations).
- Be adaptable and be prepared to learn new things (ZNE is a new design concept and as such, expect unanticipated design and construction challenges).
- Remember to share lessons learned.

For more information visit
EnergyCenter.org/sdzn3

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