



EPC-15-085: Annual Measurement and Verification with Cost-Benefit Analysis Report

City of San Diego Public Library ZNE Demonstration Project

Prepared for
California Energy Commission

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I. Introduction

The Center for Sustainable Energy (CSE) and the City of San Diego developed this *Annual Measurement and Verification with Cost-Benefit Analysis Report* as part of the California Energy Commission (CEC) EPIC demonstration project, EPC-15-085¹. This project is a demonstration of zero net energy (ZNE) and integrated demand-side management strategies that includes installing, testing and measuring energy conservation improvements in three San Diego libraries (Point Loma/Hervey, Serra Mesa-Kearny Mesa and Valencia Park/Malcolm X) with the goal of achieving ZNE or near-ZNE. These libraries are owned and operated by the City of San Diego, located in California Climate Zone 7 and in the San Diego Gas & Electric® (SDG&E) service territory. This report outlines findings from the 12-month measurement and verification period (nine months measured and a three-month projection) along with providing an initial cost-benefit analysis.

II. Annual Measurement and Verification

M&V began on May 1, 2020 after energy efficiency retrofit activities concluded at all three libraries in April 2020. The first (Q1), second (Q2), third (Q3) and fourth quarter (Q4) M&V findings are documented in the *May-July 2020 Measurement & Verification Report*, *August-October 2020 Measurement & Verification Report* and *November 2020-April 2021 Measurement and Verification Report*². All quarterly data was combined to form an annual projection of library energy use. A projection can only be provided at this time due to limited library operations as part of the COVID-19 shutdown and as highlighted previously, typical savings from efficiency measures were not clearly defined by the data.

Annual Energy Performance Assessment

Electric Consumption

As estimated in the Report of ECM Integration Activities and Financial Considerations³, all libraries are expected to decrease in annual electric consumption (Figure 1). The Point Loma/Hervey Library was projected to have the highest annual gross electric site consumption post-retrofit (359.642 kWh, 111 kW), and unexpectedly, the Serra Mesa-Kearny Mesa had the lowest annual gross site consumption (154.693 kWh, 104 kW), most likely due to longer periods of no public occupancy. All libraries are projected to have HVAC as the highest consuming electric end use followed by lighting, plug loads and

¹ *Energy Innovation Showcase*. 2020. California Energy Commission.

<http://innovation.energy.ca.gov/SearchResultProject.aspx?p=30919&tk=636842721307653350>

² *EPC-15-085: May-July 2020 Measurement and Verification Report*. 2020. Center for Sustainable Energy.; *EPC-15-085: August-October 2020 Measurement and Verification Report*. 2020. Center for Sustainable Energy.; *EPC-15-085: November 2020-April 2021 Measurement and Verification Report*. 2020. Center for Sustainable Energy.

³ *EPC-15-085: Report of ECM Integration Activities and Financial Considerations for City of San Diego Public Library ZNE Demonstration Project*. 2019. Center for Sustainable Energy.

misc. (Figures 2, 4, and 6). Point Loma/Hervey was estimated to have the highest HVAC percent (81%), Valencia Park/Malcolm X the highest lighting percent (23%), and Serra Mesa-Kearny Mesa, the highest plug percent (11%). These projections can be compared to the calibrated energy model for 2017 energy consumptions detailed in the Updated City of San Diego Public Library ZNE ECMs and Modeled Savings Report⁴. The electric end-use breakouts from the models are provided in Figures 3, 5, and 7. It seems that HVAC will become a larger percent of total electric use at all three libraries post-retrofit.

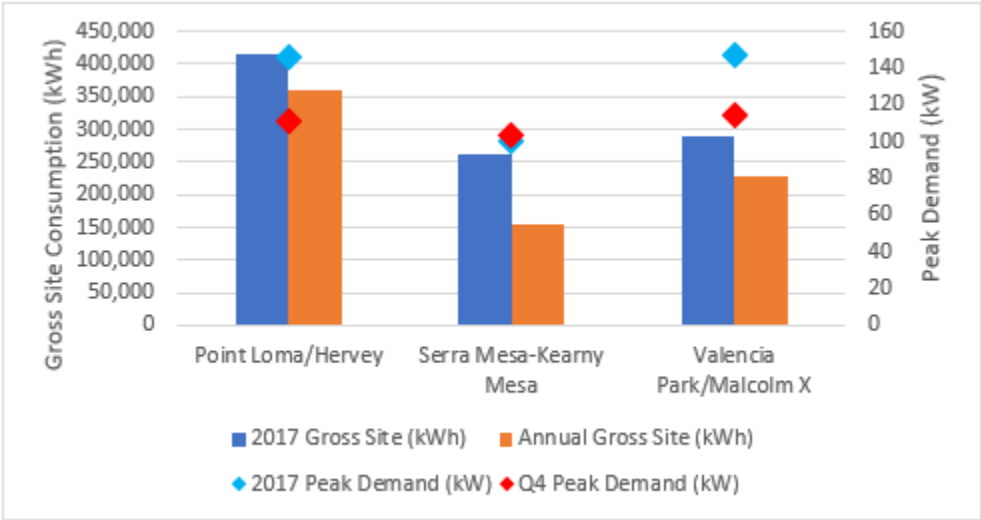


Figure 1: Projected Annual Gross Site Electric Consumption Comparison (May 2020-April 2021 vs. 2017)

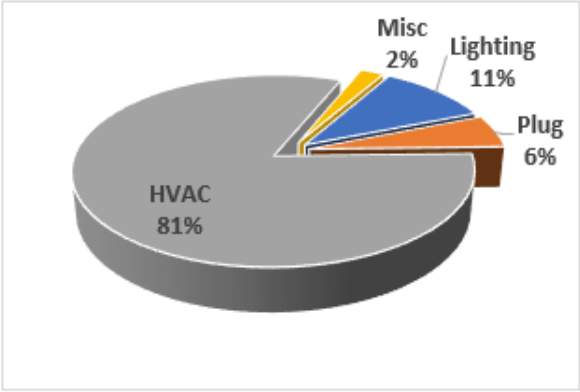


Figure 2: Projected Annual Electric End-Use Breakout at Point Loma/Hervey (May 2020-April 2021)

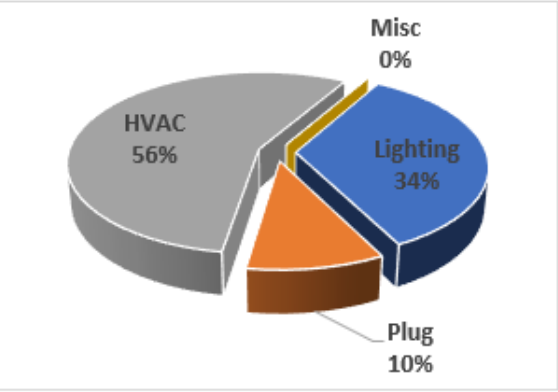


Figure 3: Calibrated Model Annual Electric End-Use Breakout at Point Loma/Hervey (2017)

⁴ EPC-15-085: EPC-15-085: Building Energy Baseline & Modeling Report for the City of San Diego Public Library ZNE Demonstration Project. 2018. [EPC-15-085 Baseline and Modeling Energy Report.pdf\(energycenter.org\)](https://energycenter.org)

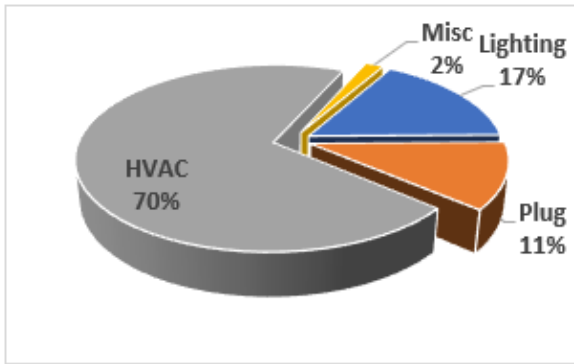


Figure 4: Projected Annual Electric End-Use Breakout at Serra Mesa-Kearny Mesa (May 2020-April 2021)

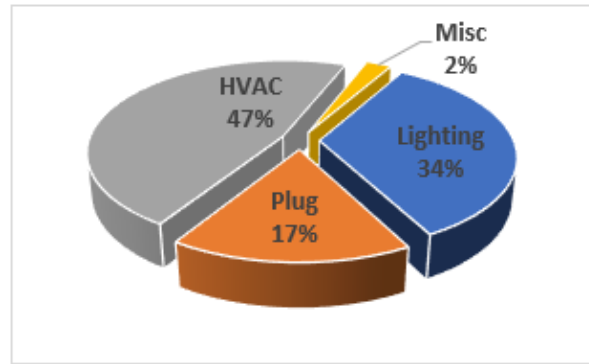


Figure 5: Calibrated Model Electric End-Use Breakout at Serra Mesa-Kearny Mesa (2017)

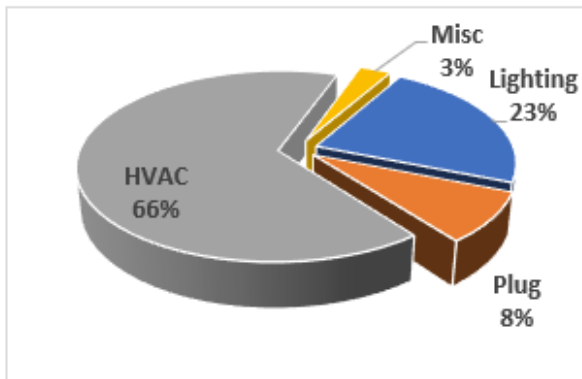


Figure 6: Projected Annual Electric End-Use Breakout at Valencia Park/Malcolm X (May 2020-April 2021)

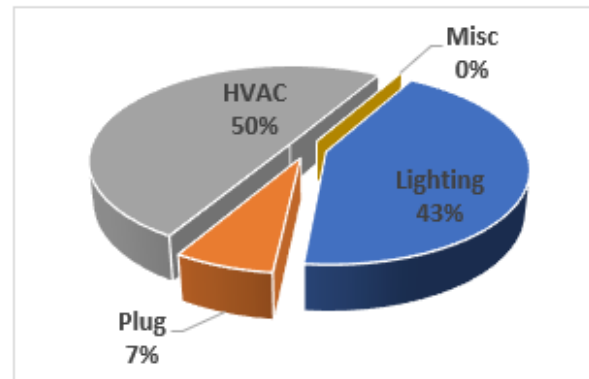


Figure 7: Calibrated Model Electric End-Use Breakout at Valencia Park/Malcolm X (2017)

Gas Consumption

Natural gas consumption and savings were not the focus of this project. However, it was considered when calculating ZNE valuations, ZNE status and City energy expenditures. There was no energy conservation measure (ECMs) implemented that specifically targeted natural gas savings and any reduction in consumption would be a result of an indirect benefit. Point Loma/Hervey Library was projected to have the highest annual gross gas consumption post-retrofit (Figure 5). The gas consumption at Point Loma/Hervey is still uncharacteristically high when compared to previous years without COVID-19 operations and weather conditions as noted in the Ongoing Retrocommissioning and Maintenance Plan.⁵ Valencia Park/Malcom X will have the lowest annual gross gas consumption.

⁵ EPC-15-085: Ongoing Retrocommissioning and Maintenance Plan. 2021. Center for Sustainable Energy.

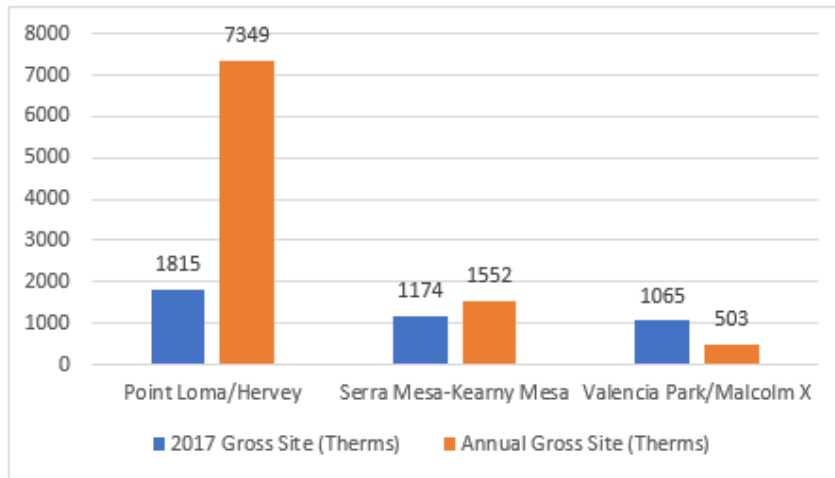


Figure 8: Projected Annual Natural Gas Consumption Comparison (May 2020-April 2021 vs. 2017)

PV Generation

Onsite PV systems at the libraries provided renewable generation that offsets grid-consumed electricity and is critical to achieving ZNE or near-ZNE status. During the libraries' COVID-19 shutdown and as measured during Q1-Q3, PV accounted for a larger-than-estimated portion of the site's electrical consumption. It should be noted in both Q2 and Q3, the PV system at Point Loma/Hervey was found to be underperforming based on measured data. Annual PV generation projections are provided in Figure 6. Point Loma/Hervey is projected to generate the least PV energy (116,836 kWh, 59.7 kW), followed by Serra Mesa-Kearny Mesa (195,634 kWh, 110.2 kW) and Valencia Park/Malcolm X (224,615 kWh, 109.9 kW).

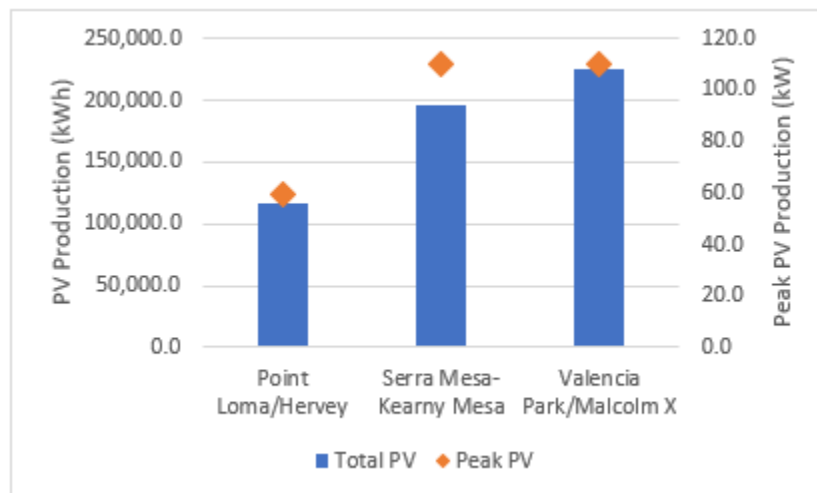


Figure 9: Projected Annual PV Production (May 2020-April 2021)

Net Energy Use Intensity

Energy use intensity (EUI) is an important indicator and used frequently for comparison to other energy-efficient buildings. Pre-retrofit EUIs vs. post-retrofit net EUIs (PV generation accounted) for each library are detailed in Figure 7. Point Loma/Hervey was projected to have a post-retrofit net EUI of 40.1. Serra Mesa-Kearny Mesa was projected to have a 0.7 net EUI, and Valencia Park/Malcolm X a 16.6.

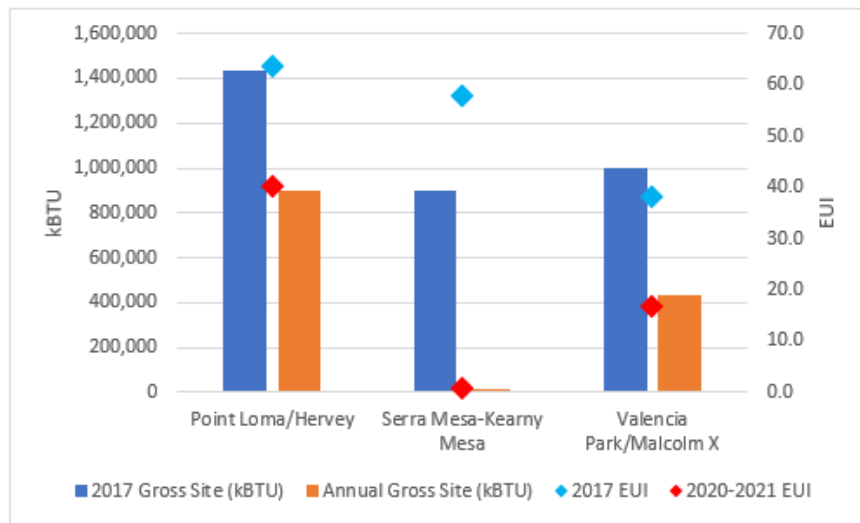


Figure 10: Projected Annual kBtu and Net EUI Comparison (May 2020-April 2021 vs. 2017)

III. ZNE Achievement

Considering the seasonal variations in energy consumption and onsite PV production, ZNE status must be evaluated on an annual basis. There were four ZNE calculations evaluated: TDV⁶, Site, Source⁷, and Electric Only/ZNE Electric⁸. Pre-M&V ZNE estimates indicated that Valencia Park/Malcolm X would achieve ZNE, Serra Mesa-Kearny Mesa would be near-ZNE and Point Loma/Hervey would be a high-performance building (Table 1). Post-ZNE projections indicate Serra Mesa-Kearny Mesa will reach ZNE, Valencia Park/Malcolm X will be near-ZNE, and Point Loma will a high performance-building, although not as close as estimated (Table 2)⁹.

⁶ *Reducing Costs for Communities and Businesses through Integrated Demand-side management and Zero Net Energy Demonstrations (GFO-15-308)*. 2015. California Energy Commission. Page 3.

⁷ Used same Energy Start multiplier (2.80) for electricity and onsite PV production to match Pre-M&V calculation. State of California uses 3.15 and same multiplier for electricity and onsite PV production. <https://www.dgs.ca.gov/-/media/Divisions/OS/ADA-Checked/ZNE-Calculator/StateofCAZeroNetEnergyCalculator.xlsx?la=en&hash=5BE1AAAF86A1C39B29B0D85FB3E0C44B721F9EB9&hash=5BE1AAAF86A1C39B29B0D85FB3E0C44B721F9EB9>

⁸ *The Vocabulary of ZNE: A Guide to Zero Net Energy Terminology*. 2015. New Buildings Institute.

https://gettingtozeroforum.org/wp-content/uploads/sites/2/2017/08/ZNE_NBI_CommsToolkit_Terminology_.pdf

⁹ Point Loma/Hervey Library's EUI to fall below 2012 Commercial Buildings Energy Consumption Survey median for public assembly buildings.

ZNE Value	Point Loma/Hervey	Serra Mesa - Kearny Mesa	Valencia Park/Malcolm X
TDV (kBtu/ft ² /yr.)	178	62	29
Site (kBtu/yr.)	734,938	291,100	159,661
Source (kBtu/yr.)	1,915,877	367,803	80,886
Electric Only (kWh)	159,621	19,555	-3,245

Table 1: Pre-M&V Estimated Library Net ZNE Values (Post-Retrofit Consumption Minus PV Generation)

ZNE Value	Point Loma/Hervey	Serra Mesa - Kearny Mesa	Valencia Park/Malcolm X
TDV (kBtu/ft ² /yr.)	305.7	-26.7	92.5
Site (kBtu/yr.)	835,803	-138,139	7,925
Source (kBtu/yr.)	2,327,389	-389,506	21,310
Electric Only (kWh)	242,806	-40,941	2,175

Table 2: Post-M&V Projected Library Net ZNE Values (Post-Retrofit Consumption Minus PV Generation)

IV. Cost-Benefit Analysis

To determine the cost-benefit of this project, the upfront cost of the ECMs was calculated alongside an estimation of all energy costs. Upfront costs used subcontractor invoices (no upfront cost for PV) and annual energy costs were estimated with Q1-Q3 utility bills and monthly Power Purchase Agreement payments (\$/kWh of PV production). See Table 3 and 4. Pre-retrofit, the libraries were enrolled in San Diego Gas & Electric’s (SDG&E) AL-TOU-CP2 electric tariff and GN-3 gas tariff.¹⁰ Post-retrofit, the libraries were enrolled in the SDG&E’s Time of Use Plus - ALDG-R-Commercial and stayed enrolled in the GN-3 gas tariff.

Valencia Park/Malcolm X had the highest retrofit cost at about \$573,000 and realized the most cost savings. Conversely, Point Loma/Hervey had the lowest retrofit cost at about \$365,400 and did not realize cost savings due to an increase in natural gas use, likely attributed to a controls issue combined with Covid-10 operations. The highest individual ECM cost was for light-emitting diode (LED) lighting for all three libraries, and the least costly was the smart plugs (plug load management devices). Due to COVID-19 health restrictions during the M&V period, cost savings under post-COVID operations will need to be verified with continued measurement and verification into 2022. However, under COVID-19 operations, Valencia Park/Malcolm X had a simple payback of about 10 years and Serra Mesa-Kearny Mesa about 15 years for the installation of demand-side management energy efficiency measures when including the installation of PV. Point Loma/Hervey would not receive installation payback under

¹⁰ EPC-15-085: Building Energy Baseline & Modeling Report for the City of San Diego Public Library ZNE Demonstration Project. 2018. [EPC-15-085 Baseline and Modeling Energy Report.pdf \(energycenter.org\)](https://energycenter.org/EPC-15-085_Baseline_and_Modeling_Energy_Report.pdf)

current conditions. It is important to note the simple payback calculations do not include ongoing maintenance of equipment and retrocommissioning costs or savings.

Measure	Point Loma/Hervey	Serra Mesa-Kearny Mesa	Valencia Park/Malcolm X
Permits & Management	\$108,519.35	\$108,519.40	\$108,519.35
LED Lighting	\$115,398.00	\$127,392.70	\$199,358.72
Lighting Controls	\$90,669.86	\$100,094.30	\$156,638.99
BAS & HVAC Controls	\$46,150.00	\$44,450.00	\$103,753.35
Smart Plugs	\$4,690.90	\$3,518.18	\$4,690.90
Total	\$365,428.11	\$383,974.58	\$572,961.31

Table 3: Cost of ECMs and Installation by Library

Type of Cost/Savings	Point Loma/Hervey	Serra Mesa-Kearny Mesa	Valencia Park/Malcolm X
Pre-retrofit Electric Cost	\$ 95,366.00	\$ 65,282.66	\$ 79,737.00
Pre-retrofit Utility Gas Cost	\$ 1,140.31	\$ 931.54	\$ 858.82
Post-retrofit Utility Electric Costs & PPA Payments	\$ 91,170.13	\$ 27,573.98	\$ 41,443.85
Post-retrofit Gas Cost	\$ 7,971.15	\$ 1,778.46	\$ 657.78
Total Electric Savings	\$ 4,195.87	\$ 37,708.68	\$ 38,293.15
Total Gas Savings	\$ (6,830.84)	\$ (846.92)	\$ 201.04
Total Energy Savings	\$ (2,634.97)	\$ 36,861.76	\$ 38,494.19

Table 4: Projected Annual Cost Savings by Library

V. Conclusion

Serra Mesa-Kearny Library is projected to achieve ZNE from May 2020 to April 2021, the. The Valencia Park/Malcolm X Library is estimated to be near-ZNE. However, the Point Loma/Hervey Library will not achieve full estimated savings due to an unidentified issue, likely a controls issue, combined with limited COVID-19 operations that is causing an increase in natural gas use. The retrofit cost for two of the three libraries to achieve near-ZNE was projected to have a simple payback of about 10-15 years for installation of demand-side management energy efficiency measures when including the installation of PV. However, this simple payback estimate does not include future costs or savings for ongoing maintenance of equipment and retrocommissioning. It is recommended City of San Diego continue to investigate the natural gas spike and lower PV generation at Point Loma as well as monitor the energy consumption and PV generation at the libraries into 2022 to verify ZNE status, individual ECM savings, and simple payback of all measures of the libraries under post-Covid library operations.