

EPC-15-085: Report of ECM Integration Activities and Financial Considerations for City of San Diego Public Library ZNE Demonstration Project

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Prepared for
California Energy Commission

Prepared by
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I. Introduction

The Center for Sustainable Energy (CSE), Mazzetti Inc. (Mazzetti), San Diego Gas & Electric (SDG&E) and City of San Diego (City) developed this *Report of ECM Integration Activities and Financial Considerations* for three City of San Diego public libraries (Serra Mesa-Kearny Mesa, Valencia Park/Malcolm X, and Point Loma/Hervey) as part of the California Energy Commission (Energy Commission) Electric Program Investment Charge¹ demonstration project, EPC-15-085. This project is a demonstration of cost-effective zero net energy (ZNE) and integrated demand-side management strategies that are referred to throughout this report as energy conservation measures (ECMs). ECMs proposed in this report will be installed in all three existing libraries with the goal of achieving ZNE or near-ZNE when coupled with existing photovoltaic (PV) systems. Specifically, this report presents the Energy Commission and the City with ECMs and control systems identified to be installed, an overview of estimated energy and cost savings, anticipated ZNE-results, an installation timeline, permits that need to be secured and an assessment of participation in available demand response and distributed energy resource programs.

II. ECM and Control System Identification

A design evaluation of each library was conducted from December 2018 to February 2019 by Mazzetti. At each library, significant opportunities based on a baseline analysis² were found to reduce energy consumption, to improve occupant comfort, to reduce building maintenance and to extend equipment life. **Total energy consumption could be reduced by as much as 20% per building, resulting in cumulative energy cost savings of more than \$60,000 per year.** The ECMs identified include,

- Retrofitting lighting systems and adding controls,
- Replacing existing select HVAC equipment with new high-efficiency units,
- Upgrading building management systems (BMS) to enable smart building control strategies,
- Optimizing plug loads and securing the building envelope with window film, and;
- Weather stripping where currently needed.

Additionally, existing photovoltaic systems were accounted for as existing ECMs and energy storage options were evaluated. Across all three libraries these measures are estimated to save a total of 237,983kWh/year which is equivalent to ~168 metric tons of carbon dioxide (CO₂) or ~20 homes' electricity use for one year. Estimated energy savings for each library are shown in Table 1 and described in each measure-specific subsection.

¹ *Electric Program Investment Charge*. California Energy Commission. <https://www.energy.ca.gov/research/epic/>

² *EPC-15-085: Building Energy Baseline & Modeling Report for City of San Diego Public Library ZNE Demonstration Project*. October 2018. Center for Sustainable Energy.

Table 1: Estimated Energy Savings per Library (kWh, Therms, kBtu)

| Library | Measure | Demand Savings (kW) | Electricity Savings (kWh/yr.) | Natural Gas Savings (Therms/yr.) | Total Energy Savings (kBtu/yr.) |
|----------------------|---------------|---------------------|-------------------------------|----------------------------------|---------------------------------|
| Serra Mesa | ECM 1-3, 5, 6 | 23 | 38,687 | -542 | 77,805 |
| Valencia Park | ECM 1-7 | 41 | 84,272 | -39 | 283,648 |
| Point Loma | ECM 1-3, 5, 6 | 42 | 115,024 | -442 | 348,278 |
| TOTAL FOR ALL | | 106 | 237,983 | -1,023 | 709,731 |

Lighting Retrofits (ECM-1)

At each library, lighting retrofits will be completed with one of the following three strategies to replace existing luminaires,

- Install LED retrofit lamps in existing luminaires,
- Install LED retrofit kits, replacing the internal lighting components within an existing housing, and;
- Replace existing luminaires in a one-for-one replacement, with new LED luminaires at existing lamp locations.

Based on these three strategies, existing non-LED sources will be replaced with LED sources to **reduce each library’s total connected load (TCL) by approximately 20,000–30,000 watts or about 64–67% from baseline.** These retrofits will also provide consistent color through the libraries. In addition to replacing non-LED sources, the replacement of linear pendants with new luminaires in the bookstack areas will be completed at Valencia Park/Malcolm X to not only decrease energy use but also to increase uniformity and vertical brightness within the stack areas (Figure 1). At Serra Mesa-Kearny Mesa, there are opportunities to maintain the aesthetic of existing luminaires with simple lamp replacements and for new linear pendants used in some areas (Figure 2). Lastly, at Point Loma/Hervey, approximately 10,000 watts will be saved through the replacement of old 2x2 troffers with fixtures that will improve the visual quality of working areas (Figure 3).



Figure 1: Valencia Park Existing Lighting Source



Figure 2: Serra Mesa Existing Lighting Source



Figure 3: Point Loma Existing Lighting Source

Lighting Controls (ECM-2)

Lighting control systems will be installed based on each library's need. The existing programmable lighting control panels (PLCP) at each library will be replaced with new digital control systems that provide additional layers of efficiency, including BMS interface, daylight harvesting, and demand-side management capabilities. The working condition of all existing lighting control devices, occupancy sensors and daylight sensors will be verified by lighting contractors and replaced if any are found to be not working properly. In addition, automatic shut-off devices such as occupancy sensors or timer switches will be verified to be in proper working order in all discrete spaces including restrooms, private and open offices, utility and storage closets and back-of-house corridors. Low-voltage control stations will also be installed to provide local control for library staff, however, the City will make the final determination if building-level control will be implemented or if they will retain centralized control through a City database.

HVAC Retrofits (ECM-3 & 4)

Replace RTU or AHU and Implement CO₂ Demand-Controlled Ventilation (ECM-3)

Serra Mesa-Kearny Mesa and Valencia Park/Malcolm X will benefit from replacing a select rooftop unit (RTU), and Point Loma/Hervey an air handler unit (AHU), with new high-efficiency units. They are all stand-alone units that serve the library community/multipurpose rooms at Serra Mesa-Kearny Mesa and Point Loma/Hervey and the Teen Tech Center at Valencia Park/Malcolm X. The new units integrate into a Tridium Niagara 4 BMS (see HVAC Controls ECM-5) to allow smarter, more optimal temperature and fan speed control based on zone demand and occupancy (i.e. people in the room). Fan speed control based on occupancy is called demand-controlled ventilation (DCV). With a controllable variable speed fan on the RTU or AHU, a building automation system (BAS) will be able to optimize the ventilation to the space based on occupancy via an indoor carbon dioxide (CO₂) sensor in each zone. When the space is empty or at its minimum occupancy, the CO₂ level in the space will drop and the sensor will tell the RTU or AHU to reduce ventilation.

Install Ventacity Heat Recovery Ventilator (ECM-4)

At Valencia Park/Malcolm X-only an ultraefficient Ventacity VS100RT Smart Ventilation™ Management System heat recovery ventilator (HRV) and dedicated outdoor air system (DOAS) will be installed (Figures 4, and 5). This system will be an emerging technology solution and was recommended by way of SDG&E's Emerging Technologies Program, which supports increased energy efficiency market demand and technology supply by contributing to the development and deployment of new and under-utilized energy efficiency measures

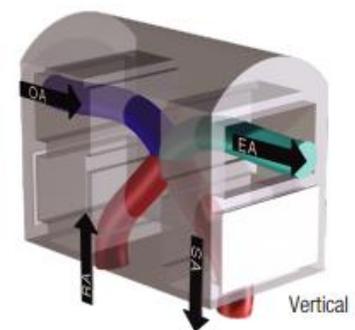
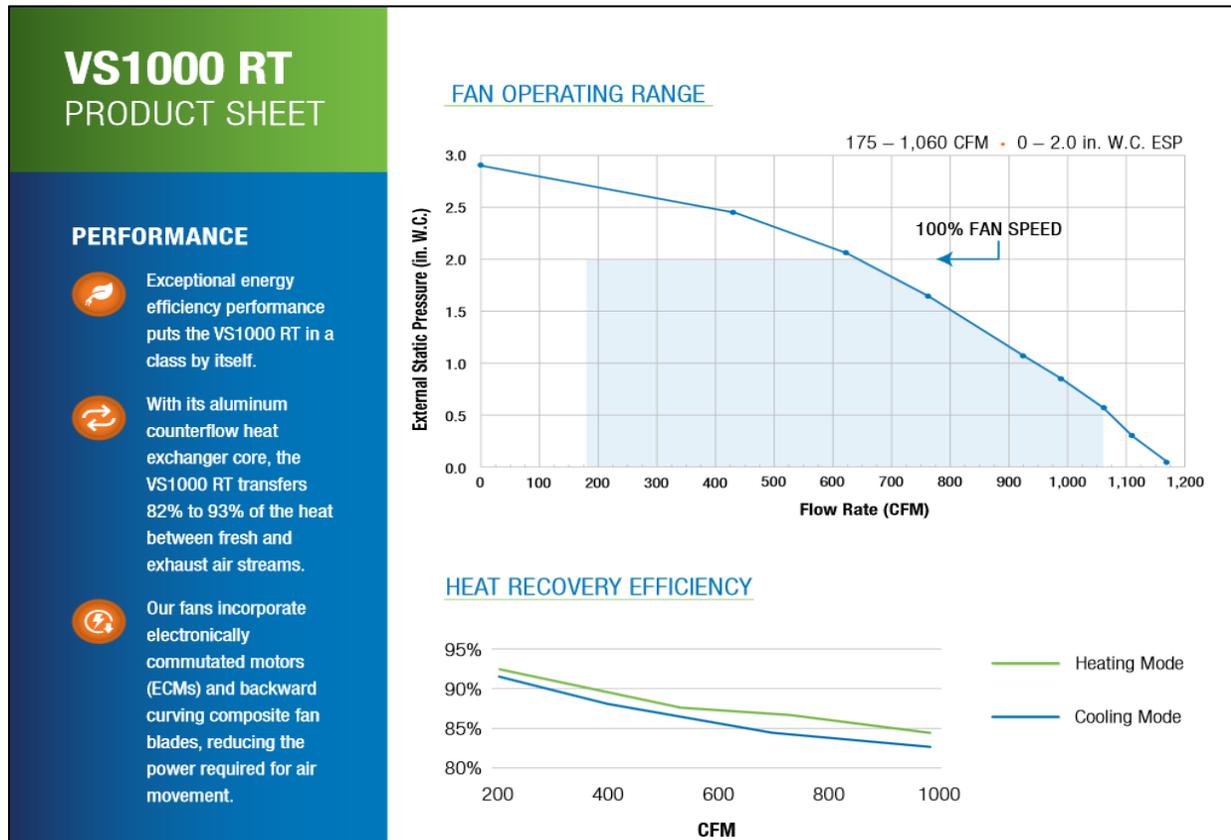


Figure 4: Ventacity HRV Diagram

(i.e., technologies, practices, and tools).³ This system is designed to continuously improve building health and indoor air quality, while minimizing building energy usage by reducing strain on the chiller that serves Valencia Park/Malcolm X's multipurpose room. The unit includes an aluminum counterflow heat exchanger that facilitates a transfer of 82-93% of the heat between fresh and exhaust air streams. This system is capable of preheating or precooling the outside air before it is conditioned and supplied to the space. The heat recovery efficiency feature will save a significant amount of cooling and heating energy in this building. The unit also includes an electronically commutated motor that allows for variable fan speed control. The unit will be installed in conjunction with the RTU and the existing chiller serving the multipurpose room and will reduce the cooling and heating capacity of this unit by ~10% by providing an airside economizer-like benefit. Unit accessories include room and duct CO₂ sensors, a relative humidity sensor, a volatile organic compound (VOC) sensor and a smart building gateway. These sensors and controls will allow integration into the BAS and enable demand-controlled ventilation while monitoring and optimizing the indoor air quality of the space.

Figure 5: Ventacity VS100 RT Product Sheet Excerpt



³ Fact Sheet: Energy Efficiency Statewide Emerging Technologies Program. (2013). California Public Utilities Commission. <http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5415>

HVAC Controls (ECM-5)

A Tridium Niagara N4 BMS (Figure 6) will be installed at each library. The control system will include a supervisory-level control front-end system to be installed on a centralized City server along with a JACE with BACnet drivers to connect to the BACnet BAS as well as an additional LON driver to communicate to the existing Trane controls (installed previously by the project to collect building baseline data).

The BMS license will include up to 25 controllers that enable all existing devices to tie in as well as allow new devices to be integrated into the system. The Tridium BMS will provide central access for the City to control the buildings, along with improved analytics to assist in active commissioning of each library. The system will control all existing HVAC equipment as well as integrate with an existing lighting control system and any other BACnet ready devices. The BMS upgrade will reveal additional control strategy opportunities for each building as well. Control sequences, such as equipment scheduling and occupancy control, as well as supply air temperature (SAT) setpoint reset based on outside air temperature can be programmed into the BMS. When implemented, these control sequences will optimize the performance of the HVAC equipment and reduce the energy consumption of the building.



Figure 6: Tridium Niagara 4

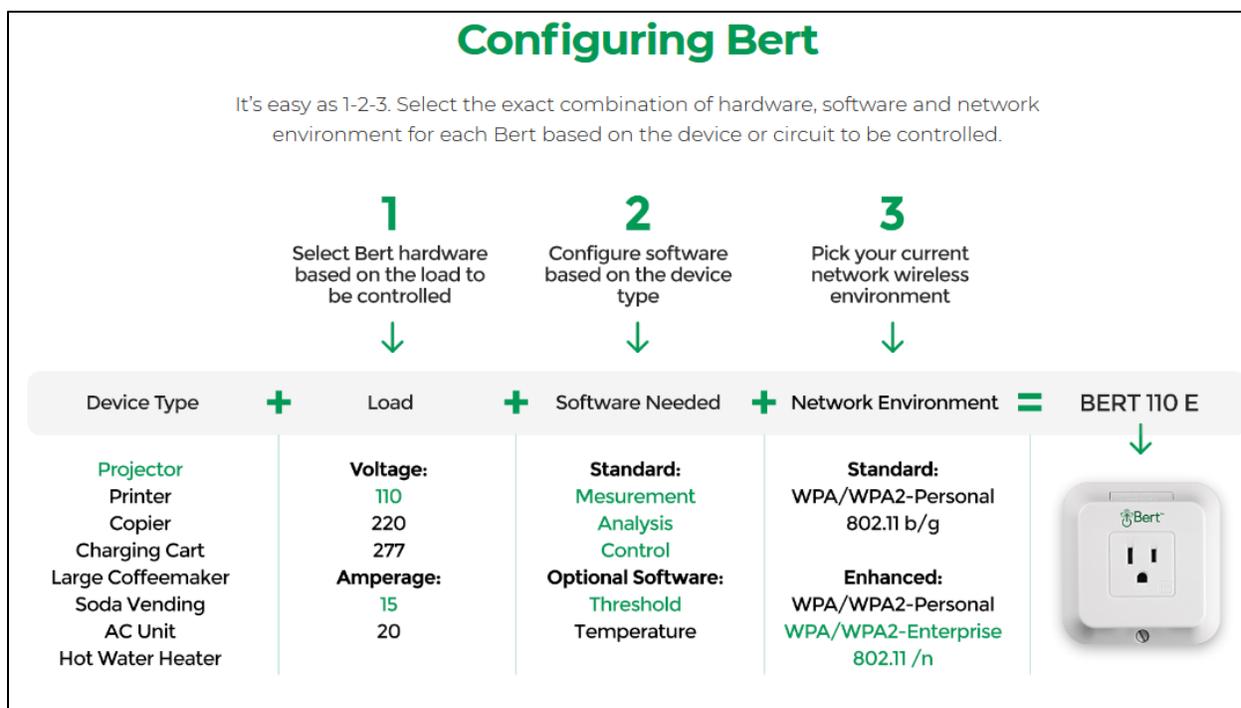
Plug Load Management (ECM-6)

Another recommended emerging technology solution from SDG&E's Emerging Technologies Program from Bert was identified to manage and control the energy consumption of plug load devices at all libraries. Their BertBrain smart plugs will be installed between the power cable for devices and the wall receptacle and connect to the facility Wi-Fi network to integrate to the Tridium Niagara N4 BMS (Figure 7). This allows each library's plug load devices such as copiers, printers, kitchen appliances, vending machines, coffee makers, water coolers/heaters and small air conditioners or fans to be controlled centrally by the City. The smart plugs have the capability to collect and store real-time interval energy use and space temperature data for each device installed. There will be seven devices installed at Serra Mesa-Kearny Mesa, eight at Valencia Park/Malcolm X and nine at Point Loma/Hervey.

Building Envelope (ECM-7)

Valencia Park/Malcolm X features a large cylindrical glass window with two glass doors leading to an exterior space that contains a fountain within the building's footprint. This glass cylinder is responsible for a large solar heat gain during the day, and a half-inch gap was found along the perimeter of the doors resulting in air infiltration and heat loss. Window film to reduce solar heat load and improve occupant comfort will be installed as well as weather stripping along the perimeter of the door to mitigate air infiltration.

Figure 7: Bert Configuration



Source: <https://bertbrain.com/solutions>

Photovoltaic Systems

As discussed previously in the *Building Energy Baseline and Modeling Report*, photovoltaic (PV) system sizing and installation are typically performed after energy efficiency improvements are made to buildings. However, 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. The technical specifications for each system are present in Table 2. ECM identification and ZNE performance estimates were completed taking existing PV systems into account.

Table 2: Photovoltaic System Size, Type and Production at Each Library

| Library | PV System Capacity (kW-DC) | Mounting Type | Estimated Annual PV Production (kWh-AC) | Estimated Annual Offset (% of pre-retrofit kWh) | Estimated Annual Offset (% of post-retrofit kWh) |
|---------------|----------------------------|------------------|---|---|--|
| Serra Mesa | 138.69 kW | Ground (Carport) | 204,014 kWh | 78% | 91% |
| Valencia Park | 138.69 kW | Ground (Carport) | 230,283 kWh | 74% | 101% |
| Point Loma | 84.42 kW | Roof | 129,699 kWh | 32% | 45% |

Energy Storage

Energy storage was determined as infeasible for this project due to budget, time and an existing initiative for energy storage procurement and installation at City of San Diego buildings. CSE investigated the possibility of a power efficiency agreement and other financing options for energy storage that

would be at no upfront cost to the City. However, batteries were estimated to take about six months to procure and ship, and the City was already in process of securing approved energy storage vendors for future installation at to-be-determined City buildings that would not be completed by the installation on ECMs for this project. However, CSE will later provide an energy storage analysis for each library in Energy Toolbase™ to the City of San Diego.

III. ECM Modeling and ZNE Verification

The purpose of implementing ECMs is to reduce the energy consumption of the building to a level that achieves ZNE or near-ZNE based on the Energy Commission definition of a ZNE building,⁴ also known as ZNE Time-Dependent Valuation (TDV) definition. In addition, “ZNE Site” and “ZNE Source” definitions⁵ were evaluated to enable comparison to other ZNE projects who use these industry metrics. Using calibrated EnergyPro Models and typical metrological year (TMY) weather data, post-retrofit (after ECMs are installed) energy consumption values were estimated for each library to see if ZNE is achievable for TDV, Site and Source ZNE targets. If the ZNE net value is near or less than or equal to zero, then ZNE or near-ZNE will be achieved. Results are detailed in Table 3.

Table 3: Estimated Library Net ZNE Values (Post-Retrofit Consumption Minus PV Generation)

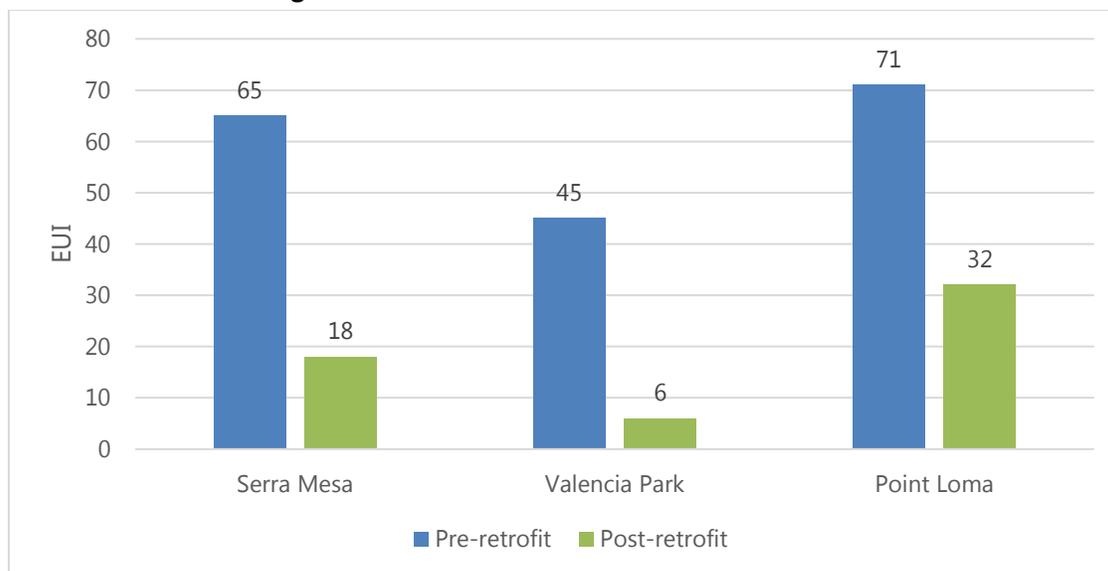
| ZNE Value | Serra Mesa | Valencia Park | Point Loma |
|---------------------------------|------------|---------------|------------|
| TDV (kBtu/ft ² /yr.) | 62 | 29 | 178 |
| Site (kBtu/yr.) | 291,100 | 159,661 | 734,938 |
| Source (kBtu/yr.) | 367,803 | 80,886 | 1,915,877 |
| Electric Only (kWh) |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

All three libraries will be near-ZNE, but Valencia Park/Malcolm X will be closest to achieving all ZNE definitions. A few modeling assumptions of note were to reduce the lighting power density in each library by 5% to account for the reduced lighting power resulting from dimming in daylight areas, but this will be further refined and may increase energy savings. Also, the City of San Diego separately from this project will be upgrading the existing 90-ton rotary liquid chiller at Point Loma with a 70-ton air cooled scroll chiller in 2019. This improvement was incorporated into net ZNE calculations and modeling. Another important indicator, energy use intensity (EUI) is used frequently for comparison to other energy-efficient buildings. Pre-retrofit EUIs and post-retrofit net EUIs (PV generation accounted for) for each library are detailed in Figure 8.

⁴ California Energy Commission. 2015. Reducing Costs for Communities and Businesses through Integrated Demand-side management and Zero Net Energy Demonstrations. GFO-15-308, page 3. http://www.energy.ca.gov/contracts/GFO-15-308/01_Application_Manual_GFO-15-308_2015-11-02.docx

⁵ New Buildings Institute. 2013. ZNE Definitions and Key Considerations. https://gettingtozeroforum.org/wp-content/uploads/sites/2/2017/08/ZNE_Definitions.pdf

Figure 8: Pre-retrofit EUI vs. Post-retrofit Net EUI



IV. ECM Procurement, Permitting and Installation Timeline

The estimated cost for each proposed ECM was calculated by Mazzetti using subcontractor bids that included the cost for procurement, labor and construction management. ECM costs and bill savings are listed in Table 4. Costs for permit fees were estimated separately using the City of San Diego Development Services fee schedules⁶ and are expected to total \$34,800 for all library retrofits (Serra Mesa = \$13,000, Valencia Park = \$9,800, Point Loma = \$12,000).

Table 4: Estimated Total Library ECM Bill Savings vs. Project Cost

| Library | Measure | Electricity Savings (\$/yr.) | Natural Gas Savings (\$/yr.) | Total Energy Savings (\$/yr.) | Project Cost (\$) | Simple Payback (yrs.) |
|----------------------|---------------|------------------------------|------------------------------|-------------------------------|--------------------|-----------------------|
| Serra Mesa | ECM 1-3, 5, 6 | \$9,672 | -\$430 | \$9,242 | \$383,424 | 41.5 |
| Valencia Park | ECM 1-7 | \$23,091 | -\$31 | \$23,060 | \$783,796 | 34.0 |
| Point Loma | ECM 1-3, 5, 6 | \$31,517 | -\$351 | \$31,166 | \$573,601 | 18.4 |
| TOTAL FOR ALL | | \$64,280 | -\$812 | \$63,468 | \$1,740,821 | 27.4 |

⁶Fees. City of San Diego Development Services. <https://www.sandiego.gov/development-services/fees>

ECMs are estimated to be procured in April and May 2019 and installed from May to July 2019. Procurement and installation timelines by ECM are shown in Table 5.

Table 5: ECM Procurement and Installation Timeline

| ECM | Procurement Timeline (weeks) | Installation Timeline (weeks) | Other Details |
|-------|------------------------------|-------------------------------|---|
| ECM-1 | 7 | 8-12 | Includes final inspection and commissioning Additional 5-7 weeks needed for contract |
| ECM-2 | 2-3 | 2-3 | Includes integration and programming |
| ECM-3 | 3 | 8 | Includes integration, programming and commissioning |
| ECM-4 | 4-6 | 5-7 | Includes demolition, programming and commissioning |
| ECM-5 | 2-3 | 4 | Includes integration and programming |
| ECM-6 | 2-3 | 2-3 | Includes preprogramming and integration |
| ECM-7 | 1-2 | 1-2 | None |

V. Demand Response, Distributed Energy Resource, and Other Utility Programs

The libraries are located within SDG&E territory, which offers several commercial demand response and distributed energy resource programs, the most applicable being the *Technology Incentives (TI) Program*.⁷ As part of the program, participants receive a first year-only payout of 60% upfront and the remaining 40% is paid after a year when savings are verified. Participation in the TI program will require the libraries to sign up for one of the three available commercial demand response programs for at least three calendar years. SDG&E was able to provide one-time payout estimates calculated by month based on the pre-retrofit demand of each library. They are provided in Table 6. However, each library’s eligibility for demand response programs is still under consideration since these buildings are designated as “Cool Zones.”⁸ Cool Zones are public places for senior citizens, people with special needs and the public to escape mid-day summer heat from about May to October each year. Library eligibility is possibly limited since electricity may not be able to be reduced enough during peak grid days due to their requirement of maintaining a cool building.

⁷ *Save on Upgrades with the Technology Incentives Program*. San Diego Gas and Electric. <https://www.sdge.com/businesses/savings-center/energy-management-programs/demand-response/technology-incentives>

⁸ *Cool Zones*. San Diego Gas and Electric. <https://www.sdge.com/tools/summer/coolzones>

Table 6: TI Program Monthly Estimated Savings for All Libraries

| Month/Year | Maximum Demand | TI Program Payout |
|----------------------|----------------|-------------------|
| Serra Mesa | | |
| 2/2018 | 64 | \$1,280 |
| 3/2018 | 60.2 | \$1,204 |
| 4/2018 | 65 | \$1,300 |
| 5/2018 | 61.8 | \$1,236 |
| 6/2018 | 62.4 | \$1,248 |
| 7/2018 | 76.2 | \$1,524 |
| 8/2018 | 73 | \$1,388 |
| 9/2018 | 76.2 | \$1,524 |
| 10/2018 | 69.4 | \$1,388 |
| 11/2018 | 67.2 | \$1,344 |
| 12/2018 | 64.3 | \$1,286 |
| 1/2019 | 60.8 | \$1,216 |
| Total Payout: | | \$15,938 |
| Valencia Park | | |
| 3/2018 | 64.6 | \$1,292 |
| 4/2018 | 82.6 | \$1,652 |
| 5/2018 | 69.8 | \$1,396 |
| 6/2018 | 63.4 | \$1,268 |
| 7/2018 | 91.5 | \$1,830 |
| 8/2018 | 108.8 | \$2,176 |
| 9/2018 | 96.6 | \$1,932 |
| 10/2018 | 102.4 | \$2,048 |
| 11/2018 | 83.8 | \$1,676 |
| 12/2018 | 84.5 | \$1,690 |
| 1/2019 | 61.4 | \$1,228 |
| 2/2019 | 56.3 | \$1,126 |
| Total Payout: | | \$19,314 |
| Month/Year | Maximum Demand | TI Program Payout |
| Point Loma | | |
| 2/2018 | 101.8 | \$2,036 |
| 3/2018 | 93.4 | \$1,868 |
| 4/2018 | 110.1 | \$2,202 |
| 5/2018 | 101.1 | \$2,022 |
| 6/2018 | 90.2 | \$1,804 |
| 7/2018 | 90.9 | \$1,818 |
| 8/2018 | 103.7 | \$2,074 |
| 9/2018 | 100.5 | \$2,010 |
| 10/2018 | 123.5 | \$2,470 |
| 11/2018 | 93.4 | \$1,868 |
| 12/2018 | 105 | \$2,100 |
| 1/2019 | 82.6 | \$1,652 |
| Total Payout | | \$23,924 |
| TOTAL FOR ALL | | \$59,176 |

SDG&E was also able to assess if the libraries may participate in other offered energy efficiency incentive programs. They found several programs to investigate further such as Energy Efficiency Business Rebates (EEBR), Premium Efficiency Cooling (PEC), and Energy Efficiency Business Incentives (EEBI), that could provide about \$37,920 in rebates. All findings are detailed in Table 7. EEBI incentives could not be estimated without proposed ventilation control limits and schedules, which are still to be determined. Additionally, SDG&E offers an On-Bill Financing (OBF) option that will most likely will not be used for any incentives pursued based on the need for project funds to be applied by March 2020.

Table 7: Estimated Incentives for SDG&E Energy Efficiency Programs

| ECM | SDG&E Incentive Available | Estimated Incentives (Serra Mesa) | Estimated Incentives (Valencia Park) | Estimated Incentives (Point Loma) | Estimated Total Incentives (All) |
|--------------|---------------------------|-----------------------------------|--------------------------------------|-----------------------------------|----------------------------------|
| ECM-1 | EEBI | \$8,257 | \$12,740 | \$6,950 | \$27,947 |
| ECM-3/4 | PEC | \$2,191 | \$4,397 | \$3,385 | \$9,973 |
| TOTAL | | \$10,448 | \$17,137 | \$10,335 | \$37,920 |

VI. Report Summary and Next Steps

In summary, all libraries will receive lighting retrofits and control systems, HVAC retrofits and control systems and plug load management. Valencia Park/Malcolm X will also receive building envelope improvements. Emerging technologies from Bert (at all libraries) and Ventacity (at Valencia Park/Malcolm X) will be installed. **The total cost to upgrade the libraries is estimated to be \$1,775,621. This includes all ECM installation costs and permit fees. Total energy consumption is estimated to be reduced by 709,731 kBtu, which amounts to approximately \$63,468 per year in savings. The libraries additionally have the potential to save more money with a one-time payout of \$59,176 if enrolled in SDG&E's TI demand response program and \$37,920 in other utility incentives.**

The next steps for the project are to secure the identified permits needed and to install identified ECMs and control systems. In preparation, the project team will be hosting pre-construction meetings and planning community outreach activities to both minimize disruption and inform staff and visitors. Commissioning and retrocommissioning will also be completed following installation of ECMs to ensure all new and existing equipment are operating as designed and fully integrated.



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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