EPC-15-085: Building Energy Baseline & Modeling Report for City of San Diego Public Library ZNE Demonstration Project

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Abbreviations and Acronyms

AC	Air Conditioner
AHU	Air handler unit
AMY	Actual meteorological year
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BAS	Building automation system
Btu	British thermal unit
MMBtu	Million Btu
CBECS	Commercial Buildings Energy Consumption Survey
CSE	Center for Sustainable Energy
ECM	Energy conservation measure
EUI	Energy use intensity
HVAC	Heating, ventilation and air conditioning
kBtu	Thousand British thermal units
kW	Kilowatt
kWh	Kilowatt-hour
M&V	Measurement & verification
NBC	Non-bypassable charge
NBI	New Buildings Institute
PPA	Power purchase agreement
PV	Photovoltaic
RTU	Rooftop unit
TDV	Time Dependent Valuation
TMY	Typical meteorological year
TOU	Time-of-use
TR	Ton of Refrigeration
SDG&E	San Diego Gas & Electric
VAV	Variable air volume
ZNE	Zero net energy
zEPI	Zero Energy Performance Index

Acknowledgements

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Executive Summary

Introduction & Purpose

The Center for Sustainable Energy (CSE) developed this *Building Energy Baseline and Modeling Report* for three City of San Diego public libraries (Serra Mesa-Kearny Mesa, Point Loma/Hervey, and Valencia Park/Malcolm X) as part of the California Energy Commission Electric Program Investment Charge[1] demonstration project, EPC-15-085. This project is a demonstration of cost-effective zero net energy (ZNE) and integrated demand-side management strategies that will be installed, tested and measured in three existing buildings with the goal of achieving ZNE or near-ZNE at all three of the participating libraries. These libraries are owned and operated by the City of San Diego, are located in California Climate Zone 7 and in the San Diego Gas & Electric (SDG&E) service territory.

The purpose of this report is to present the baseline year established for this project (January – December 2017) and the results of CSE's baseline analysis for each library. CSE used end-use monitoring data collection and energy modeling as baseline data collection strategies. Both were informed by detailed facility characteristics gathered from CSE's 2017 ASHRAE Level II Audits and SDG&E meter data from January through December 2017. Results from these activities are detailed in this report and used as the foundation for identifying energy conservation measures.

End-Use Monitoring Method

End-use monitoring equipment was selected and installed at each library to collect three months of baseline end-use consumption data for analysis from July to October 2018. Autani™ Wireless Packaged Meters and Autani Managers monitor lighting and plug load energy consumption (kWh) at a panel level. Mechanical loads are monitored using the current system that is installed at each library. At Valencia Park/Malcolm X mechanical use is monitored by a Pelican™ Gateway© that gathers temperature, economizer and demand ventilation data from Pelican programmable thermostats and Pelican PEARL© devices. Serra Mesa-Kearny Mesa and Point Loma/Hervey libraries are monitored by Trane™ Tracer© Supervisory Control systems that collect energy use at the individual heating, ventilation, air conditioning unit-level and from building subsystems such as variable air volume and chilled water systems. Lastly, on-site solar photovoltaic (PV) generation data is gathered from and monitored by separate Accuenergy 9100© meters installed along with the PV systems.

Modeling Method

CSE created two sets of EnergyPro™ energy models for each library: Baseline Energy Models and Calibrated Energy Models. The Baseline Models represent each library's current energy use based on existing facility characteristics and 12 months of utility data (January – December 2017). These models were then used to generate the Calibrated Energy Models, which incorporate actual meteorological year weather data and are aligned to utility metered energy consumption for baseline year, 2017. The Calibrated Models **kilowatt and kilowatt hour results are within 3% accuracy of the utility data baseline** and **therms consumed are within 5%**.

[1] *Electric Program Investment Charge*. 2018. California Energy Commission. https://www.energy.ca.gov/research/epic/

Finally, additional modeling was done during this reporting period that supplements CSE's baseline energy analysis. A generous in-kind donation from one of the project's Technical Advisory Committee members, New Building Institute (NBI), was provided to CSE to assist with the diagnosis of energy improvements that can be made to the libraries. Using the project's 2017 baseline year, NBI developed "FirstView Energy Models" for each library using their FirstView® software engine. The NBI FirstView software is a fee-based instrument that can be used in the early stages of an energy efficiency project, or even a portfolio analysis, for initial building energy analysis that "reveals underlying patterns in building end use consumption…[and] allows you to invest audit resources where they will be most effective."[2]

[2] *Take a FirstView of Your Building's Energy Performance*. 2018. New Buildings Institute. https://newbuildings.org/wp-content/uploads/2017/01/nbi_fv_overview.pdf

I. Introduction

This *Building Energy Baseline and Modeling Report* presents the current building performance of Serra Mesa-Kearny Mesa, Point Loma/Hervey and Valencia Park/Malcolm X libraries and establishes the foundation for energy conservation measure (ECM) evaluation and deployment that will achieve ZNE or near-ZNE at each facility. ECM identification, design and installation are anticipated to occur between Q4 2018 and Q2 2019. In 2017, ASHRAE Level II Energy Audits[3,4,5] and site visits were used to develop an end-use monitoring strategy that enabled CSE to collect three months of consumption data broken out by electrical and mechanical end-uses and to inform the Baseline Energy Models. The Baseline Models were calibrated within 3% of electrical-load accuracy in EnergyPro using site-specific information, actual meteorological year (AMY) weather data and 2017 baseline year utility metered data (January – December). The models will be used to identify ECMs and project design for each library, with consideration given to existing on-site solar PV generation.

Zero Net Energy Goal

California's 2008 Long Term Energy Efficiency Strategic Plan[6] outlines four "Big Bold Energy Efficiency Strategies," one of which requires all new commercial construction to be ZNE and 50% of existing commercial buildings to be retrofitted to ZNE by 2030. The goals of this demonstration project are to achieve ZNE or near-ZNE at each of the three selected City of San Diego libraries and develop a blueprint for other existing commercial buildings to use in order to reach the state's ZNE target. This project will be using the Energy Commission's "Zero-Net-Energy Code Building"[7] definition to guide establish methods and evaluation criteria:

> A Zero-Net-Energy Code Building is one where the net amount of energy produced by on-site renewable energy resources is equal to the value of the energy consumed annually by the building, at the level of a single "project" seeking development entitlements and building code permits, measured using the Energy Commission's Time Dependent Valuation metric.

For example, when selecting end-use monitoring equipment and energy modeling software significant consideration of this definition along with 2016 Title 24 building energy code requirements was given. End-use monitoring equipment needed the capability to break down energy data in to 15-minute and hourly intervals. Energy modeling software needed to be proficient for use with the 2016 Title 24 Standards and have the capability to calculate the time dependent valuation (TDV) metric.

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[3] *City of San Diego Serra Mesa-Kearny Mesa Library ASHRAE Level II Audit Report*. 2017. Center for Sustainable Energy. https://energycenter.org/sites/default/files/docs/microsites/sdzn3/Serra-Mesa-Library_ASHRAE-Audit-Report_FINAL.pdf

[4] *City of San Diego Point Loma-Hervey Branch Library ASHRAE Level II Audit Report.* 2017. Center for Sustainable Energy. https://energycenter.org/sites/default/files/docs/microsites/sdzn3/Point-Loma-Library_ASHRAE-Audit-Report_FINAL.pdf

[5] *City of San Diego Valencia Park-Malcolm X Library ASHRAE Level II Audit Report*. 2017. Center for Sustainable Energy. https://energycenter.org/sites/default/files/docs/microsites/sdzn3/Valencia-Park-Library_ASHRAE-Audit-Report_FINAL.pdf

[6] *California Energy Efficiency Strategic Plan, January 2011 update.* 2011. California Public Utilities Commission. http://www.cpuc.ca.gov/General.aspx?id=4125

[7] *Integrated Energy Policy Report.* 2013. California Energy Commission. Publication Number: CEC-100-2013-001-CMF.

II. General Facility Characteristics

Detailed facility characteristics, obtained from the 2017 ASHRAE Level II Audit, were important to both the chosen end-use monitoring strategy and development of energy models for the libraries. Characteristics specific to each library are briefly summarized in the following subsections. All libraries are in California's Climate Zone 7 and receive separately metered electricity and gas service from SDG&E. HVAC units all have locked local thermostats, and the Public Works Facilities Division must be called to request a temperature change of 1-2°F up or down from 72°. Each library contains study and seminar rooms, staff workrooms, computer rooms/areas and large community rooms. They are all open to the public during the same hours:

- Monday, Thursday-Saturday: 9:30 a.m.– 6 p.m.
- Tuesday and Wednesday: 11:30 a.m.– 8 p.m.
- Sunday: 12:30 – 5 p.m.

Serra Mesa-Kearny Mesa Library

The Serra Mesa-Kearny Mesa Library (Figures 1 and 2) is located at 9005 Aero Drive and serves City of San Diego residents in the Serra Mesa and Kearny Mesa neighborhoods. The library was constructed in 2006, is 15,626 square feet and estimates 5,000-10,000 visitors each month. The HVAC equipment includes 10 packaged air conditioning (AC) units located on the roof of the library. Overall, these units are of 2005 vintage. A 40-gallon natural gas water heater, also 2005 vintage, provides hot water to the building's public restroom facilities and community room kitchen. Additionally, there are approximately 304 interior and 119 exterior light fixtures, 58 desktop computers and five copiers/printers.

Figure 1: Serra Mesa-Kearny Mesa Ceiling Lamps

Figure 2: Serra Mesa-Kearny Mesa Book Stacks

Point Loma/Hervey Library

The Point Loma/Hervey Branch Library (Figures 3 and 4) is located at 3701 Voltaire Street and serves City of San Diego residents in the Point Loma neighborhood. The library was constructed in 2003, is 22,480 square feet and estimates 19,000-22,000 visitors each month. The facility HVAC equipment is 2002 vintage and includes one split AC unit, a central 100-ton Evapco chiller, a boiler and 10 air handler units (AHU) on the roof, known as four-pipe fan coil units, that are served by the chiller and boiler. There is

also an 81-gallon natural gas water heater (2002 vintage) that provides hot water needs to the library's restrooms and kitchen area. Additionally, there are approximately 86 interior and 13 exterior light fixtures, 24 desktop computers and seven copiers/printers.

Figure 3: Point Loma/Hervey Book Stacks

Figure 4: Point Loma/Hervey Children's Area

Valencia Park/Malcolm X Library

The Valencia Park-Malcolm X Library (Figures 5 and 6) is located at 5148 Market Street and serves City of San Diego residents in the Valencia Park, Lincoln Park and Encanto neighborhoods. The library constructed in 1995, is 26,328 square feet and estimates 25,000 visitors each month. There are 10 packaged heating and AC units, a split AC unit, a 24-ton air-cooled chiller, an inline duct heater, and one ductless AC unit that are of 2014 vintage. There is also a 40-gallon natural gas water heater of 2010 vintage that provides hot water needs to restroom facilities. Additionally, there are approximately 721 interior and 57 exterior light fixtures, 78 desktop and laptop computers and six copiers/printers (including two 3D printers). This library additionally has a Teen IDEA Lab and Performing Arts Center.

Figure 5: Valencia Park/Malcolm X Performing Arts Center

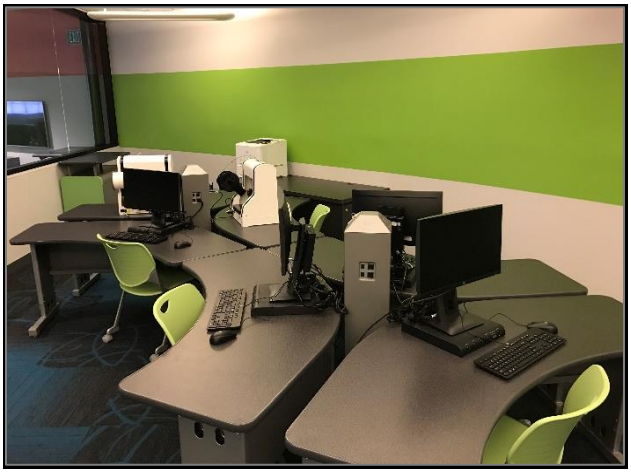

Figure 6: Valencia Park/Malcolm X Teen IDEA Lab Computers

Utility Data Baseline

Determining a utility data baseline was necessary for comparison of any collected end-use monitoring data and to complete energy model calibration. January to December 2017 was determined as the project baseline year for utility metered data since it is the most recent calendar year data available and aligned with obtained weather data. Metered utility data was obtained for each library from the City of San Diego. Present and historical energy usage data is accessible by City staff through an online platform called C3Platform™, or it can be requested from an SDG&E account representative. The libraries have meters installed by SDG&E that can produce electrical consumption (kWh) and demand (kW) values in 15-minute intervals. As a point of emphasis, this project's selected ECMs will focus on electricity savings only, thus the baseline energy data provided in the subsections below is focused on electric consumption and demand information.

Serra Mesa-Kearny Mesa Library

In 2017, the Serra Mesa-Kearny Mesa Library consumed 1,007,449 kBtu of energy, which translates to 260,856 kWh (88% electricity use) and 117 MMBtu (12% natural gas use). Figure 7 shows Serra Mesa-Kearny Mesa's energy consumption broken out by month over the baseline year. Electricity is consumed primarily for lighting and space cooling, with the annual peak occurring in the summer months. The library consumes natural gas for both space and hot water heating, with the annual peak generally occurring in the winter months when the demand for space heating is greatest.

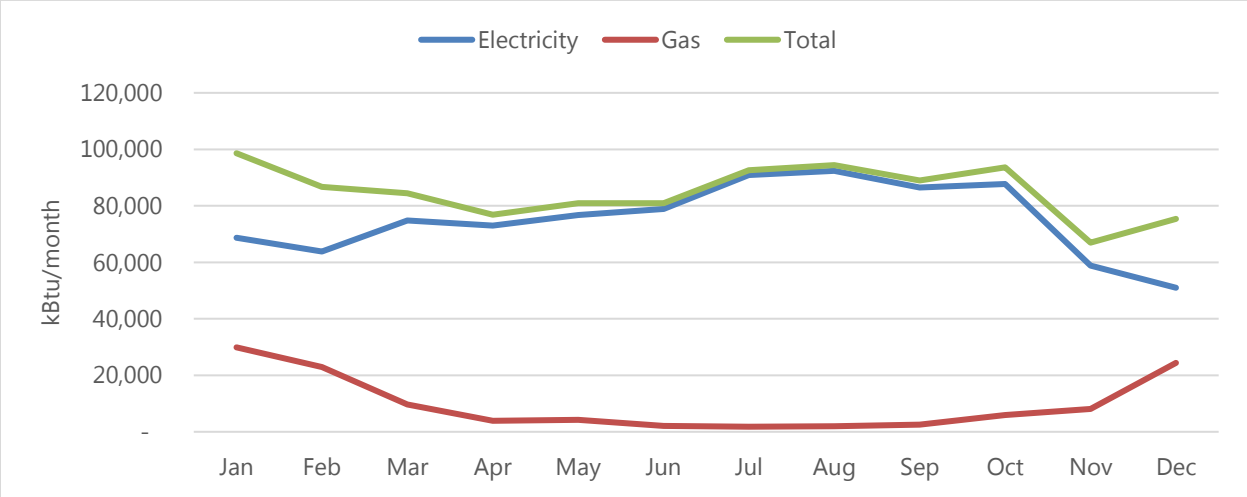

Figure 7: Serra Mesa-Kearny Mesa 2017 Baseline Energy Consumption (kBtu)

The library is enrolled in SDG&E's AL-TOU-CP2 commercial tariff featuring both an energy use and demand component along with a critical peak pricing rate that occurs during periods of system peaks deemed by SDG&E a few times a year. Additionally, the building receives natural gas on a GN-3 commercial gas tariff. Table 1 shows Serra Mesa-Kearny Mesa's electricity and natural gas usage and total energy costs ($66,214) during the baseline year, of which $65,283 was spent on just electricity use.

Utility	SDG&E Meter	Tariff	Energy Consumption	Annual Energy Costs	Avg. Cost per Unit
Natural Gas	1300058	GN-3	1,174 therms/yr.	$931.54	$0.793/therm
Electricity	6693453	AL-TOU-CP2	260,856 kWh/yr.	$65,282.66	$0.250/kWh

Table 1: Serra Mesa-Kearny Mesa 2017 Utility Meter Data

Using 15-minute interval data and the billed time-of-use (TOU) tariff, Table 2 breaks down electricity consumption that occurs during each TOU period (on-peak, semi-peak, off- peak, and critical peak), as well as the noncoincident and coincident peak monthly demand. Noncoincident peak demand is calculated using several readings taken at different times to determine what actual peak demand periods may be for a customer, while coincident peak demand is usually calculated from meter readings taken at the time when the customer's demand is likely to be at peak. For the AL-TOU tariff, coincident on-peak demand is currently from 4 – 9 p.m. and critical peak pricing from 2 – 6 p.m. Understanding when energy consumption and demand is highest will aid in the determination of ECMs for the libraries. Energy reductions achieved during on-peak or critical peak periods will amount to more in monetary energy savings than those achieved during semi- or off-peak periods since the library is on a TOU tariff. Also, energy reductions during those periods are valued more and require less renewable energy production in the TDV metric to achieve ZNE. **Serra Mesa-Kearny Mesa Library will need to produce and/or reduce 260,856 kWh of energy to achieve ZNE**.

	Energy Use (kWh)					Demand (kW)	
Month	**On-Peak**	**Semi-Peak**	**Off-Peak**	**Critical Peak**	**Total**	**Noncoincidental Peak**	**Coincident Peak**
Jan	2,767	9,609	7,763	-	20,139	60	60
Feb	2,634	8,990	7,078	-	18,702	62	60
Mar	3,037	11,182	7,534	-	21,753	76	67
Apr	2,665	10,169	8,548	-	21,382	74	63
May	8,791	5,813	7,901	-	22,505	75	73
Jun	9,563	5,678	7,876	-	23,117	86	86
Jul	10,179	6,283	10,166	-	26,628	87	84
Aug	11,104	7,006	8,509	456	27,075	95	95
Sep	9,449	6,016	8,933	961	25,359	100	100
Oct	10,347	6,323	9,026	-	25,696	94	94
Nov	2,920	6,291	5,604	-	14,815	69	68
Dec	2,789	4,375	6,521	-	13,685	62	61
Total	**76,245**	**87,735**	**95,459**	**1,417**	**260,856**	**100**	**100**

Table 2: Serra Mesa-Kearny Mesa 2017 TOU Electricity Consumption

Table 3 displays a breakdown of Serra Mesa/Kearny Mesa's 2017 electric charges by month. Certain charges, denoted as "Other" charges, are fixed by the utility provider and will not be not factored into ECM energy savings because they are not based on consumption. Non-bypassable charges (NBC) add up to approximately 2-3 cents per kWh and go towards funding energy efficiency, low-income customer assistance and other related programs. As mentioned previously, Serra Mesa/Kearny Mesa spent

approximately $65,283 on electricity consumption in 2017. This amount establishes the baseline of the annual cost savings that the project will evaluate when identifying ECMs.

Month	Other	NBC	Energy	Demand	Total	Avg. Blended Rate
Jan	$249.68	$503.48	$1,409.33	$2,036.05	$4,198.55	$0.208
Feb	$249.68	$467.53	$1,312.71	$2,087.91	$4,117.83	$0.220
Mar	$249.68	$543.83	$1,541.80	$2,506.93	$4,842.24	$0.223
Apr	$249.68	$534.55	$1,485.22	$2,423.05	$4,692.51	$0.219
May	$249.68	$562.63	$1,963.95	$2,736.00	$5,512.26	$0.245
Jun	$249.68	$577.90	$2,030.35	$3,162.15	$6,020.08	$0.260
Jul	$249.68	$665.73	$2,295.53	$3,166.39	$6,377.32	$0.239
Aug	$249.68	$676.88	$2,947.26	$3,493.07	$7,366.89	$0.272
Sep	$249.68	$633.95	$3,361.44	$3,676.91	$7,921.99	$0.312
Oct	$249.68	$642.40	$2,245.38	$3,456.30	$6,593.76	$0.257
Nov	$249.68	$370.40	$1,053.22	$2,333.45	$4,006.76	$0.270
Dec	$249.68	$342.15	$944.74	$2,095.91	$3,632.49	$0.265
Total	**$2,996.20**	**$6,521.40**	**$22,590.94**	**$33,174.12**	**$65,282.66**	**$0.250**

Table 3: Serra Mesa-Kearny Mesa 2017 Electric Charges

Point Loma/Hervey Library

In 2017, the Point Loma/Hervey Library consumed 1,595,736 kBtu of energy, which translates to more than 414,472 kWh in electricity (89% of energy use) and approximately 182 MMBtu in natural gas (11% of energy use). Figure 8 shows building energy consumption by month. Similar to Serra Mesa-Kearny Mesa, electricity is consumed primarily for lighting and space cooling, with the annual peak occurring in the summer months. The library consumes natural gas for both space and hot water heating, with the annual peak occurring in the winter months when the demand for space heating is greatest.

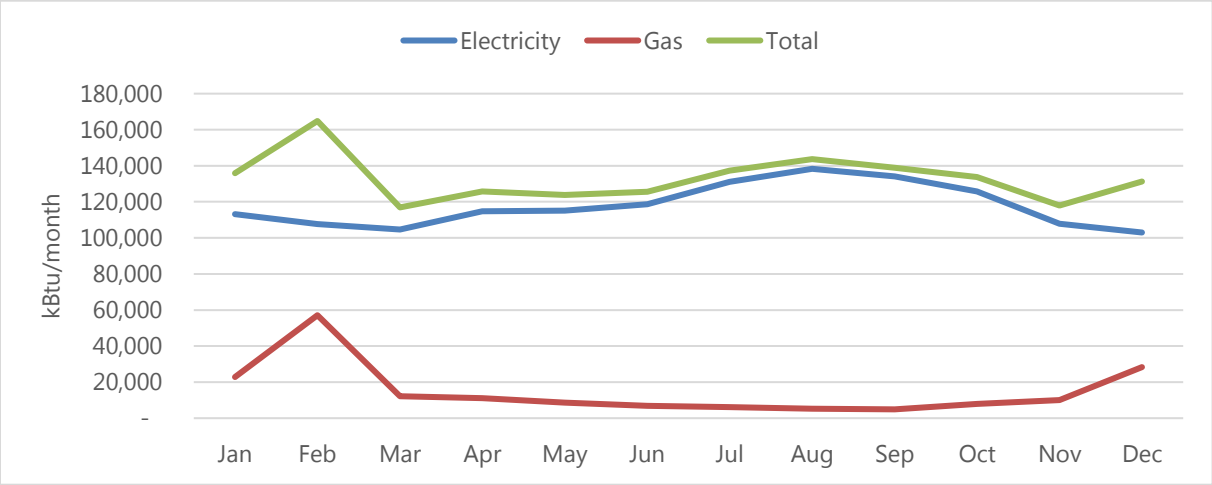

Figure 8: Point Loma/Hervey 2017 Baseline Energy Consumption (kBtu)

Point Loma/Hervey Library is enrolled in the same electric and gas tariffs as Serra Mesa-Kearny Mesa. Table 4 shows the Point Loma/Hervey's electricity and natural gas usage during the project's baseline year. Table 4 shows Point Loma/Hervey's electricity and natural gas usage and total energy costs ($96,807) during the baseline year, of which $95,366 was spent on just electricity use.

Utility	SDG&E Meter	Tariff	Energy Consumption	Annual Energy Costs	Avg. Cost per Unit
Natural Gas	1403761	GN-3	1,815 therms/yr.	$1,140.31	$0.794/therm
Electricity	6691684	AL-TOU-CP2	414,472 kWh/yr.	$95,366	$0.274/kWh

Table 4: Point Loma/Hervey 2017 Utility Meter Data

Using 15-minute interval data and the billed TOU tariff, Table 5 breaks down electricity consumption that occurs during each TOU period as well as the noncoincident and coincident peak monthly demand. Energy reductions achieved during on-peak or critical peak periods will be the highest priority to maximize cost savings and achieve ZNE using TDV metrics. Point Loma/Hervey Library will need to produce and/or reduce 414,472 kWh of energy in order to achieve ZNE.

	Energy Use (kWh)					Demand (kW)	
Month	**On-Peak**	**Semi-Peak**	**Off-Peak**	**Critical Peak**	**Total**	**Noncoincidental Peak**	**Coincidental Peak**
Jan	4,254	16,003	12,906	-	33,163	106	99
Feb	3,889	15,267	12,412	-	31,568	123	123
Mar	4,183	17,245	9,308	-	30,736	145	135
Apr	3,825	16,689	13,104	-	33,618	141	102
May	13,473	9,254	11,021	-	33,748	146	146
Jun	13,917	9,557	11,320	-	34,794	131	131
Jul	14,398	9,748	14,271	-	38,417	124	121
Aug	15,135	11,605	13,163	630	40,533	124	124
Sep	12,954	10,542	14,535	1,257	39,288	122	118
Oct	13,592	10,295	12,945	-	36,832	112	112
Nov	4,200	15,837	11,558	-	31,595	104	104
Dec	3,688	14,912	11,580	-	30,180	121	104
Total	107,508	156,954	148,123	1,887	414,472	146	146

Table 5: Point Loma/Hervey 2017 TOU Electricity Consumption

Table 6 displays a breakdown of Point Loma/Hervey's 2017 electricity charges. In total, Point Loma/Hervey spent approximately $95,366 on electricity consumption in 2017. This amount establishes the baseline of the annual cost savings that the project will evaluate when identifying ECMs.

Month	Other	NBC	Energy	Demand	Total	Avg. Blended Rate
Jan	$236.04	$829.05	$2,141.55	$3,347.49	$6,554.13	$0.198
Feb	$236.04	$789.20	$2,033.47	$3,945.84	$7,004.55	$0.222
Mar	$236.04	$768.40	$2,043.68	$4,575.90	$7,624.02	$0.248
Apr	$236.04	$840.45	$2,163.11	$4,228.05	$7,467.65	$0.222
May	$236.04	$843.70	$2,765.67	$5,074.96	$8,920.37	$0.264
Jun	$236.04	$869.85	$2,852.92	$4,553.56	$8,512.37	$0.245
Jul	$236.04	$960.40	$3,087.60	$4,279.49	$8,563.53	$0.223
Aug	$236.04	$1,013.35	$4,029.12	$4,310.24	$9,588.75	$0.237
Sep	$236.04	$982.20	$4,569.48	$4,199.72	$9,987.44	$0.254
Oct	$236.04	$920.80	$2,980.33	$3,893.12	$8,030.29	$0.218
Nov	$236.04	$789.88	$2,057.85	$3,336.32	$6,420.09	$0.203
Dec	$236.04	$754.50	$1,949.56	$3,752.99	$6,693.09	$0.222
Total	$2,832.48	$10,361.78	$32,674.34	$49,497.68	$95,366.28	$0.230

Table 6: Point Loma/Hervey 2017 Electric Charges

Valencia Park/Malcolm X Library

In 2017, the Valencia Park/Malcolm X Library consumed 1,099,325 kBtu of energy, which translates to 290,976 kWh in electricity (90% of energy use) and 107 MMBtu in natural gas (10% of energy use). Figure 9 shows building energy consumption by month. Similar to Serra Mesa-Kearny Mesa and Point Loma/Hervey, electricity is consumed primarily for lighting and space cooling, with the annual peak occurring in the summer months. The library consumes natural gas for both space and hot water heating, with the annual peak occurring in the winter months when the demand for space heating is greatest.

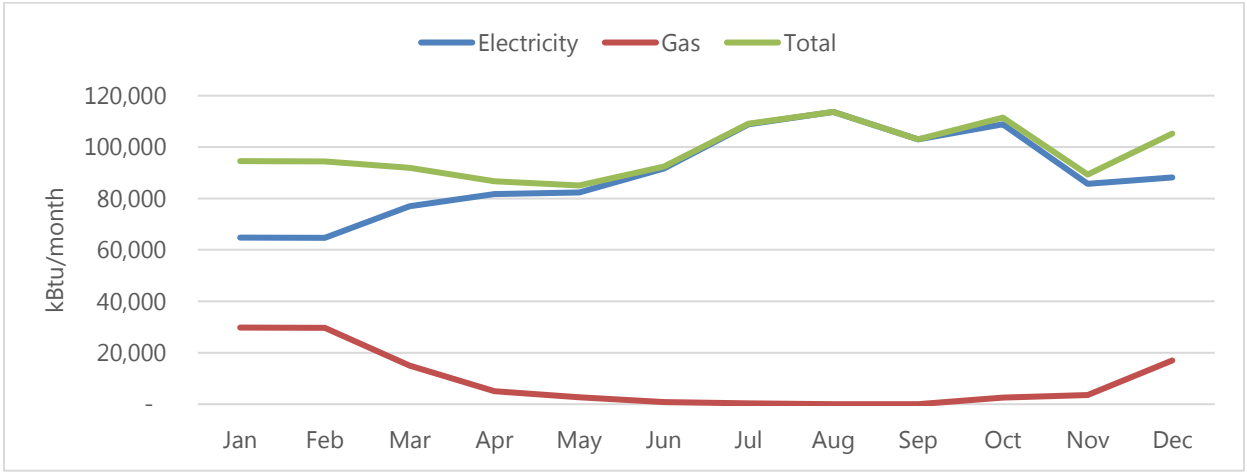

Figure 9: Valencia Park/Malcolm X 2017 Baseline Energy Consumption (kBtu)

Valencia Park/Malcolm X is enrolled in the same electric and gas tariffs as the other two libraries. Table 7 shows Valencia Park/Malcolm X's electricity and natural gas usage and total energy costs ($80,595) during the baseline year, of which $79,737 was spent on just electricity use.

Utility	SDG&E Meter	Tariff	Energy Consumption	Annual Energy Costs	Avg. Cost per Unit
Natural Gas	1423938	GN-3	1065 therms/yr.	$858.82	$0.806/therm
Electricity	6693453	AL-TOU-CP2	290,976 kWh/yr.	$79,737.00	$0.274/kWh

Table 7: Valencia Park-Malcolm X Library 2017 Utility Meter Data

Using 15-minute interval data and the billed TOU tariff, Table 8 breaks down electricity consumption that occurs during each TOU period as well as the noncoincident and coincident peak monthly demand. As mentioned previously, energy reductions achieved during on-peak or critical peak periods will be highest priority to maximize cost savings and to most efficiently achieve ZNE using the TDV metric. Valencia Park/Malcolm X library will need to produce and/or reduce 290,976 kWh of energy to achieve ZNE.

	Energy Use (kWh)					Demand (kW)	
Month	**On-Peak**	**Semi-Peak**	**Off-Peak**	**Critical Peak**	**Total**	**Noncoincidental Peak**	**Coincidental Peak**
Jan	2,690	9,113	7,176	-	18,979	59	55
Feb	2,745	8,948	7,269	-	18,962	75	68
Mar	3,540	11,343	7,610	-	22,493	95	84
Apr	3,447	10,934	9,572	-	23,953	100	88
May	9,873	6,097	8,169	-	24,139	116	99
Jun	11,322	6,790	8,741	-	26,853	115	115
Jul	12,613	7,954	11,319	-	31,886	111	111
Aug	13,536	9,055	10,176	545	33,312	129	129
Sep	11,776	7,490	9,588	1,348	30,202	133	133
Oct	13,496	7,594	10,808	-	31,898	147	147
Nov	3,234	6,688	6,041	-	15,963	95	77
Dec	2,822	3,356	6,158	-	12,336	65	59
Total	91,094	95,362	102,627	1,893	290,976	147	147

Table 8: Valencia Park/Malcolm X 2017 TOU Electricity Consumption

Table 9 displays a breakdown of Valencia Park/Malcolm X's 2017 electric charges. In total, Valencia Park/Malcolm X spent approximately $79,737 on electricity consumption in 2017. This amount establishes the baseline of the annual cost savings that the project will evaluate when identifying ECMs.

Month	Other	NBC	Energy	Demand	Total	Avg. Blended Rate
Jan	$249.68	$474.48	$1,332.55	$1,970.09	$4,026.80	$0.212
Feb	$249.68	$474.05	$1,330.09	$2,489.01	$4,542.84	$0.240
Mar	$249.68	$562.35	$1,604.58	$3,135.67	$5,552.28	$0.247
Apr	$249.68	$598.83	$1,671.27	$3,297.33	$5,817.11	$0.243
May	$249.68	$603.48	$2,120.71	$4,080.90	$7,054.76	$0.292
Jun	$249.68	$671.33	$2,373.55	$4,228.45	$7,523.00	$0.280
Jul	$249.68	$797.15	$2,780.23	$4,081.37	$7,908.44	$0.248

Month	Other	NBC	Energy	Demand	Total	Avg. Blended Rate
Aug	$249.68	$832.83	$3,614.96	$4,743.22	$9,440.68	$0.283
Sep	$249.68	$755.05	$4,286.32	$4,890.29	$10,181.35	$0.337
Oct	$249.68	$797.45	$2,806.45	$5,405.06	$9,258.64	$0.290
Nov	$249.68	$399.08	$1,136.20	$3,079.62	$4,864.58	$0.305
Dec	$249.68	$308.40	$850.40	$2,157.68	$3,566.16	$0.289
Total	$2,996.20	$7,274.45	$25,907.31	$43,558.69	$79,736.65	$0.274

Table 9: Valencia Park/Malcolm X 2017 Electric Charges

Solar PV Systems

Solar PV systems are currently installed at each library, and the technical specifications of each system are presented in Table 10. These systems are important to this project as they produce on-site renewable energy that will offset energy consumption and enable the buildings to achieve ZNE or near-ZNE. Serra Mesa-Kearny Mesa's PV system is estimated to offset 78.2% of its 2017 electric use, and similarly, Valencia Park/Malcolm X is estimated to offset 79.1% of its 2017 electric use. However, Point Loma/Hervey's system is estimated to only offset 31.3% of its 2017 electric use and will need to achieve the most energy reduction by way of ECMs.

- ***Serra Mesa-Kearny Mesa's PV system is estimated to offset 78% of its electric use.***
- ***Point Loma/Hervey's system is estimated to offset 31% of its electric use.***
- ***Valencia Park/Malcolm X is estimated to offset 79% of its electric use.***

It is important to note that typically it is preferred to perform energy efficiency improvements to buildings before sizing and installation on-site PV, however, existing PV is something that may be more commonly encountered when converting existing buildings to ZNE. In this case, the city's agreement with a power purchase agreement (PPA) provider accelerated the timeline for design and installation of these systems before ECMs could be installed.

Library	PV System Capacity (kW-DC)	Mounting Type	Estimated Annual PV Production[8] (kWh-AC)	Estimated Annual Offset (% of 2017 kWh)
Serra Mesa- Kearny Mesa	138.69 kW	Ground (Carport)	204,014.2 kWh	78.2%
Point Loma/Hervey	84.42 kW	Roof	129,698.5 kWh	31.3%
Valencia Park/Malcolm X	138.69 kW	Ground (Carport)	230,283.0 kWh	79.1%

Table 10: Library PV Systems

[8]Estimated Annual PV Production was calculated using PV Watts.

III. End-Use Monitoring

Using facility site characteristics, 2017 utility metered data and PV system production information, a strategy for end-use monitoring data collection was implemented at each library. Electrical and mechanical energy uses are being monitored at the submeter or system level. This section discusses the end-use monitoring strategy, hardware and software installed, the data that has been collected and how that data will be applied.

End-Use Monitoring Strategy

Site visits were conducted to develop an end-use monitoring strategy for electrical panel and mechanical systems at each library. It was noted that solar PV monitoring would be provided by the City's PPA. To monitor lighting, plug load, miscellaneous load and smaller HVAC components, it was determined Autani Wireless Packaged Meters would be installed for every electrical panel, and the meters would report to a single Autani Manager at each facility. It also was determined that each library's HVAC equipment is powered by a series of breakers installed on main switch gear panels or on larger, multiple-circuit panels that could not metered with Autani devices. In order to enable HVAC monitoring, several different approaches were determined: 1) a Trane™ Tracer© Supervisory Controller (Tracer SC) Building Automation System (BAS) already installed at Serra Mesa- Kearny Mesa would need trends set up, 2) the existing Trane Summit BAS at Point Loma/Hervey would need to be upgraded to a Tracer SC BAS and 3) Pelican PEARL economizer devices would need to be installed at Valencia Park/Malcolm X as well as reconnection of the existing Pelican Wireless Gateway (Pelican Gateway) to the City's internal network. Each monitoring device is explained in more detail in the subsections below.

<u>Autani Wireless Packaged Meter & Autani Manager</u>

The Autani monitoring system consists of Veris Industries E50 Series Wireless Packaged Meters (Figure 10) installed adjacent to the electrical panels where current transducers (CTs) measure total panel energy consumption. The Veris meters collect multiple data points and send it wirelessly to a central Autani Manager that reports on-site meter data to the Autani Cloud platform. Following is a description of the different targeted end-uses being monitored with this method.

- *Lighting* – Interior and exterior lighting fixtures throughout all rooms and spaces within the library as well as exterior perimeter lighting, decorative fixtures, wall packs and parking lot poles.

Figure 10: Autani Wireless Packaged Meters Connected to Electrical Panels

- *Plug Load* – All receptacle loads including but not limited to computers, printer/copiers, task lighting, various office equipment and outlets serving common spaces often used for powering visitor laptops and devices.
- *Miscellaneous* – Various, infrequent loads that cannot be easily defined by another category include such items as hand dryers, instant hot water heaters and range ovens.
- *HVAC* – Smaller components of the HVAC system that are connected to local panels being metered include exhaust fans, variable air volume (VAV) boxes and similar equipment.

Trane Tracer SC

Upgrading the existing Trane Summit BAS to Trane Tracer SC (Figure 11) at Serra Mesa-Kearny Mesa allowed for an easy approach to monitoring the main HVAC equipment. City facilities staff, in coordination with Trane service technicians, were able to configure the system to report metrics that are related to energy consumption and system performance. At Point Loma/Hervey, where the BAS was upgraded to Trane Tracer SC, the system was configured to match Serra Mesa-Kearny Mesa's metrics. The equipment being metered by the Tracer SC system at each location is as follows:

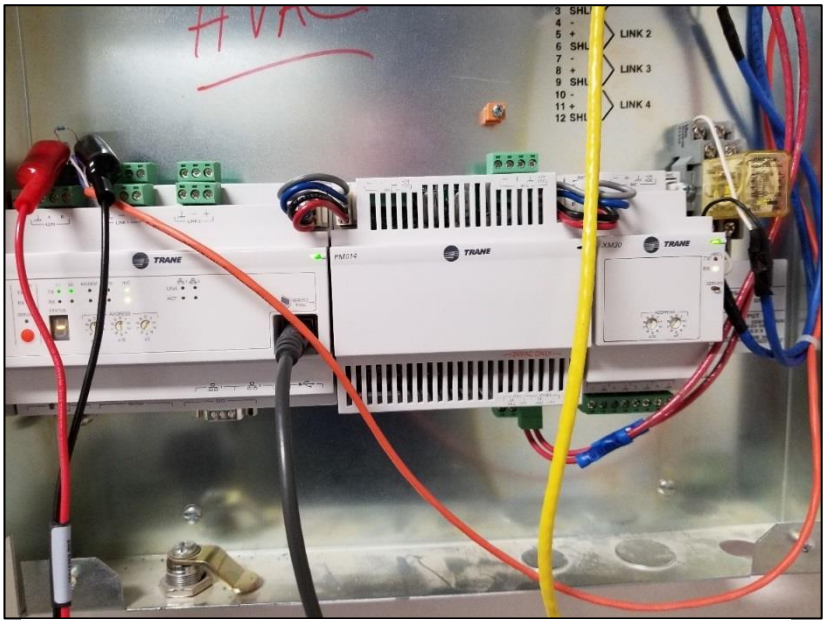

Figure 11: Installed Trane Tracer SC BAS

- *Serra Mesa-Kearny Mesa Library* – Ten Trane Rooftop Top Units (RTUs) ranging from 2 to 12.5 Ton of Refrigeration (TR) serving all interior spaces (Unit ID AC-1 through AC-10).
- *Point Loma/Hervey Library* – Ten Petra Rooftop AHUs with local gas heat and district cooling served by a central Trane Chiller with a 90 TR capacity (Unit ID AH-1 through AH-10; CU-1).

Pelican Thermostat & PEARL

At Valencia Park/Malcolm X Library a BAS system was not present, and HVAC units instead respond to calls for heating and cooling from local Pelican Thermostats throughout the building. These thermostats communicate through a wireless mesh network to their corresponding units, each other, and a central control unit located on-site called the Pelican Gateway. One Pelican PEARL device (Figure 12) was installed on each RTU unit to enable control and monitoring of the economizer damper position. These devices are also connected to the wireless mesh network and are able report system status. The equipment and metrics being monitored by each set of devices is as follows:

- *Pelican Thermostats* – Measuring area temperature, current set points, call for heating or cooling, and systems status for 11 Carrier RTUs ranging from 2-15 TR serving all interior spaces, except the Multipurpose Room (Unit ID AC-1 through AC-11). Similar metrics are monitored by a Pelican Thermostat that controls a 24 TR chiller, associated air handler and duct heater serving the Multipurpose Room (Unit ID CH-1, AH-1 and DH-1).
- *PEARL Economizers* – Measuring status and position of economizer dampers on all HVAC RTUs mentioned above, which will indicate when the dampers are open and cooler outside air is being used in place of air conditioning.

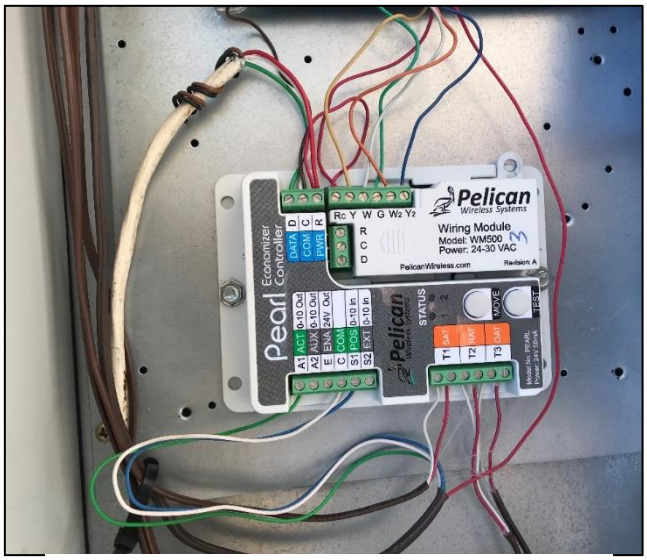

Figure 12: Installed PEARL Economizer

The figures below provide graphical representation of the end-use monitoring approaches at the three libraries. Serra Mesa-Kearny Mesa and Point Loma/Hervey have similar monitoring arrangements, shown in Figure 13, while Valencia Park/Malcolm X's monitoring arrangement is shown in Figure 14.

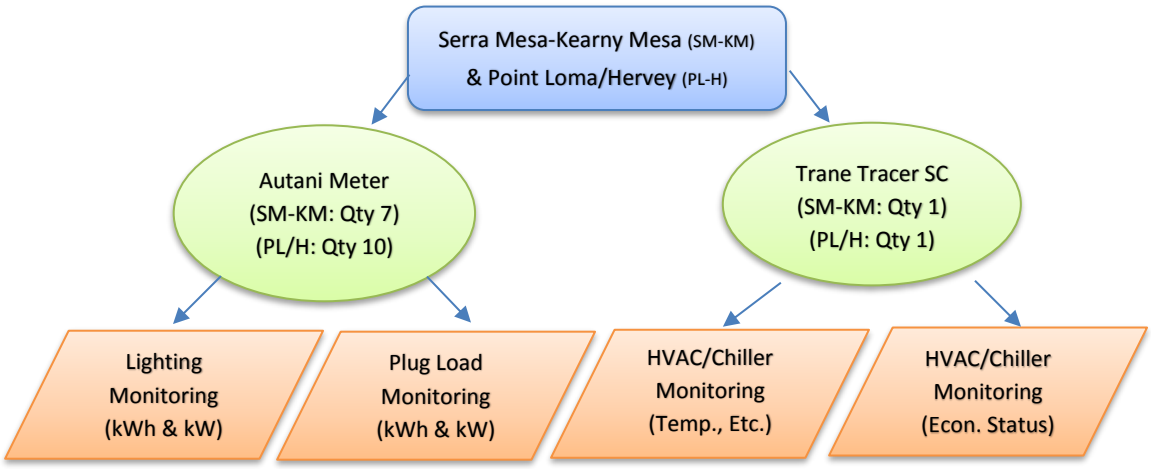

Figure 13: End-Use Monitoring Approach at Serra Mesa-Kearny Mesa and Point Loma/Hervey

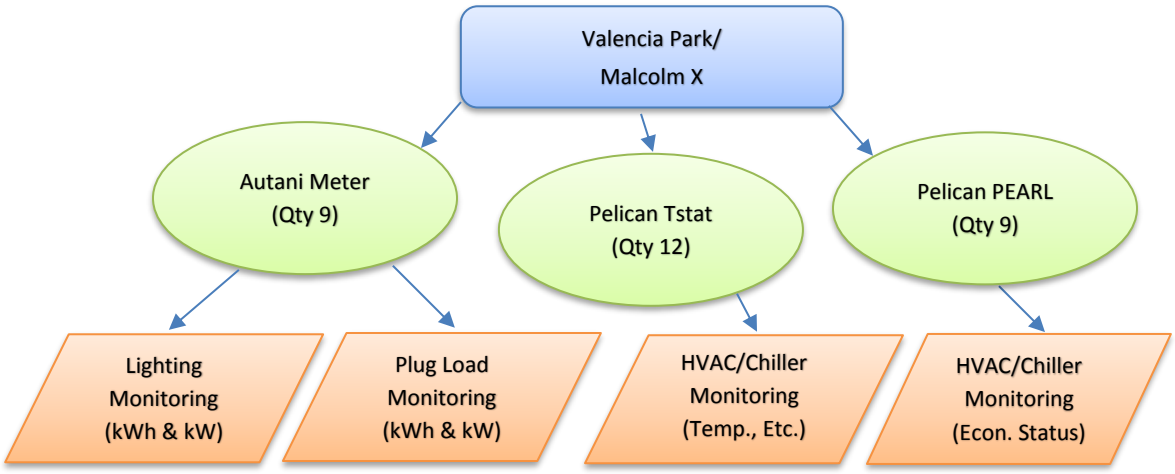

Figure 14: End-Use Monitoring Approach at Valencia Park/Malcolm X

Solar PV Monitoring System

Solar PV production is metered by an Accuenergy 9100 device provided by Onyx, the City's PPA provider. No additional monitoring equipment was purchased or installed for this project. However, monitoring solar PV is important to the accuracy of data collection and energy modeling tasks. City staff can access Onyx's online portal to retrieve interval PV produced kWh data, which helps establish gross site consumption when paired with utility data from SDG&E.

Data Collection, Organization, & Interpretation

End-use monitoring began in July 2018, which was followed by three months of end-use consumption data collection for initial analysis, ending in October 2018. It should be noted that July to October are the warmest months of the year and that electric use for this initial analysis will be higher than other months due to higher air conditioning demands. Data was retrieved by City of San Diego staff through their local access network and then provided to CSE for organization and interpretation. Data organization was challenging because monitoring is conducted through several different devices that record and send data differently. However, this is a common hurdle that existing buildings and multi-building portfolios will experience when attempting to monitor and evaluate energy data at specific end-uses, particularly if building equipment is older or controlled by multiple management systems, such as the case with these project libraries. As a result, it was a time-consuming exercise to accurately integrate and pair the multiple energy data sources together with different recording intervals and file types. The following subsections briefly explain how data was collected, organized, and interpreted by device in order to establish an energy consumption end-use breakdown. Figures 15, 16 and 17 depict end-use breakdown results for each library as well as gross site consumption and PV energy production for the three months of initial end-use data collection.

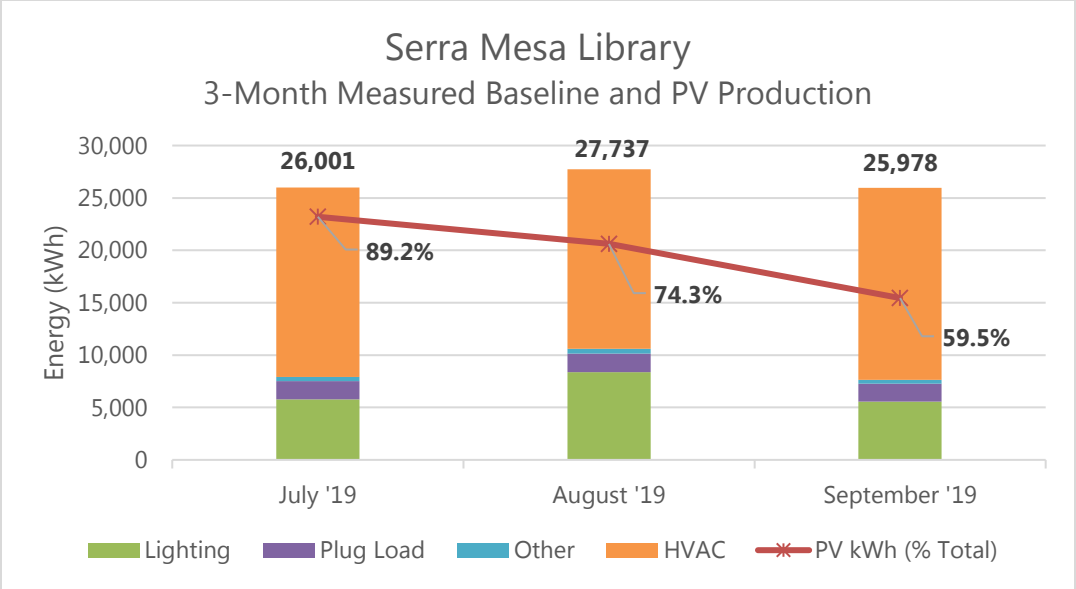

Figure 15: Serra Mesa-Kearny Mesa End-Use Breakdown with PV Production

Autani Wireless Packaged Meter and Manager Data Collection

Autani data is monitored by individual panel submeters and recorded through a wireless connection to the Autani Manager at each location. The data is reported in real time to the Autani cloud-based platform where energy consumption and demand can be viewed live via a few simple dashboards or accessed as historic data through available reports. Each library's data is accessed individually where reports can be created for varying time periods for any given submeter and metric that is being recorded. To calculate energy consumption by end-use, 'real energy delivered' (kWh) and 'real instantaneous power' (kW) data can be reported for each meter at all three locations in Microsoft Excel (Excel) format. One obstacle in doing this was that the Autani cloud-based platform reports data in a report count format instead of consistent intervals. To address this, a macro-enabled Excel workbook was generated that extracts the data into clean 15-minute intervals. Using this interval data in combination with panel circuit information, energy demand and consumption can be calculated by end-use by accounting for energy loads associated with that panel. When combined with the energy breakdown for all other panels inside of a single library, the estimated end-use breakdown of energy consumed by the lighting systems, plug load, miscellaneous equipment and small HVAC components can be calculated. Autani submeter data will only account for a portion of the buildings gross site consumption as it is later paired with estimated HVAC energy consumption.

Trane Tracer SC Data Collection

The Trane Tracer SCs currently operating at Serra Mesa-Kearny Mesa and Point Loma/Hervey are connected to each individual RTU and recording signals from the thermostats as well as unit specific controls. These signals include but are not limited to zone temperature, outside temperature, call for heating or cooling and economizer status if applicable. These signals are recorded in an interval data format where the operating status of each unit is known on a five-minute basis, which was chosen to capture equipment cycling that might be too quick to notice at 15-minute intervals. These data points will then inform how the system or equipment is operating and what power consumption metrics to

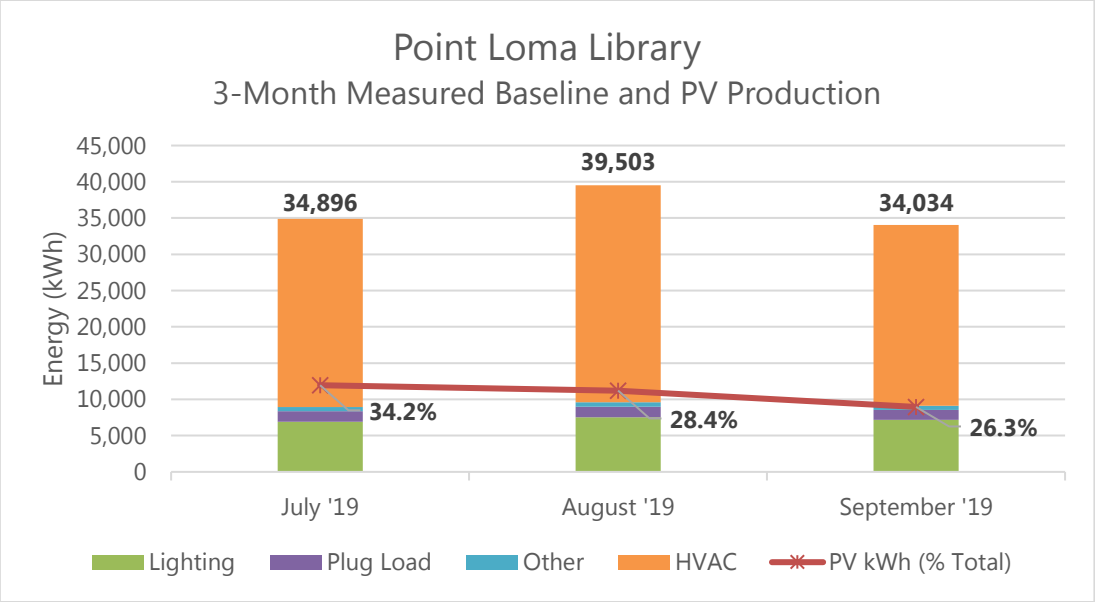

Figure 16: Point Loma/Hervey End-Use Breakdown with PV Production

apply to that timestamp and then can be used to extrapolate the energy usage and demand on a 15-minute interval basis to compare with the other data signals. This Tracer SC data is accessed and saved monthly by City staff through an online platform to ensure data continuity due to limited onsite storage capabilities of the Tracer SC. Available reports are in Excel format, and a software tool is available that ties together all incoming data to calculate gross site energy consumption and end-use breakdown. With all HVAC unit consumption accounted for in this data, a more complete look at total site consumption can be recognized at the libraries when paired with Autani submeter data.

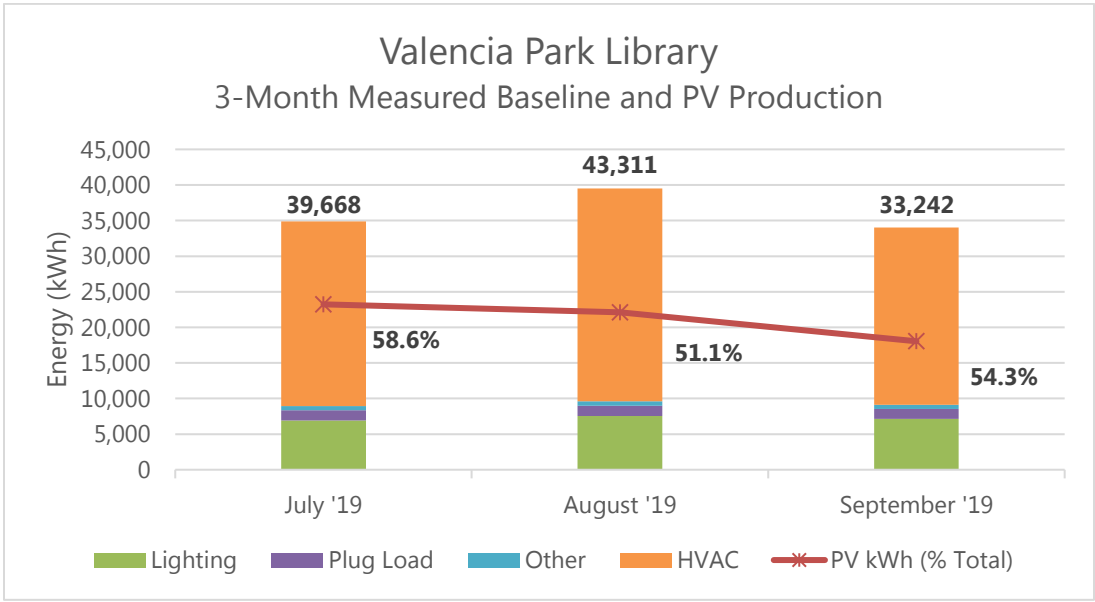

Figure 17: Valencia Park/Malcolm X End-Use Breakdown with PV Production

Pelican Thermostat & PEARL Data Collection

As mentioned previously, Valencia Park/Malcolm X's HVAC units differ from the other two libraries because there is no existing BAS. Existing Pelican programmable thermostats were configured to provide key data points for the project's end-use analysis. Using an additional installed device, the PEARL economizer, the thermostats can record zone temperatures, outside temperature, call for heating or cooling and the status of associated economizers. These PEARL devices were installed on each unit that has an existing economizer, and they report the damper position and status of 'free cooling' from outside air. The Pelican Thermostats communicate to each other and their associated PEARL devices through a wireless mesh network throughout the building and report back through a Pelican Gateway located in the library's Telecom Room. Reports are set to be generated monthly, where five-minute interval performance data is collected for all HVAC units at the library. The smaller interval period is serving the same purpose as the Tracer SC and ensuring that any equipment that could cycle in under a 15-minute period are captured. The data can be sent in Excel format for easy organization and interpretation, where it will be paired with Autani data to establish total end-use consumption at Valencia Park/Malcolm X Library.

Solar PV Data Collection

The solar PV monitoring systems from Onyx implemented at each library were designed prior to the start of this project and installed during the early phases. Therefore, no input on the data collection or reporting capabilities of these systems were made. Detailed system information is currently recorded within the DC-AC inverter and data management device where most of it is typically used for diagnostics and system performance, but metrics such as PV production (kWh) are available on a 15-minute interval basis, which allows utility metered data to be paired to net generating energy that is sent back to the grid. This data is being collected by City staff from their PPA provider online portal. These values will be paired with SDG&E consumption and over-production data to establish gross site consumption for continued analysis. Having access to this data is imperative to calculating the gross site consumption as well as 15-minute interval TDV metrics to establish ZNE or near-ZNE goals for each site. Figure 18 represents the monthly PV production of each site from when they were first commissioned through the calendar year of 2018 including estimated production for the months of October through December.

Applying End-use Monitoring Data

End-use monitoring data was collected for each library as described above. This information will be used to increase the accuracy of building energy models by accurately defining end-uses and thus variable loads and giving insight into where most of the energy in the building is being consumed. With this knowledge ECM's can be prioritized to make the biggest impact on the overall energy consumption of the building by focusing the most effort on the end-uses with the highest energy consumption. With accurate accounting of end-uses in a building energy model, a higher level of confidence is expected in simulated outcomes of ECM's. An initial end-use consumption breakdown of end-uses by percent (Figures 19, 20 and 21) currently indicates energy consumption heavily weighted towards HVAC, but current data is only from summer months. This indicates a prime opportunity to reduce this

consumption through targeted ECMs involving both equipment and controls for HVAC, but further analysis is needed. End-use monitoring will continue for a full year after ECMS are installed to allow for such additional analysis.

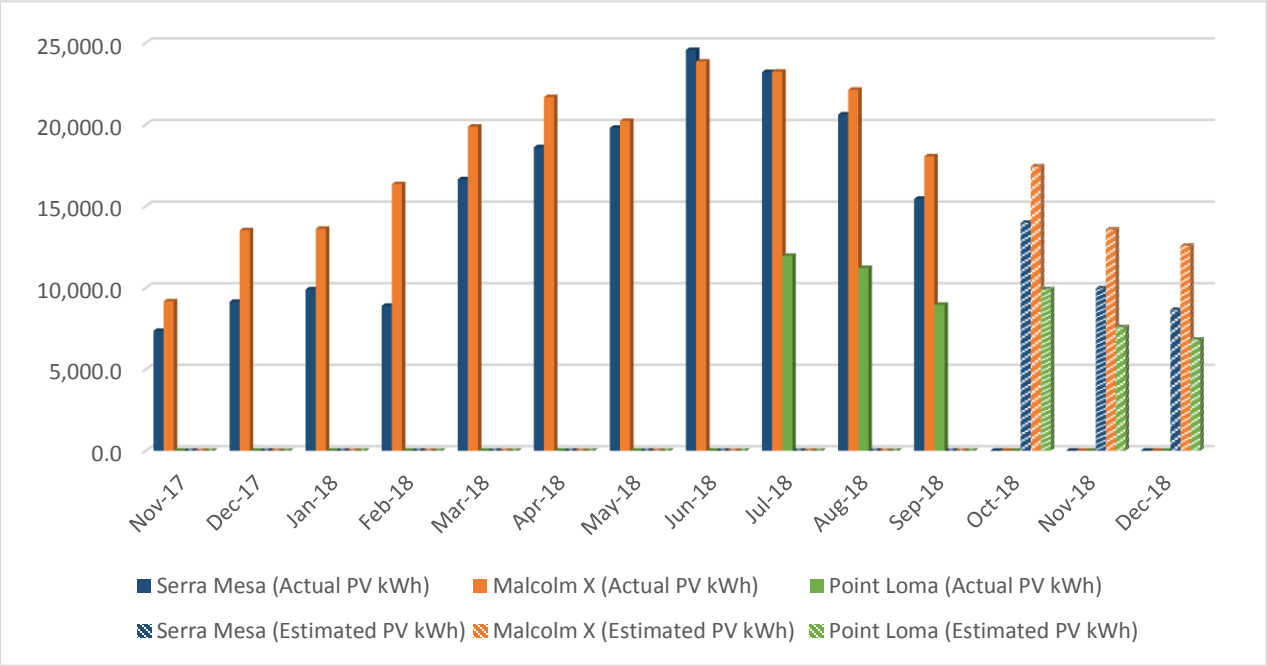

Figure 18: Library PV System Production (Actual and Estimated)

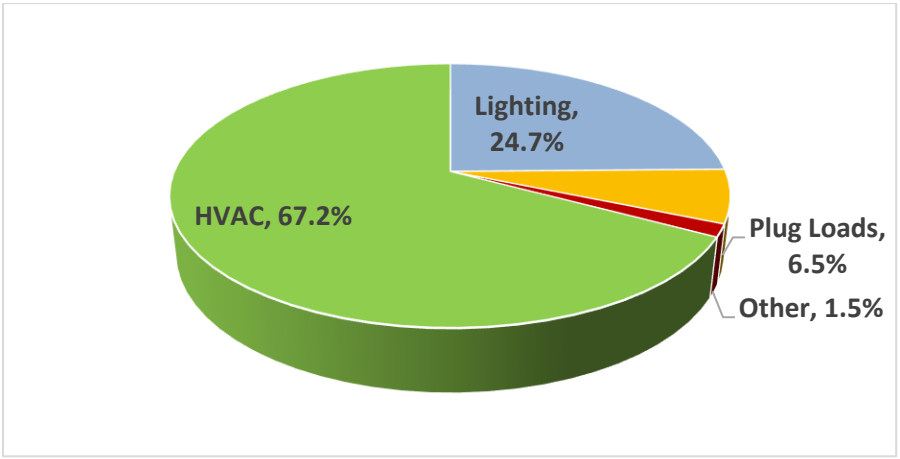

Figure 19: Serra Mesa-Kearny Mesa End-Use Breakdown (%)

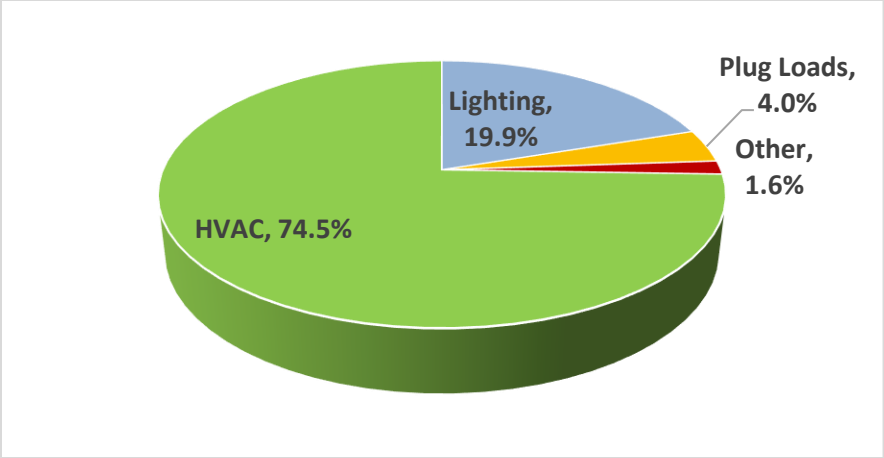

Figure 20: Point Loma/Hervey End-Use Breakdown (%)

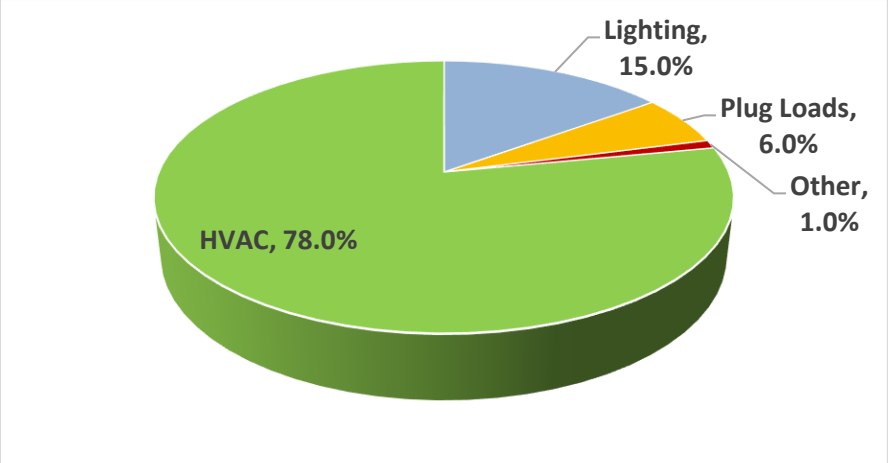

Figure 21: Valencia Park/Malcolm X End-Use Breakdown (%)

IV. Modeling

Using facility site characteristics and 2017 utility metered data, three different types of energy models were prepared for each library: NBI FirstView Models, Baseline Energy Models and Calibrated Energy Models. Each model is described in detail below. End-use energy consumption monitoring findings will be incorporated into the Calibrated Models during the next project task, "ECM Identification."

NBI FirstView Models

Using NBI's FirstView software tool, an initial building analysis and energy model of each library was completed applying only utility bills from the 2017 reference year and a few building characteristics to quickly diagnose opportunities for improvement and compare each library against similar buildings. Benchmarking and diagnostic findings for each library are listed in subsections below. The annual energy use intensity (EUI) compares the total energy use of the building and the median nationwide and climate zone building energy use over a year as reported by The Commercial Buildings Energy Consumption Survey (CBECS)[9] and ASHRAE Standard 100[10], respectively. The Zero Energy Performance Index (zEPI) normalizes the building and climate zone. A lower score is better, with 0 representing zero net energy performance.

Serra Mesa-Kearny Mesa Library

The Serra Mesa-Kearney Mesa Library was found to have an EUI of 65 (Figure 22) and a zEPI of 56 (Figure 23). The library's heating and ventilation systems rated poor in efficiency (Table 11). The library may be a good candidate for potential heating system improvements. Excess outside air rate, high outside infiltration, poor control settings and 24-hour fan schedules may be present.

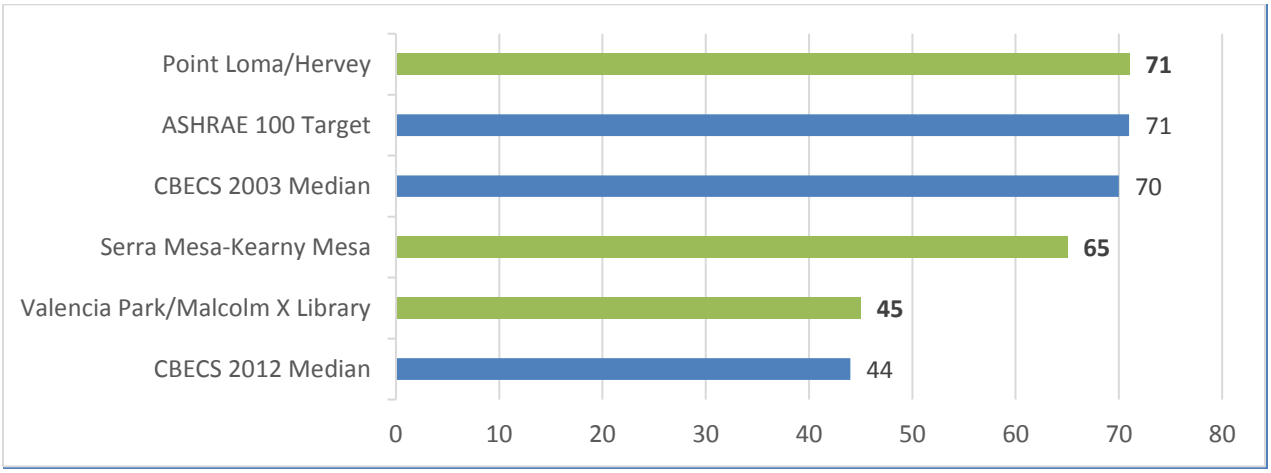

Figure 22: 2017 Library EUI Comparison

[9] CBECS was published is 2003 and 2012 and is commonly used to represent the energy use of typical existing building stock in the United States.

[10] ASHRAE Standard 100 details energy use targets for specific building types and climate zones that are derived from CBECS data.

Point Loma/Hervey Library

The Point Loma/Hervey Library was found to have an EUI of 71 (Figure 22) and a zEPI of 61 (Figure 23). The library's heating and ventilation systems, lighting and plug load rated poor in efficiency (Table 11). The library may be a good candidate for potential heating system improvements. Excess outside air rate, high outside infiltration, poor control settings and 24-hour fan schedules may be present. The building has an elevated electrical baseload. Savings may be available via lighting upgrades and/or plug load management.

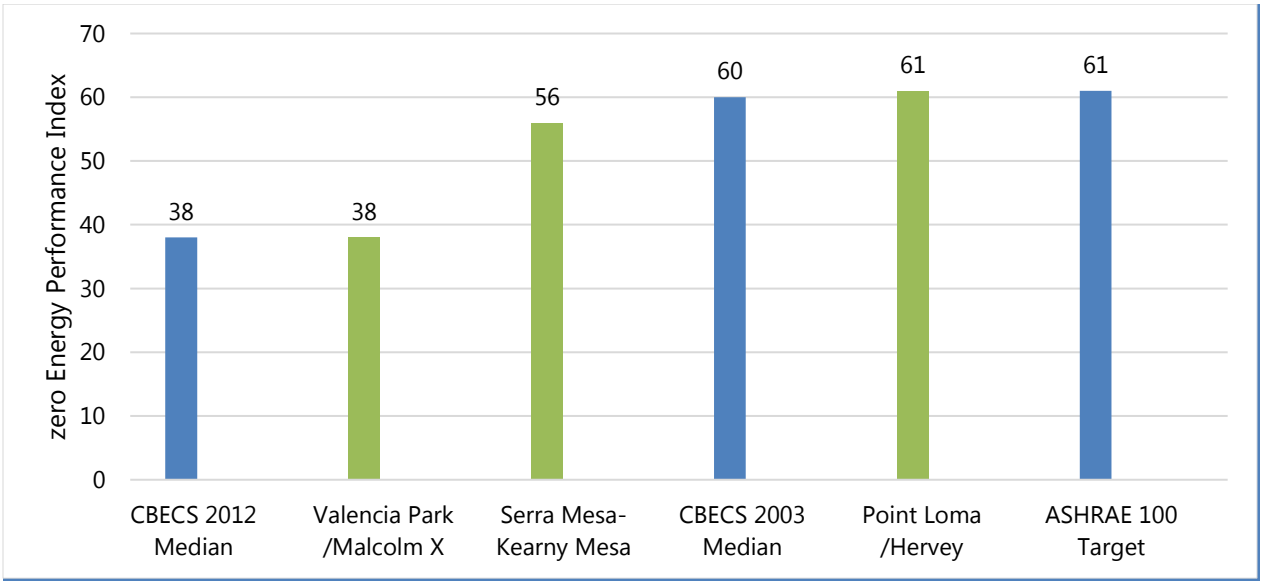

Figure 23: Library zEPI Comparison, 2017

Valencia Park/Malcolm X Library

The Valencia Park/Malcolm X Library was found to have an EUI of 45 (Figure 22) and a zEPI of 38 (Figure 23). The library showed relatively good performance, and it was recommended to evaluate systems and strategies in this building and to find examples to improve other, similar buildings (Table 11).

Library & Diagnostic Category	Serra Mesa-Kearny Mesa	Point Loma/Hervey	Valencia Park/Malcolm X
Heating and Ventilation Efficiency	Poor	Poor	Typical
Cooling Efficiency	Good	Good	Typical
Controls	No apparent problems	No apparent problems	No apparent problems
HVAC Reheat	No apparent problems	No apparent problems	No apparent problems
Thermal Baseload	Typical	Typical	Typical
Light and Plug Load	Typical	High	Low
External Process Load	No apparent problems	No apparent problems	No apparent problems
Data Consistency	Orderly	Orderly	Orderly

Table 11: 2017 Library Diagnostics Comparison

Baseline Models

Each library was subjected to a detailed evaluation process to create initial baseline models using Energy Pro v7.2.4 software. The ASHRAE Level II Audits provided inputs to represent existing conditions. As-built plans and Title 24 energy documentation were also reviewed and compared to capture existing conditions when available. Furthermore, 2017 calendar year utility metered data was selected for use in the models since it is the most recent data available that aligns with obtained weather data. Baseline models were created as a stepping stone to complete calibrated models.

Calibrated Models

The creation of calibrated models began with the baseline models. Typical meteorological year (TMY) weather data was added in the first iterations of the models as this weather data set is used by default in Energy Pro v7.2.4. After several unsuccessful attempts to calibrate the model to the historical energy usage TMY, it was decided that AMY weather data is more appropriate for this type of application. Following the addition of AMY data, an iterative process was used to complete calibration of the models to match utility data. The most significant adjustments were as follows:

- Adjusted the internal base loads to attempt to accurately reflect the conditions in the library for lighting power density, receptacle load density and approximate number of occupants.
- Adjusted occupancy, lighting, HVAC and receptacle schedules to match library hours and estimated occupancy patterns as reported by library staff.
- De-rated the recovery efficiencies of the boilers and domestic hot water equipment to account for their age and state of repair.
- De-rated the efficiencies of the heating and cooling equipment to account for their age and state of repair where appropriate.

The results of calibrated models of each library are shown in Figures 24 through 32, starting on page 23. Each graph shows the utility meter data (dark green) vs. the calibrated model (light green) for the kWh consumed, the kW demand and the therms consumed. These calibrated kWh and kW modeled results are within 3% accuracy of actual utility metered data for total electric demand and electric consumption, and the therms consumed are within 5% accuracy of actual utility metered data for total gas consumption.

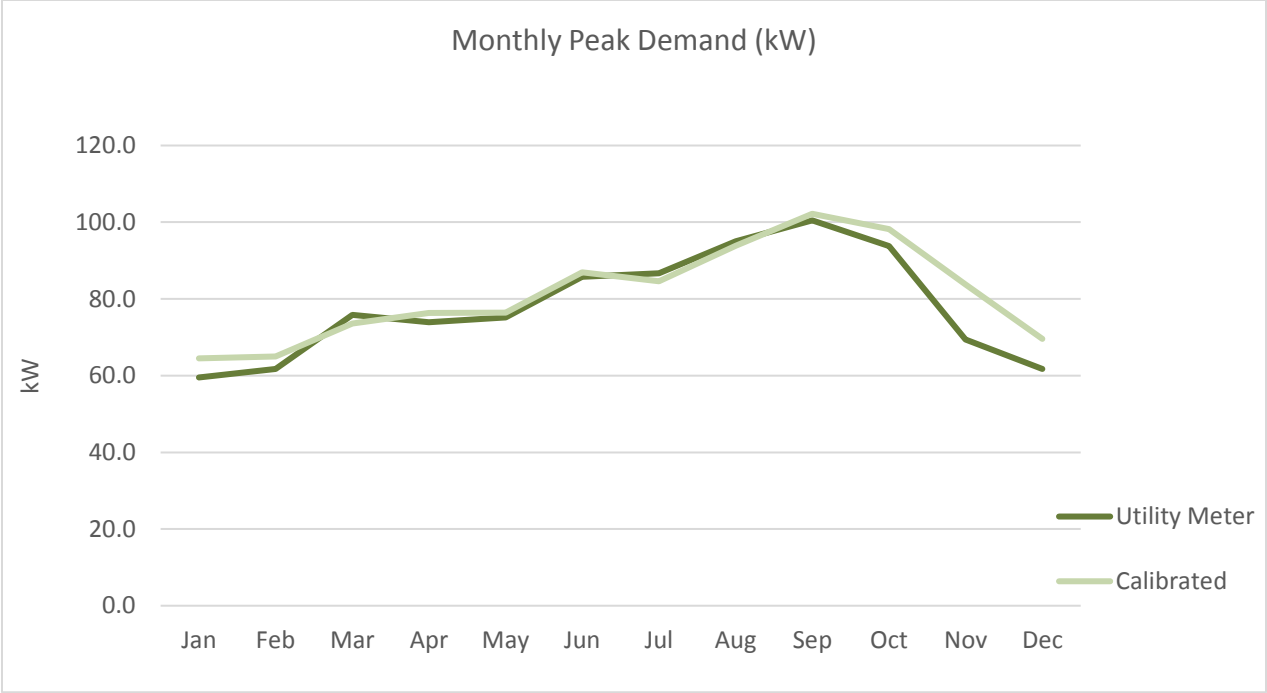

Figure 24: Serra Mesa-Kearny Mesa EnergyPro Calibration Results (kW)

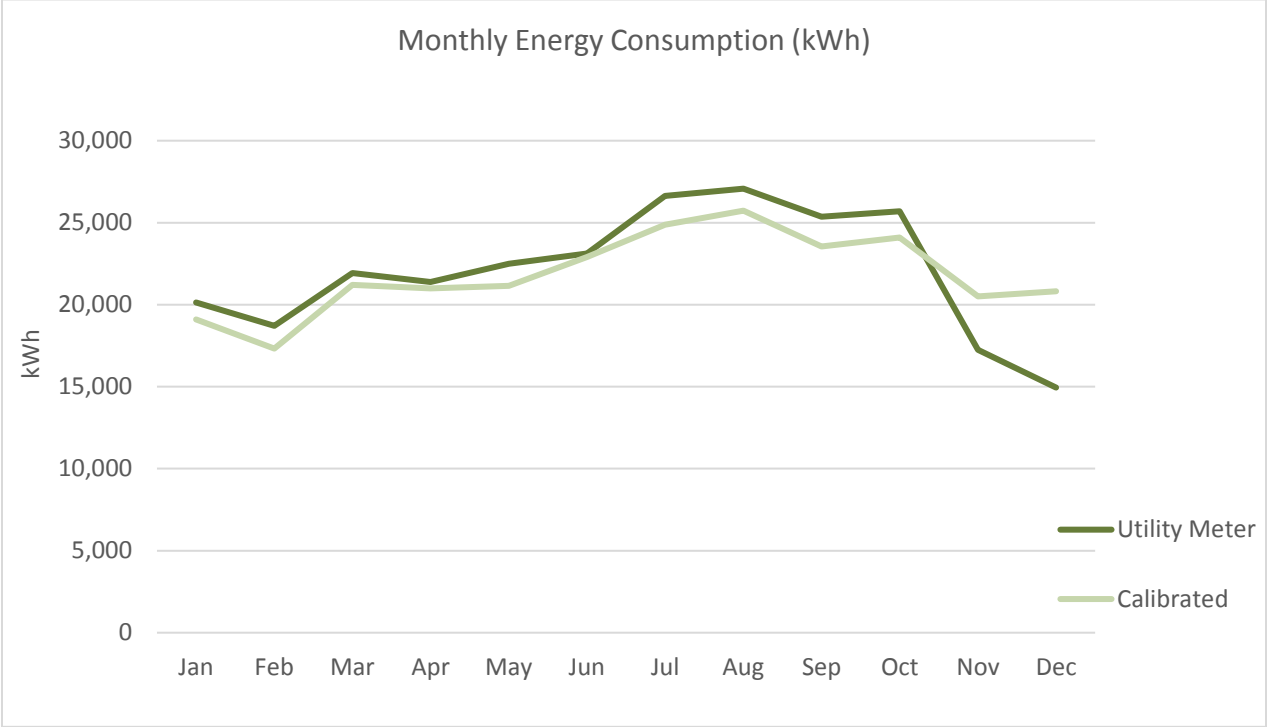

Figure 25: Serra Mesa-Kearny Mesa EnergyPro Calibration Results (kWh)

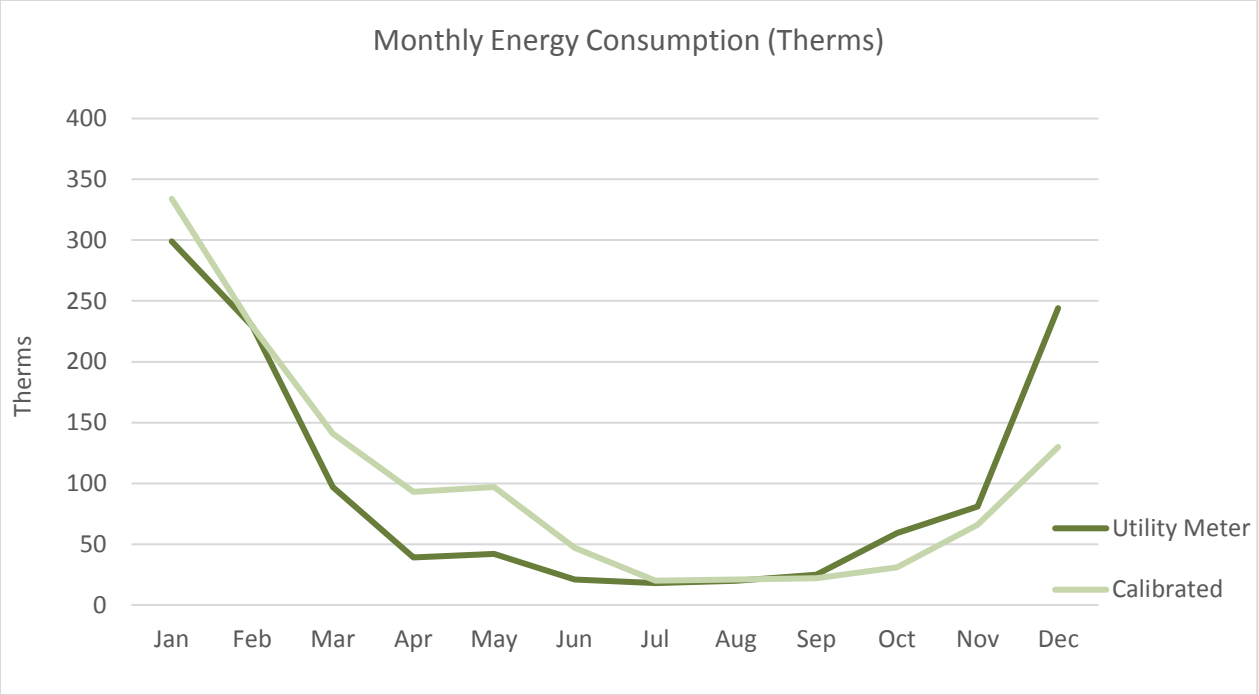

Figure 26: Serra Mesa-Kearny Mesa EnergyPro Calibration Results (therms)

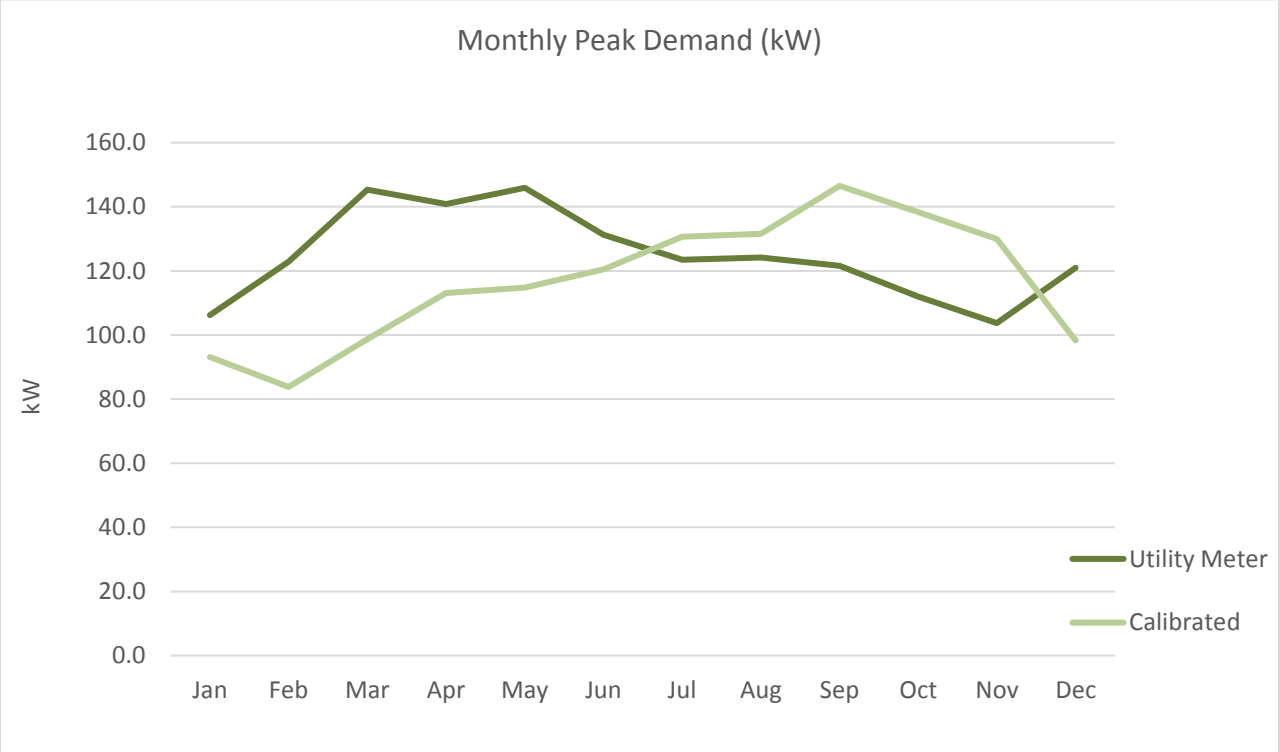

Figure 27: Point Loma/Hervey EnergyPro Calibration Results (kW)

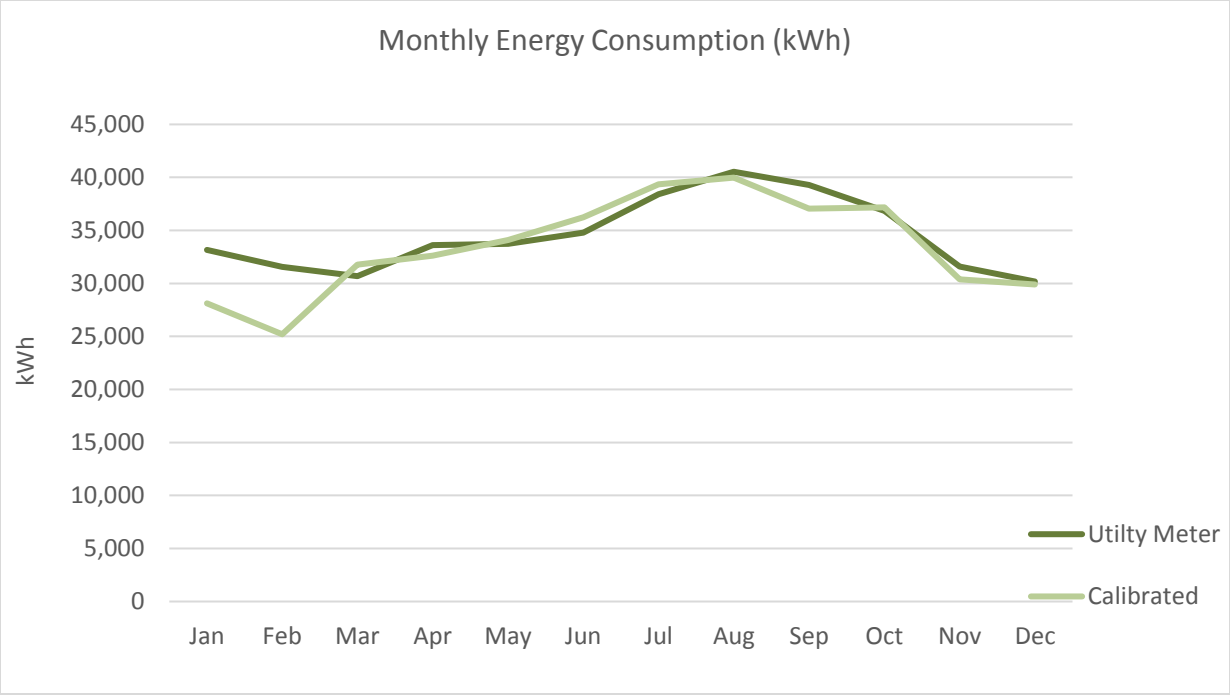

Figure 28: Point Loma/Hervey EnergyPro Calibration Results (kWh)

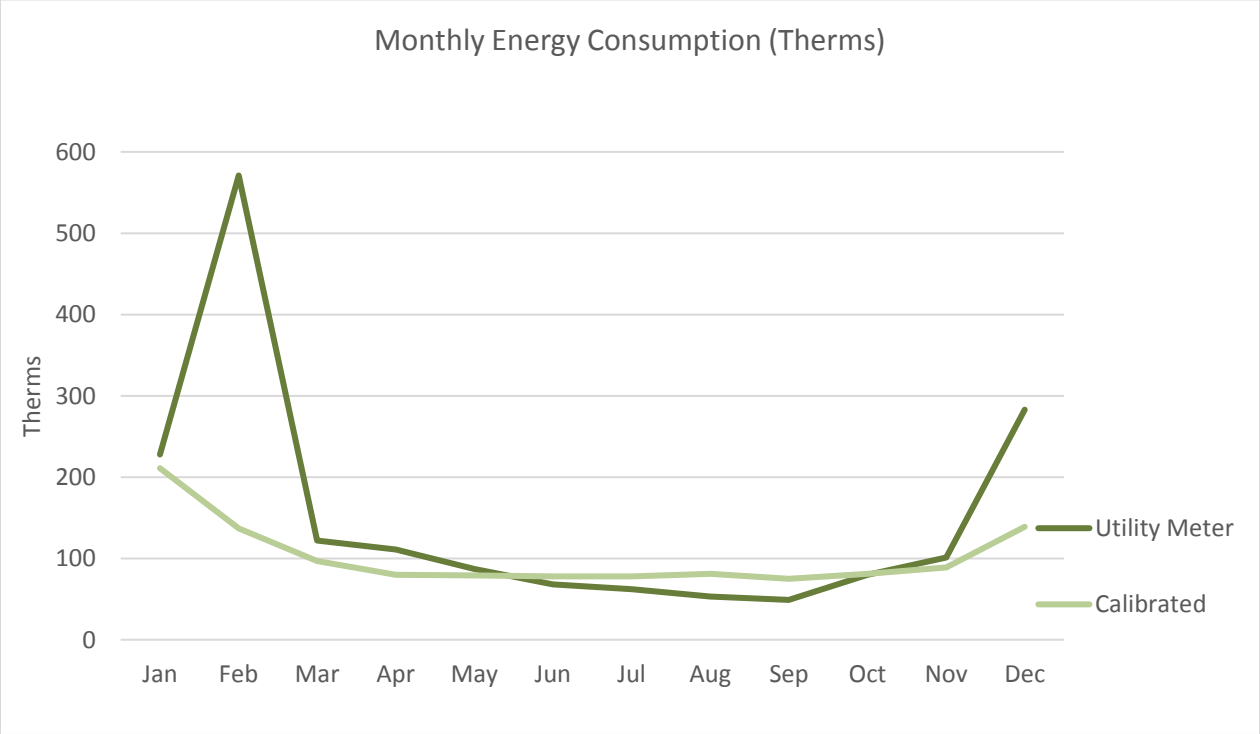

Figure 29: Point Loma/Hervey EnergyPro Calibration Results (therms)

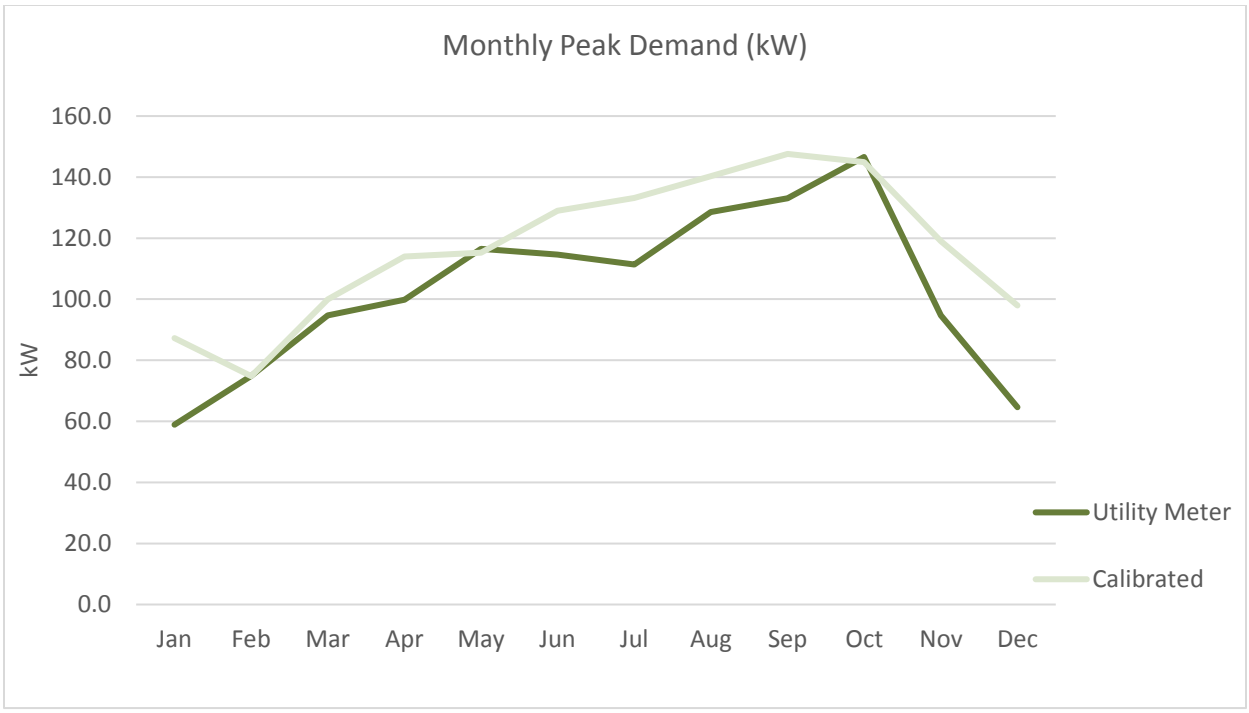

Figure 30: Valencia Park/Malcolm X EnergyPro Calibration Results (kW)

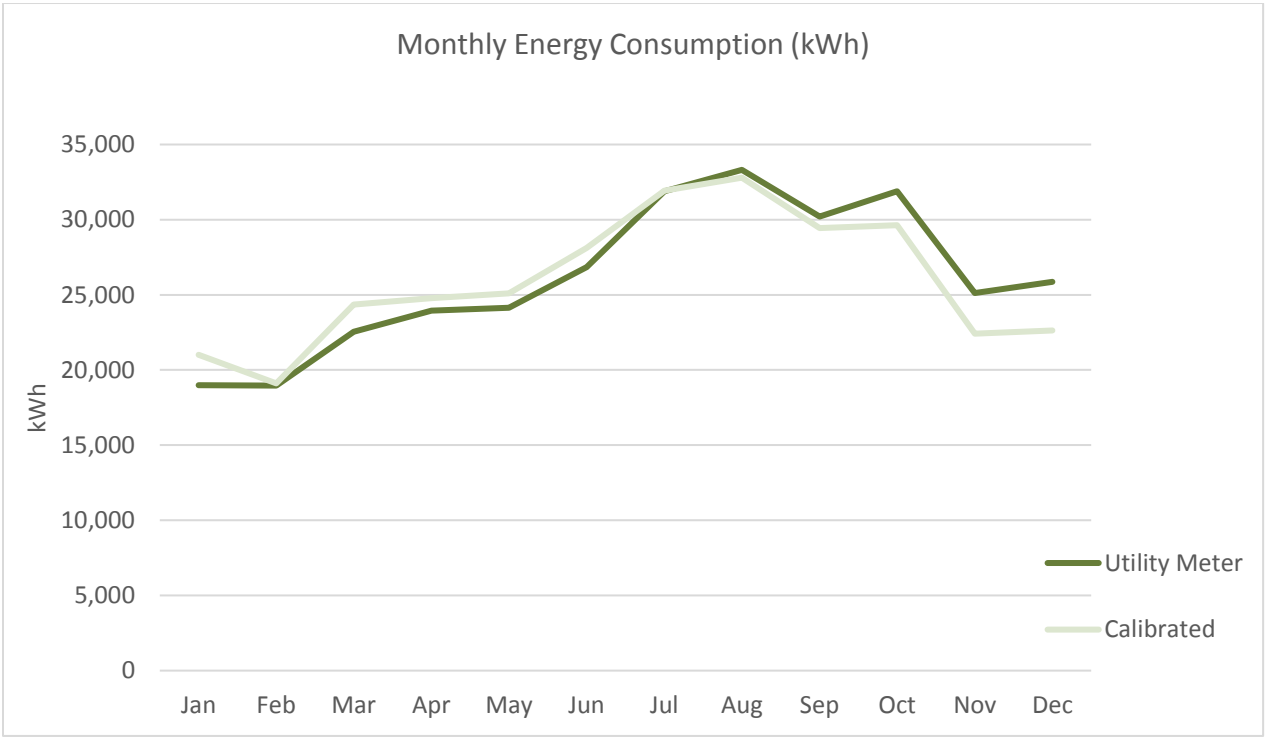

Figure 31: Valencia Park/Malcolm X EnergyPro Calibration Results (kWh)

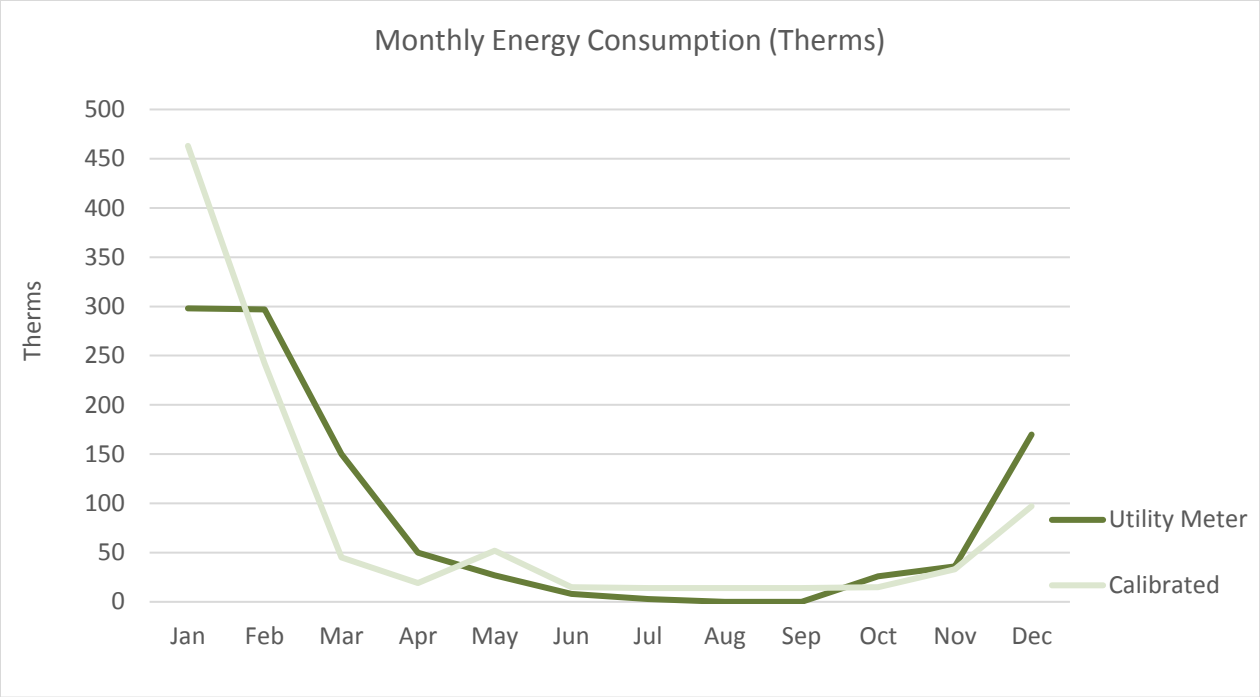

Figure 32: Valencia Park/Malcolm X EnergyPro Calibration Results (therms)

Initial Model Observations

Within the City of San Diego, monthly electrical demand (kW) is often at its highest between July and October because high temperatures persist into Fall, creating more peak loads with HVAC. This pattern can be seen clearly in the Serra Mesa-Kearny Mesa and Valencia Park/Malcolm X electrical demand curves for utility metered data plotted during 2017. The building energy models for all three libraries also predict this pattern in electrical demand using AMY weather data for the 2017 baseline year suggesting that weather should be a dominant influence on peak monthly electrical demand. However, plotting the monthly billed energy usage for Point Loma/Hervey revealed an unexpected pattern in electrical demand during the 2017 baseline period. Peak monthly electrical demand at Point Loma/Hervey Library is at its highest between March and May (Figure 27). The City of San Diego maintenance team has reported the HVAC system at Point Loma/Hervey has intermittent problems. The unexpected monthly electrical demand pattern could be a result of the HVAC system malfunctioning during the 2017 calendar year. The annual peak electrical demand at Point Loma/Hervey when compared to its square footage is close to kW per square foot of Serra Mesa-Kearny Mesa. This may suggest that the late-year decrease in monthly peak electrical demand is not the result of nonfunctioning HVAC equipment, but that the HVAC equipment was operating when it should not have been between February and May and that perhaps the library set a higher peak electrical demand than it should have given the installed equipment.

Another unexpected pattern is a large amount of natural gas consumption at Point Loma/Hervey in February of 2017 (Figure 29). The additional gas usage is estimated to be nearly 400 therms more than

expected for that month based on the usage in January and March. The City of San Diego has provided no explanation for what may have caused the unusual consumption for February. Possibly the boiler controls malfunctioned and caused the boiler to remain on for an extended period that month. Another possible scenario that explains both the unexpected peak electrical demand pattern and the increased natural gas use is that the HVAC system may have been simultaneously heating and cooling in February. This might have caused an increase in demand as the chiller would work harder to meet the cooling load and the boiler would not cycle off while trying to meet a heating load. This explanation however does not adequately explain the high monthly peak electrical demand in March through June. The NBI FirstView Model may have flagged the HVAC and ventilation efficiency as “Poor” due to this undetermined issue.

V. Results & Next Steps

The next steps for the project are to complete identification and design of ECMs, install ECMs and to accomplish a post-construction measurement and verification period (M&V). End-use consumption monitoring and modeling findings will be utilized during ECM design to help determine the most cost-effective and feasible ECMs by projecting future energy reductions of proposed ECMs, calculating equipment sizing and calibrating building management system tolerances. For instance, findings to date suggest further investigation into the Point Loma/Hervey HVAC equipment and ventilation controls is needed, and an ECM that addresses its poor efficiency should be a priority. Also, Point Loma/Hervey library needs to achieve the highest energy consumption reduction, even when solar PV production is accounted for in the design evaluation. After ECMs are finalized, models will be used to evaluate them at each of the libraries to determine which will be installed and will work together to achieve enough reduction in energy consumption to meet ZNE or near-ZNE. After ECMs are installed, the M&V period will begin. During that period, the end-use monitoring devices will be used to continuously evaluate end-use energy consumption compared to the EnergyPro calibrated model and the library monthly utility metered data (2019). This will allow for adjustments to the models or to ECM controls and enable the project team to determine if each library has achieved ZNE or near-ZNE.

As a mission-driven nonprofit organization, CSE works with energy policymakers, regulators, public agencies and businesses as an expert implementation partner and trusted information resource. Together, we are the catalysts for sustainable energy market development and transformation.

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