City of Culver City

Job No. 108159

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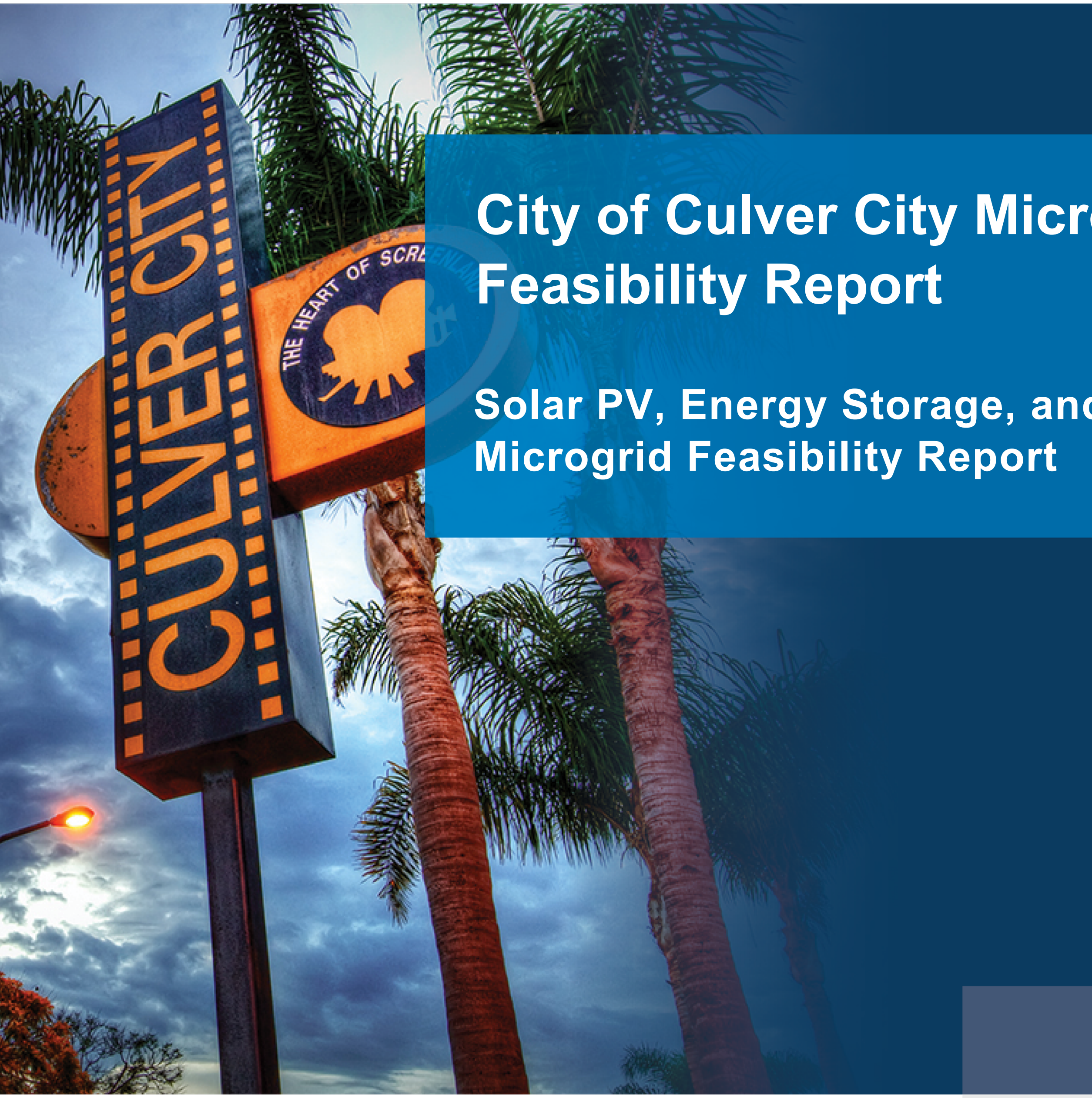

City of Culver City Microgrid Feasibility Report

Solar PV, Energy Storage, and Microgrid Feasibility Report

WILLDAN

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1. Background and Executive Summary

Culver City's stated objectives related to the microgrid project are to deliver resiliency at two sites that serve as emergency shelters (Veterans' Memorial and Senior Center) through larger-sized batteries, 100% clean energy both day and night, and zero net energy (ZNE) performance if possible. Willdan's task is to provide microgrid project recommendations along with key performance metrics including capital costs, payback, greenhouse gas reduction, operating costs savings as well as potential funding pathways. This will help staff and decision makers identify the most cost-effective path forward towards their objectives.

To reach the city's stated goals, Willdan analyzed three microgrid scenarios, including an Economic (Option A), Resilience Alternative 1 (Option B), and Resilience Alternative 2 (Option C). Willdan's preliminary analysis included an Environmental option, however, upon learning that the City would be purchasing 100% clean power for all of its sites starting May 2019 through Los Angeles County's Clean Power Alliance as discussed in Section 2.2, the baseline greenhouse gas (GHG) emissions were already near zero. The analyzed scenarios, therefore, focused on cost-effective and resilience scenarios. Each scenario assumes that the sites implement certain energy efficiency and electrification measures first, to minimize the generation and storage capacity needed to meet the sites' annual electrical needs. While these scenarios are further described in Section 4, the following table highlights their key performance metrics. While Willdan will support any decision the City makes, Option C is the recommended scenario for meeting the City's expressed goals and needs.

TABLE 1 – SUMMARY OF MICROGRID SCENARIO COSTS

Option	Energy Efficiency Cost ($)*	Infrastructure Costs ($)**	Solar Costs ($)	Battery Costs ($)	Total Capital Costs ($)
A – Economic*	371,500	199,405	1,524,250	469,800	2,564,955
B - Resilience 1	371,500	543,730	1,748,500	1,549,800	4,213,530
C - Resilience 2 (True Microgrid)	371,500	775,615	2,440,750	1,485,900	5,073,765

*The capital costs do not factor in potential SCE rebates or incentives. SoCalREN, which is concurrently assisting the City, can offer help at no cost to the District in identifying and applying for rebates or incentives available at the time of installation. As a best practice, Willdan also suggests incorporating language into solicitations requesting implementation vendors secure and apply all available rebate and incentives as part of their proposal and reduce pricing accordingly.
** Willdan evaluated adding conduit and cables to physically consolidate meters in Options B (3 of 4 meters) and C (all 4 meters). Additional infrastructure costs are added for controls.

TABLE 2 – SUMMARY OF MICROGRID SCENARIO PERFORMANCE

Option	Solar Capacity (kW)	Storage Capacity (kW)	Storage Output (kWh)	Annual Bill Savings ($)	Added Annual Resiliency Value ($)*	Energy Savings Payback	Total Value Payback
A - Economic	469	404	522	150,000	4,000	17.1	16.7
B - Resilience 1	538	484	1722	200,000	10,000	21.1	20.1
C - Resilience 2	751	676	1651	213,900	15,000	23.7	22.2

*Resiliency is quantified as the estimated avoided cost of power outage, lost productivity, project delays, or canceled events. Estimates are derived from the Interruption Cost Estimating Tool developed by Lawrence Berkeley National Lab.

2. Relevant Regulations, Definitions and Assumptions

2.1: Microgrid

For this project, Willdan defines a microgrid as a group of optimally deployed distributed energy resources (DER), including energy efficiency, renewable generation, energy storage, vehicle-to-grid, and/or controllers for islanding and interconnected modes. A microgrid can be the first step in the development of a smart city by integrating more renewables into a critical city site. The microgrid can eventually be built out to leverage system benefits for the entire community and support other city functions, such as city transportation.

2.2: Clean Power Alliance

Culver City has recently joined LA County's Community Choice Aggregator (CCA), known as the Clean Power Alliance (CPA). The City has signed up to have all of its City-owned facilities supplied by the 100% Green Power option in May 2019. Willdan has factored in CPA rates and benefits into both the baseline and proposed microgrid scenarios presented here. All four of the City's meters are currently on the SCE TOU-GS-2-B rate structure, and CPA has published 2019 Non-Residential energy generation rates for all equivalent SCE rate tariffs. A summary of the CPA energy generation rates is included in Table 3 and were used as a baseline for the City's future electricity costs. For the energy transmission and distribution charges (which will continue to be paid through SCE even under the CPA configuration), Willdan has used the most recently available proposed SCE rate designs as proposed in the General Rate Case to the California Public Utilities Commission (CPUC). A rate tariff change advice letter was submitted by SCE to the CPUC in January 2019 that has not yet been approved. The potential change in rates is not anticipated to drastically alter the baseline and proposed rates used in this analysis, but Willdan will continue to monitor changes to rate tariffs as they become publicly available.

TABLE 3 – CPA 100% GREEN POWER TOU-GS-2-B RATE STRUCTURE

Season	Unit/Period	Cost ($/kWh)	Demand Charge ($/kW)
Summer	On-peak	$0.10041	$22.77
Summer	Mid-peak	$0.05118	$4.45
Summer	Off-peak	$0.02486	-
Winter	Mid-peak	$0.04682	-
Winter	Off-peak	$0.03347	-

2.2: Zero Net Energy

Governor Order B-18-12 established adopt Zero Net Energy (ZNE) goals as a part of California's long-term Energy Efficiency Strategic Plan. A ZNE site produces the same amount of renewable energy on-site as is consumes on an annual basis. There is no current legislation requiring ZNE Action Plans for local governments; however, anticipated regulation will be established in 2025 requiring that all new and 50 percent of existing state-owned public buildings will be ZNE by 2025. By implementing recommended scenarios from this report, Culver City is minimizing its system load with energy efficiency projects, which will set up an optimal base for a cost-effective solar PV and ZNE performance.

2.3: Meter Consolidation Options

There are currently four electric meters that serve the two sites from 16 kV Southern California Edison (SCE) feeders. There were three scenarios considered as a means of combining the benefits of renewable generation across the two emergency sites.

- **Physical Consolidation** - Physically consolidating the sites to a single meter allows for a true microgrid that can be islanded from the grid where solar generation from one building can also be shared behind the meter among the buildings and the sites. It can also lower monthly fees due to reduced meter charges and energy/demand prices at a higher service level. Willdan evaluated adding conduit and cables to physically consolidate meters in Options B and C:
    - Option B – Consolidates four meters to two meters; the 3 Veterans Memorial Park meters are combined into one meter.
    - Option C (True Microgrid)– Consolidates all four meters to one meter. This involves running conduit across Culver Blvd to connect Veterans Memorial Park to the Senior Center.

- NEM Aggregation (NEM-A) allows SCE customers to over-generate renewable energy at one site (generating account) and use the corresponding bill credit to discount the bill of an adjacent site's (benefitting account) meter. Aside from some non-bypassable charges, the customer receives the full value of the credit, on both the generation and transmission & distribution side. SCE customers, including those purchasing 100% energy generation through a CCA, are eligible to participate in SCE's Net Energy Metering (NEM) program. Solar PV systems are typically sized to offset a site's annual electric usage, as any excess generation on an annual basis receives a much smaller credit. However, in a solar and storage scenario, the solar can be oversized to assist in charging the battery storage system. For sites that are buying energy through a CCA, a NEM credit will be applied to both the CCA bill as well as the SCE bill for each month.
    i. Option A – Rather than physically consolidating the four meters among the two sites, NEM-A can be employed in this scenario to combine the financial benefits of solar PV generation at Senior Center to offset the electricity bill of the Municipal Plunge meter. The Plunge meter would be the only eligible meter in this scenario, since a meter receiving bill credit through NEM-A (aka a benefitting account) cannot have any other on-site generation like solar PV

2.5: Time-of-Use Rates

Time of Use (TOU) rate structures are utility rate structures that charge various rates for electricity used at different parts of the day. These rates are structured to reflect the Utility's cost of producing electricity at that time. While TOU rate structures used to generally charge the most for electricity during the middle of the day of the summer months, peak periods will soon shift to later in the day due to the increasing amount of renewable energy that has come online during the middle of the day. While the later peak period (now 4pm-9pm) is less advantageous to solar PV systems, the impending TOU rate structure is still financially net beneficial over the course of their lifetime, especially in SCE territory.

All four of the City's meters are currently on the TOU-GS-2-B rate structure. The primary factors that determine system payback are energy charge ($/kWh) and demand charge ($/kW). Under the imminent TOU shift, Culver City should move from a TOU – B rate structure to TOU – E rate structure to see a reduction or elimination of high demand charges ($/kW) during peak and part-peak summer hours, however, the trade-off is an increase in the energy charge ($/kWh) during that same time period (peak summer). With a large enough solar PV system, a customer will likely still see additional bill savings comparison to before, since the energy production of the solar PV system will be exported at the higher utility energy charge.

If there is enough space to properly size a solar PV system and couple it with NEM, a site with solar can produce net energy for export during peak period TOU times. Net energy exported during peak period TOU times generates a bill credit at the peak period TOU price. By utilizing NEM and the best available TOU rate structure, the financial benefits of a solar system can be maximized.

2.6: Operation and Maintenance

Willdan recommends soliciting bids for Operation and Maintenance (O&M) agreements from potential solar and battery storage providers. Typically agreed to be hand-in-hand with a performance guarantee, an O&M agreement puts the responsibility of system performance and upkeep on the chosen vendor for the lifetime of the system. Typical services include system testing and visual inspection, routine preventative maintenance measures, troubleshooting and component maintenance and repair, customer service support, and module cleaning at a frequency determined by the ongoing monitoring of the system, but not less often than twice a year. It is recommended that O&M language is written into the technical design specifications of the RFP.

3. Baseline Energy and Cost Profile

3.1: Site Description

Culver City currently owns and operates two Red Cross-designated emergency shelter sites: Culver City Senior Center (4095 Overland Ave) and Veterans Memorial (4117 Overland Ave), which encompasses Veterans Memorial Park and Rec Building, the Teen Center and the Municipal Plunge.

3.2: Energy Usage and Costs Across Meters

The City currently has a combined energy load at its Senior Center and Veterans Memorial Complex of approximately 1.25 million kWh per year in electricity across four meters, three at Veterans Memorial and one at Senior Center (Table 4). The sites also consume roughly 60,000 therms of natural gas per year across three meters; two at Veterans Memorial (one at the Plunge and one for the Teen Center and Parks and Rec Building) and one at Senior Center (Table 5).

TABLE 4 – SUMMARY OF ELECTRIC METERS

Meter #	Physical Location	Service Acct.	Address	17-18 kWh	Adjusted for EE
255000-008028	Other Veterans Memorial Meter	1165004	4117 Overland Ave	301,906	197,006
039460 (Formerly 044194)	Veterans Memorial - Municipal Plunge	1165037	4117 Overland Ave	458,976	419,976
259000-072313	Veterans Memorial - Near Auditorium	15505522	4117 Overland Ave	171,354	171,354
052369 (Formerly 045554)	Senior Center	21081696	4095 Overland Ave	312,454	242,737
			Total	**1,244,690**	**1,031,073**

TABLE 5 – SUMMARY OF GAS METERS

Meter #	Physical Location	Address	2018 therms
13381968	Veterans Memorial Parks & Rec	4117 Overland Ave	3,158
13082625	Plunge and Teen Center	4175 Overland Ave	53,424
13425432	Senior Center	4095 Overland Ave	4,330
		Total	**60,912**

3.3: Distribution System

The Culver City Senior Center, Veterans Memorial Building, and Teen Center are served by SCE's 16 kV ALLA circuit and the Municipal Plunge is served by the Stevens 4 kV circuit from the Sony Substation as depicted in SCE's Distribution map (Figure 1).

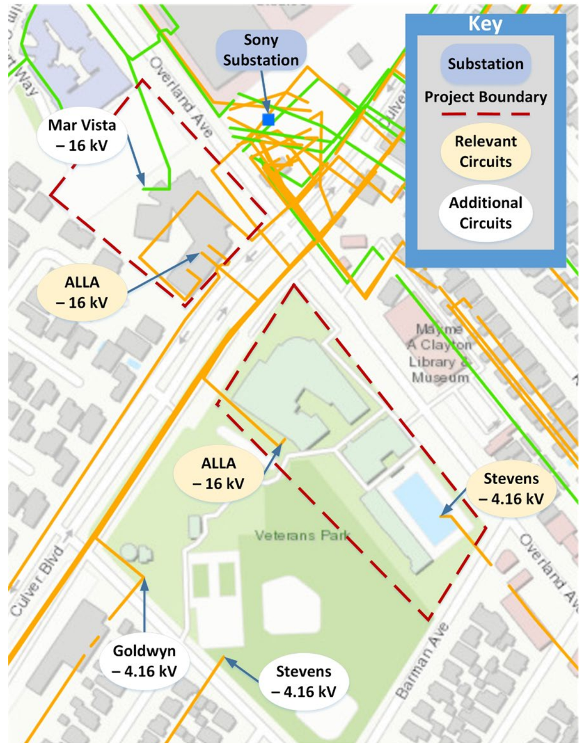

Figure 1. SCE Distribution Map for Culver City Meters

3.4: Reliability

Sony Substation is part of SCE's Santa Monica District. The Santa Monica District has fewer outages per customer annually (less than 1) that last about 25 minutes less than SCE's system wide – based on a five-year average reliability records from 2013-2017 based on SCE's January 2018 Circuit Reliability Review Report. According to this report, Culver City's five-year average reliability is slightly worse than the SCE system-wide reliability, experiencing an average of 1.15 sustained interruptions annually (SAIFI) lasting an average of 131.6 minutes each (SAIDI) (Table 6). While there are no planned capital improvements for the project area, this report indicates that there is some room for improving Culver City facilities' distribution system reliability from current levels to almost no down-time, estimated to result in $30,000 to $60,000 per year in cost savings to the City.

TABLE 6 – HISTORICAL LOCAL SUBSTATION RELIABILITY

Reliability Index	Definition	Culver City Average (2017)	ALLA Circuit (2016)
SAIDI	The cumulative amount of time the average customer is interrupted by Sustained Outages* each year	131.6	101.0
SAIFI	The number of times the average customer is interrupted by Sustained outages each year*	1.15	1.1

*Sustained Outages are defined as outages lasting longer than 5 minutes.

4. Microgrid Project Recommendations

4.1: Baseline Scenario: Energy Efficiency and Electrification

A conservative analysis indicates that approximately 19% of the combined site load at Senior Centers and Veterans Memorial can be saved through energy efficiency projects and transitioning natural gas heating equipment to electric heat pumps. All three scenarios evaluated assume that energy efficiency and HVAC electrification measures are implemented. Energy efficiency recommendations are listed in Table 7.

The City's baseline greenhouse gas emissions will already be significantly reduced by procuring 100% Green Power through the CPA. The additional greenhouse gas emissions reductions from the scenarios presented in this report are primarily from the electrification of the HVAC equipment. Through HVAC electrification the City will reduce approximately 60% of the GHG emissions at the individual building usage, which represents 7% of the overall site natural gas usage since the Plunge heating dwarfs the building usage. While not modelled in the scenarios, the City could also electrify its pool heater, [1] domestic water heaters and kitchen equipment to eliminate remaining GHG emissions. Table 7 highlights the City's natural gas usage in 2018, and estimated reductions via HVAC electrification.

TABLE 7 – SUMMARY OF ENERGY EFFICIENCY OPPORTUNITY THROUGH HVAC, PUMPING AND LIGHTING UPGRADES

		Annual Savings						
Building	**Description**	**Elect. (kWh)**	**Elect. (kW)**	**Gas (Therms)**	**Cost ($)**	**First Cost ($)**	**EUL**	**Payback (Yrs)**
Parks and Rec	Pump VFD Retro-Commissioning	2,000	0	0	302	2,000	5	7
Parks and Rec	Chiller Temperature Lock-Out	3,000	0	80	506	2,000	4	4
Parks and Rec	Auditorium Roof-Top Units	12,000	6	0	1,813	30,000	20	17

[1] Electric heat pump pool heaters for commercial sized pools are commercially available. Just one example can be found at the following site: https://www.aquacal.com/product/great-big-bopper/

Building	Description	Annual Savings Elect. (kWh)	Elect. (kW)	Gas (Therms)	Cost ($)	First Cost ($)	EUL	Payback (Yrs)
Parks and Rec	Roof-Top 2011 Heat Pumps	2,300	1	0	348	8,000	20	23
Parks and Rec	Roof-Top Older Package Units	19,200	12	0	2,901	56,000	20	19
Parks and Rec	Repair Air Duct Leaks	1,500	1	150	326	4,000	N/A	12
Parks and Rec	Reduce/Eliminate Outside Air and Water Infiltration	1,000	1	200	284	5,000	N/A	18
Parks and Rec	Upgrade Exhaust Fan and/or Motor, and Add VFD	1,000	1	100	217	4,000	15	18
Parks and Rec	Auditorium LED Lighting	1,900	3	0	287	15,000	12	52
Parks and Rec	LED Lighting and Occupancy Sensors	17,000	18	0	2,569	20,000	12	8
Parks and Rec	Bollard and Pole LED Lighting and Photocells	12,700	0	0	1,919	10,000	12	5
Parks and Rec	Upgrade Pane* and/or Film	4,500	9	0	680	9,000	N/A	13
Parks and Rec	Circulating Block Heater Pump	3,200	1	0	484	1,500	15	3
Parks and Rec	Pump VFD Upgrade and Filtration Turn/Over Time	2,400	1	0	363	1,500	10	4
Senior Center	Roof-Top Older Package Units	17,017	27	2,615	4,305	66,500	20	15
Senior Center	LED Lighting and Occupancy Sensors	34,700	21	0	5,244	25,000	12	5
Senior Center	Pole LED Lighting and Photocells	14,800	0	0	2,236	12,000	12	5
Senior Center	Circulating Block Heater Pump	3,200	1	0	484	1,500	15	3
Teen Center	Roof-Top Older Package Units	16,800	11	0	2,539	49,000	20	19
Teen Center	LED Lighting and Occupancy Sensors	4,400	6	0	665	6,000	12	9
Plunge and Memorial Park	Pole LED Lighting and Photocells	39,000	0	0	5,893	43,500	12	7
TOTAL		**213,617**	**120**	**3,145**	**34,365**	**371,500**		**10.8**

TABLE 8 – SUMMARY OF GHG REDUCTIONS THROUGH HVAC ELECTRIFICATION

Site	2018 Therms Usage	Est. Therms Saved via HVAC Electrification	2018 Annual GHG (MT CO2)	Estimated GHG (MT CO2)	% Emissions Reduction
Senior Center	4,330	2,615	23	14	60%
Parks and Recreation	3,158	1,907	17	10	60%
Plunge	53,424	-	283	-	0%
Total	**60,912**	**4,522**	**323**	**24**	**7%**

4.2: Microgrids Controls

The Culver City microgrid controller must enable the microgrid to respond quickly to energy needs, change ramp direction on demand, sustain up/down ramping for extended periods, start/stop multiple times a day, respond for defined periods of time on request, start with short notice from zero or low electricity operating level, and forecast operating capability through economic dispatch and real-time management of DERs such as solar and battery storage.

The controller must also enable the integration and interoperability of different systems and components—including real-time communication with the electric grid and the CAISO energy market—using a standard interface and cyber-secure communications protocol. The controller must be validated using IEEE 2030.7 standard and using the IEEE 2030.8 guidelines.

Using advance controls unlocks the full economic value of DERs by factoring in real-time grid conditions (power flow, network constraints) and stakeholder requirements (peak-shaving, power quality, energy costs). Its platform of capabilities should be able to manage additional public works services, increasing the benefit of the controller to Culver City. Culver City has an existing Delta Controls building management system that will need to be integrated into the microgrid controller for automated load shedding and real time load reconfiguration.

Willdan will work with Culver City during procurement to ensure these specifications are met using one of the many commercially available microgrid controllers.

4.3: Option A: Economic

Option A is least expensive way to provide Culver City with a system of solar PV and storage capacity that can maintain critical loads at the Senior Center and the Veterans Memorial building, but not the Municipal Plunge, in the event of a sustained outage. This option does not provide a true microgrid because it would not allow the sites to island off of SCE's main grid. Unlike Options B and C, this option excludes civil work and the associated costs to physically consolidate electric meters. Figure 2 presents a schematic overview of the circuit and distributed energy resources associated with Option A.

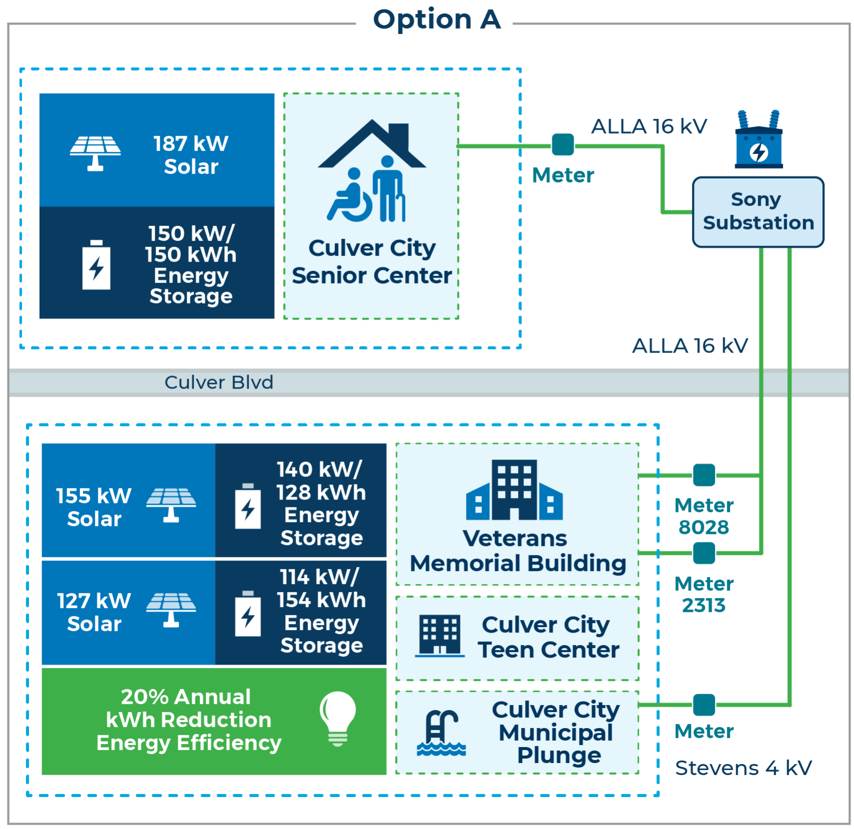

Figure 2. Option A –Circuit and DER Overview

As depicted in Figures 3 and 4, solar PV systems for Option A include shade structures, taking advantage of the most cost-effective, highest yield solar generation areas available on each site. The Senior Center system would be installed behind the Senior Center meter and take up a portion of the parking lot (Figure 3). The Veteran's Memorial system would include a large carport structures in the parking lot spanning two rows of parking spots in the lot just south of the Parks and Recreation building, along with rooftop solar installations (Figure 4). The combined electricity generated from these systems would be enough to offset the annual site load at the Senior Center and Veteran's Memorial, excluding the Municipal Plunge.

Figure 3. Senior Center 187 kW PV

Figure 4. Veterans Memorial 282 kW PV

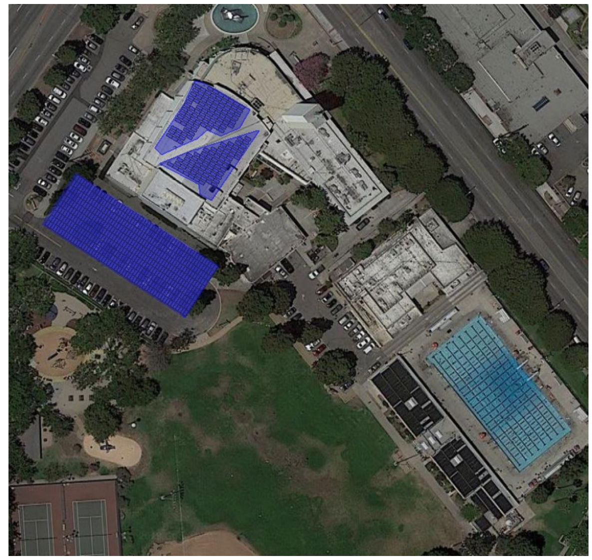

Table 9, Table 10 and Table 11 highlight the estimated performance and financial metrics for the solar PV and associated battery storage systems.

NEM-A in Option A

Note that the Municipal Plunge meter in this scenario would not be electrically interconnected to the solar and storage components, but it could still benefit financially via NEM-A. Because it is adjacent to the Senior Center site, it could receive a bill credit for excess generation produced by solar PV on that site. This would likely be marginal with the 187 kW Senior Center solar PV design, but a scenario exists where the Senior Center maximum solar design (428 kW, used in Option C) could be installed and financially offset energy bills at the Municipal Plunge. The downside to this scenario is that the Plunge does not get the benefit of actual electrical interconnection with the other sites, which is why Options B and C provide more overall resiliency. However, if the City decides both that the Plunge meter is not necessary for emergency operation and that they would like to install the maximum solar design at the Senior Center, NEM-A would provide a financial benefit for building the extra solar PV.

TABLE 9 – OPTION A SUMMARY

Meter	Solar Capacity (kW)	Storage Capacity (kW)	Storage Output (kWh)
Senior Center	187	150	150
Vet - Meter 2313	127	114	154
Vet - Meter 8028	155	140	218
Veterans Meter - 9460 (Plunge)	N/A	N/A	N/A
Total	**469**	**404**	**522**

TABLE 10 – OPTION A SOLAR PV GENERATION

Site Name	Solar PV (kW DC)	Annual Load (kWh)	Annual Production (kWh)	% Offset*
Senior Center Meter	187	242,737	305,347	126%
Veterans Meter - 8028	155	197,006	253,129	128%
Veterans Meter - 2313	127	171,354	207,528	121%
Veterans Meter - 9460 (Plunge)	N/A	N/A	N/A	N/A
Total	**469**	**611,097**	**766,004**	**125%**

*Note that the percentage offset is related to the corresponding meter to the left. As discussed above, the Plunge does not have associated generation or storage, yet NEM-A could be used to credit the Plunge meter with the financial benefit of overgeneration at the other sites.

TABLE 11 – OPTION A FINANCIAL METRICS

Distribution Infrastructure ($)	Energy Efficiency Cost($)	Solar Cost ($)	Battery Cost($)	Total Capital Cost ($)	Annual Bill Savings ($)
N/A	371,500	1,524,250	365,400	2,261,150	150,000

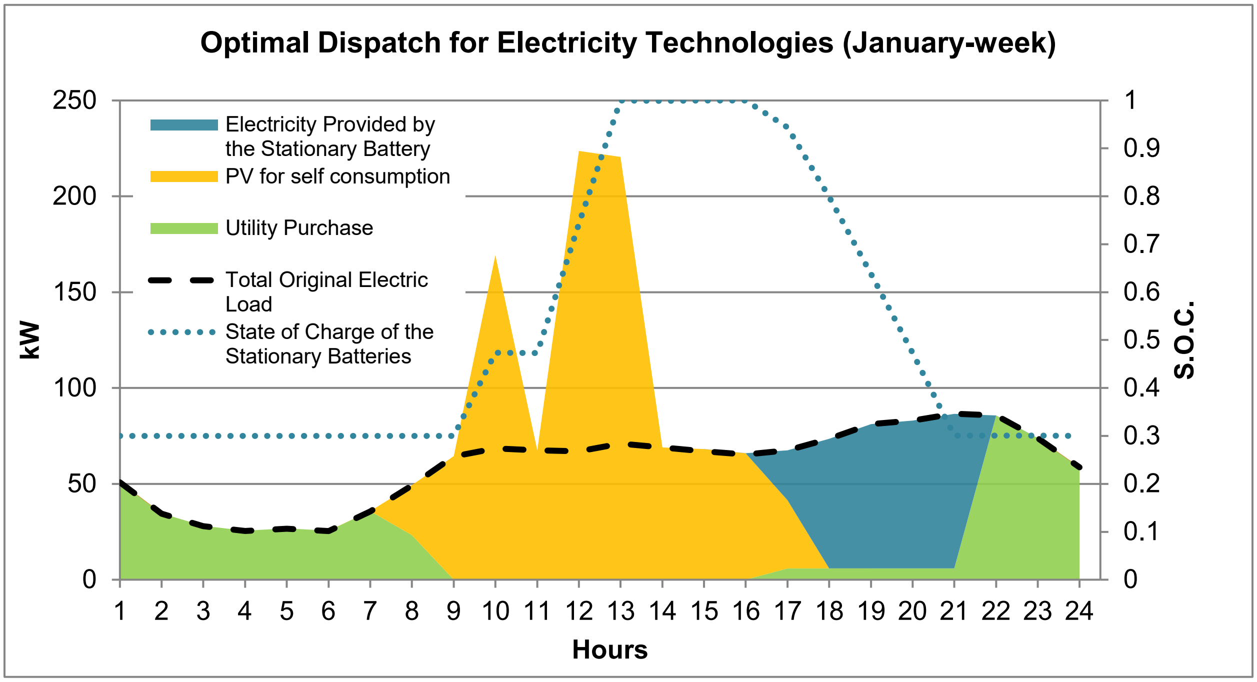

Figure 5. Option A – Economic Dispatch – Winter Normal

Figure 5 shows a normal winter day where excess PV generation is utilized to charge a battery during the day and the battery is discharged in the evening to avoid expensive demand charges. The original load (black dotted line) is the Veterans Memorial meters 8028 and 2313, and the Senior Center. Note that each meter was analyzed separately to ensure proper system sizing and this scenario considers that energy efficiency measures have been implemented.

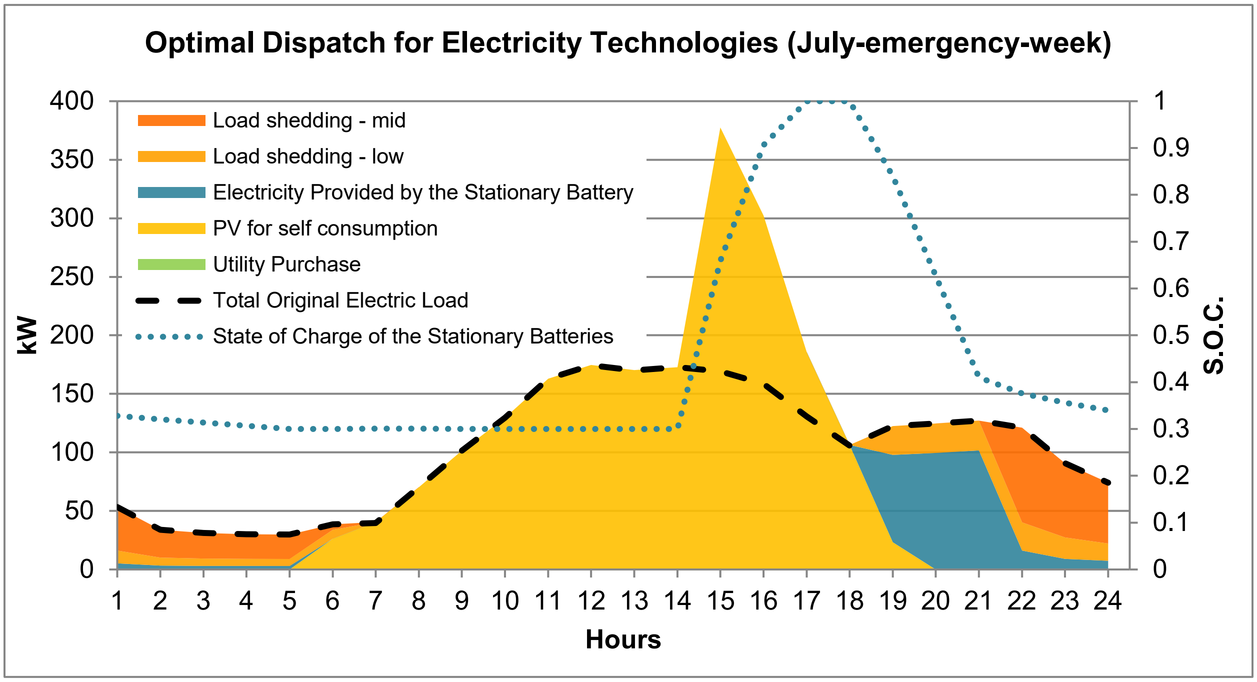

Figure 6. Option A – Economic Dispatch – Summer Emergency

Figure 6 shows an average day when an outage may occur. The orange color indicates that a portion of the electric load is shed or shut off by building controllers. Critical load and the majority of normal load is served during the day by PV generation and at night by batteries. At night or during off-peak hours, 80-90% of the load must be curtailed due to the smaller battery size. This operation could continue as long as the sun shines on an average day.

4.4: Option B: Resilience Alternative 1

Option B gives the City greater flexibility to install and integrate a larger amount of solar PV generation among Veterans Memorial sites by consolidating Memorial Building, Teen Center, and Municipal Plunge meters into one master meter (Figure 7). Figure 8 demonstrates the distribution infrastructure that would be required to consolidate the meters. Under this option the Senior Center would have a slightly larger solar and storage than presented in Option A. The meter at the Senior Center would also remain unmodified. The additional solar allows for a larger energy storage system, providing additional resilience over option A at a somewhat higher cost. Table 12 presents an overview of the DER and storage system sizes.

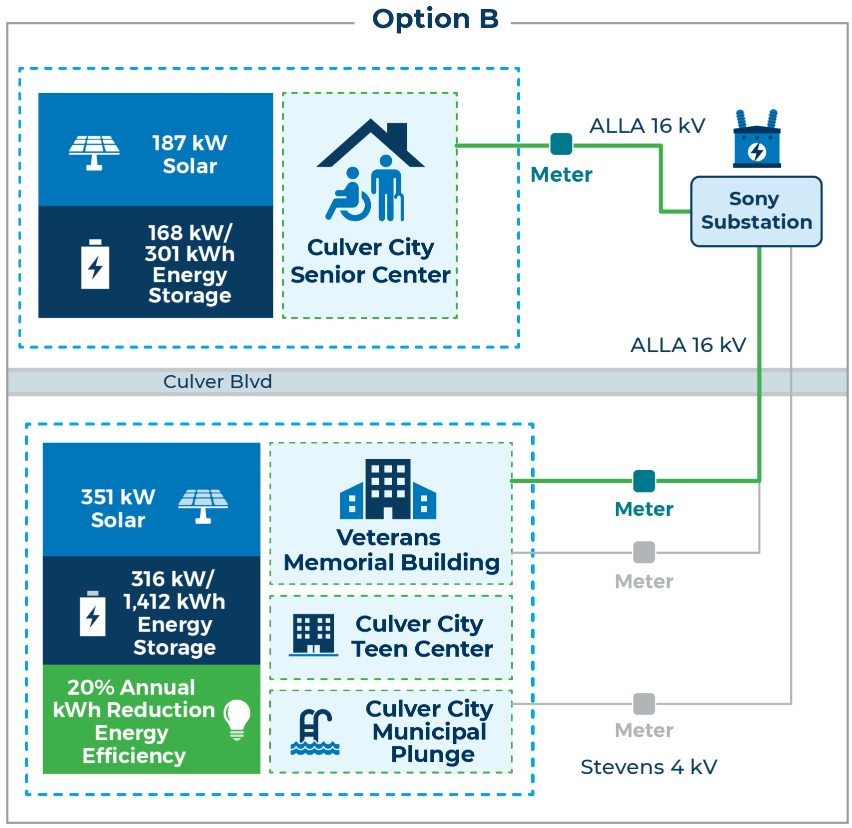

Figure 7. Option B – Circuit and DER Overview

TABLE 12 – OPTION B SUMMARY

Meter	Solar Capacity (kW)	Storage Capacity (kW)	Storage Output (kWh)
Senior Center	187	168	301
Veterans Memorial (Combined)	351	316	1,421
Total	**538**	**484**	**1,722**

Figure 8. Distribution Alternative for Option B

In Figure 8, the existing ALLA 16 kV circuit is depicted in green, whereas the proposed circuit additions are depicted in blue. The blue boxes are proposed vaults or pull boxes to facilitate the addition of future installed assets such as solar PV expansion or electric vehicle (EV) charging. The capital cost estimate includes conduit, cables, labor and meter infrastructure.

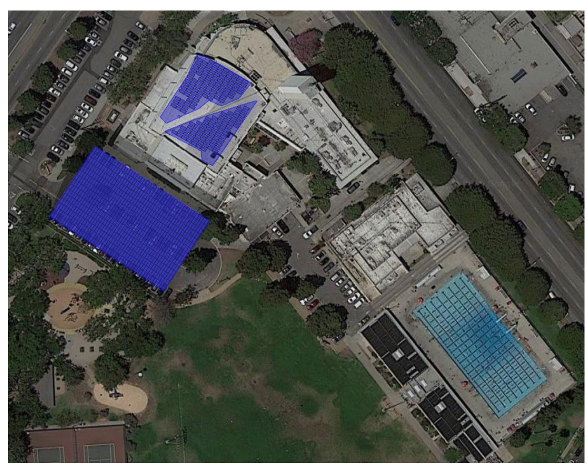

Figure 9. Proposed Veterans Memorial 351 kW PV Design

Solar PV for the Option B scenario include shade structure carport systems at the Senior Center as in Option A, along with a more robust solar design on the Veteran's Memorial side of the street. The design at the Veteran's Memorial site extends the carport shade structure to the next row of spots and includes rooftop solar PV system on top of the Parks and Recreation building (Figure 9). The Senior

Center system would be installed behind the Senior Center meter as in Option A. Note that all solar layouts are approximations based on similar type systems Willdan has encountered in the past. The selected solar vendor will take the lead on the technical design of the PV structures. This solution would involve consolidating the three meters on the Veteran's Memorial side of the street into one interconnection point, allowing the solar PV system to offset load and provide generation to all Veteran's Memorial facilities, including the Teen Center and Municipal Plunge. The energy generated from these systems would be enough to independently offset the annual site load (once adjusted for energy efficiency measures) at the Senior Center, and approximately 73% of the combined Veteran's Memorial load (all 3 meters). Table 13 and Table 14 highlight estimated performance and financial metrics for the solar PV systems.

TABLE 13 – OPTION B SOLAR GENERATION METRICS

Site Name	System Size (kW DC)	Annual Load (kWh)	Annual Production (kWh)	% Offset
Veterans (3 meters-combined)	351	788,336	573,676	73%
Senior Center Meter	187	242,737	305,347	126%
Total	**538**	**1,031,073**	**879,023**	**85%**

TABLE 14 – OPTION B SOLAR FINANCIAL METRICS

Infrastructure Cost ($)	Energy Efficiency Cost ($)	Solar Cost($)	Battery Cost ($)	Total Capital Cost ($)	Annual Bill Savings ($)
213,900	371,500	1,748,500	1,205,400	3,539,300	200,000

Figure 10 shows a normal winter day where excess PV generation is utilized to charge a battery during the day and the battery is discharged in the evening to avoid expensive demand charges. This diagram shows the combined load from all of the sites, but each grouped meter was analyzed separately to ensure resilience and proper system sizing. Energy efficiency measures are considered to be adopted for this analysis.

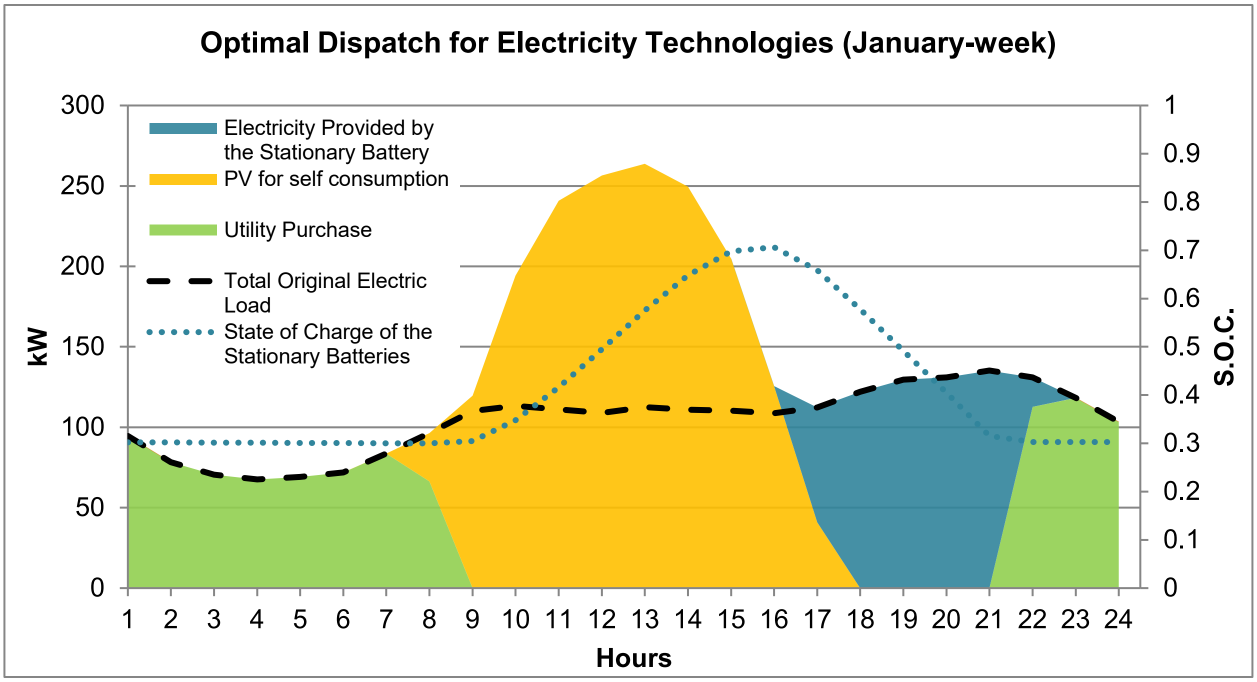

Figure 10. Option B – Economic Dispatch – Winter Normal

Figure 11 shows an average day when an outage may occur. The orange color indicates that a small portion of the electric load is shed, or shut off by building controllers. Critical load and the majority of normal load is served during the day by PV generation and at night by batteries. Between 10-20% of the load at night would need to be shed. This could be achieved by shutting off the non-critical pool pumps and limiting lighting or HVAC consumption in non-critical areas. This operation could continue as long as the sun shines on an average day.

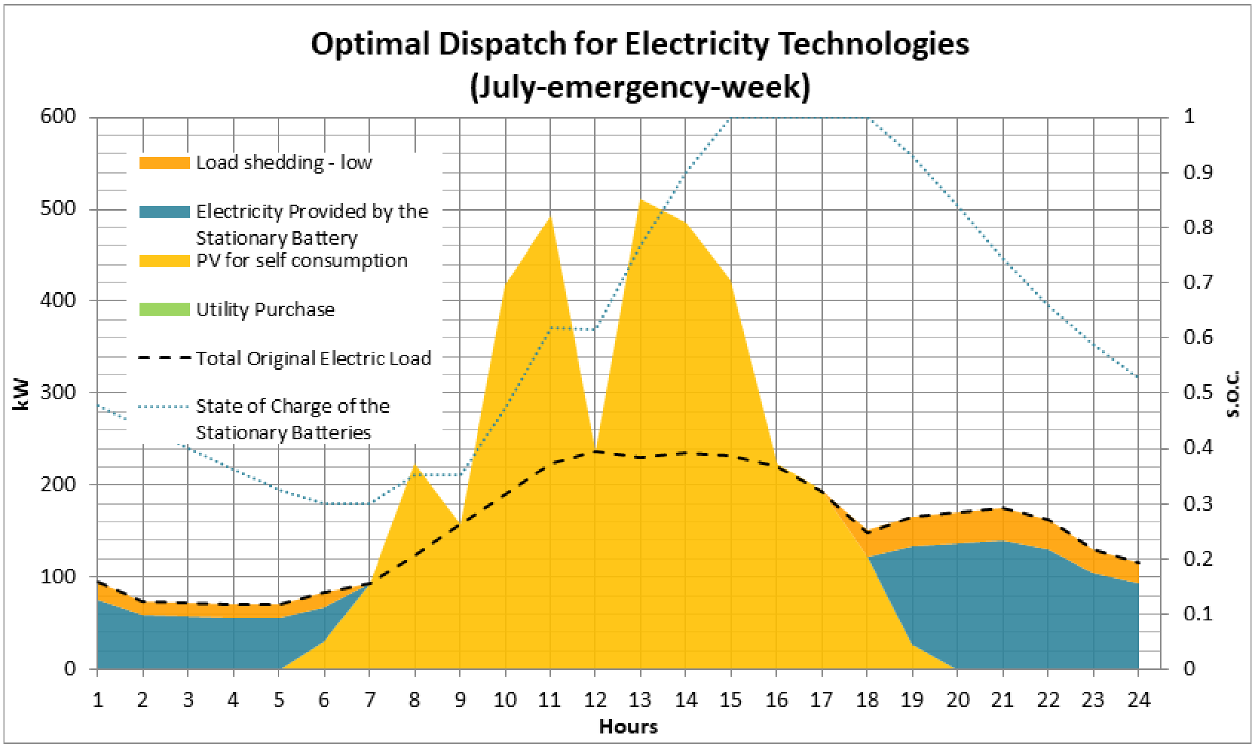

Figure 11. Option B – Economic Dispatch – Summer Emergency

4.5: Option C: Resilience #2

Option C provides the truest microgrid of the analyzed scenarios with the greatest resilience by combining all four of the meters into one main meter. This option maximizes the solar and battery systems that can be installed. Option C combines all four existing meters into one, enabling the sharing of solar and energy storage resources between the sites and across Culver Blvd (Figure 12). Figure 13 demonstrates the infrastructure work required to combine all four meters into a single master meter.

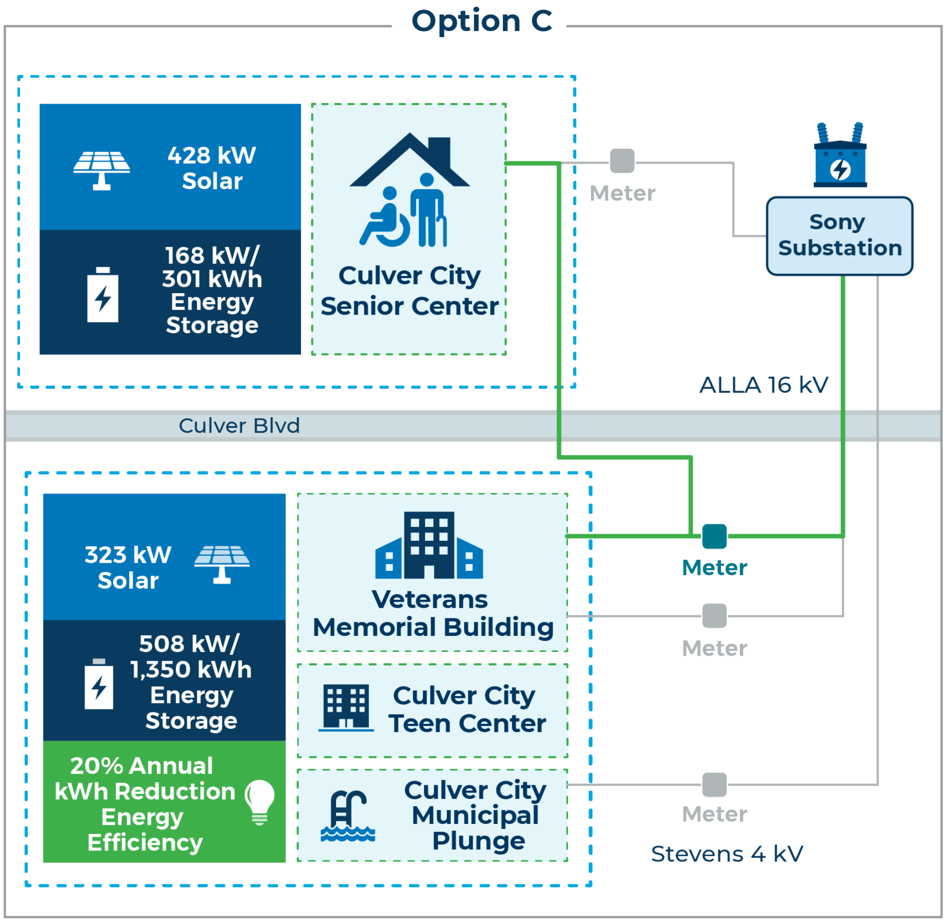

Figure 12. Option C – Circuit and DER Overview

TABLE 15 – OPTION C SUMMARY

Meter	Solar (kW)	Storage (kW)	Storage (kWh)
All Meters (combined)	751	676	1,651

Figure 13. Distribution Alternative 2 for Microgrid Option C

Figure 13 depicts Distribution Alternative 2 for Option C with proposed new circuit additions in blue crossing Culver Blvd to connect the senior center to the veteran's memorial complex.

Solar PV systems for the Option C microgrid scenario include a more robust solar design for both Senior Center and Veteran's Memorial, as well as additional electrical infrastructure to electrically connect the two sides of the street. This interconnection would allow solar

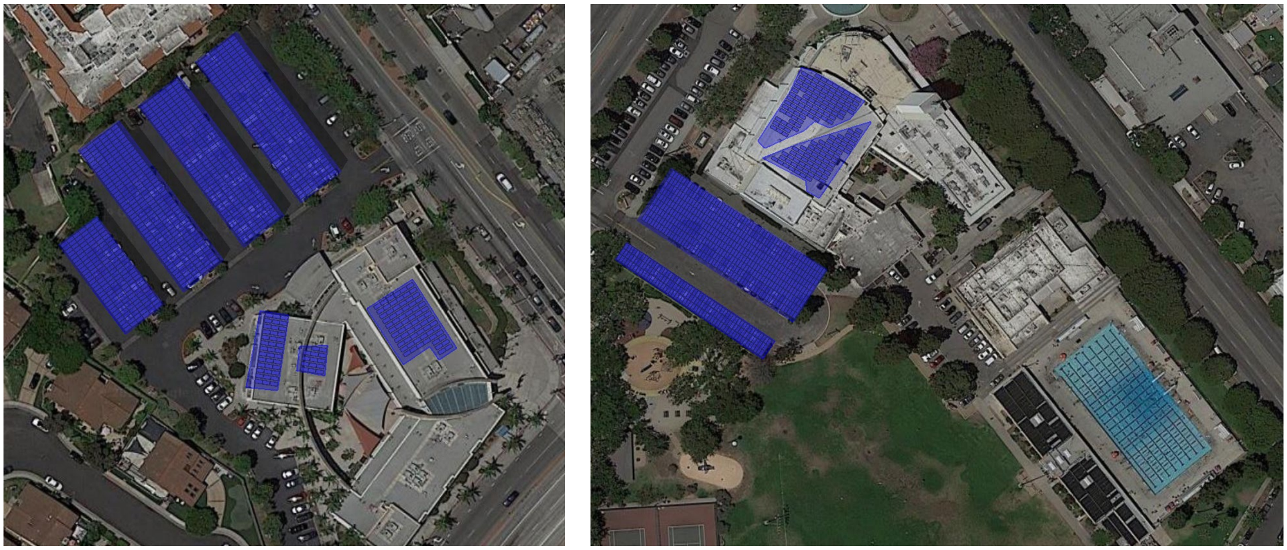

Figure 14. Senior Center 428 kW Design and Veteran's Memorial 323 kW Design

generation from systems at either side of the street to offset electricity and provide generation to any facility. The design at the Veteran's Memorial site reduces the full parking lot carport into two smaller carports and includes rooftop solar PV system on top of the Parks and Recreation building. The Senior Center system would include a full parking lot of carport shade structures, with T shaped structures extended further northwest, as well as a rooftop solar PV system. This solution would involve consolidating the three meters on the Veteran's Memorial side of the street and the Senior Center into one interconnection point, leading to maximum flexibility, bill offset, and resilience. The energy generated from these systems would be enough to offset the annual site load (once adjusted for energy efficiency measures) of all four City meters at the Senior Center and Veteran's Memorial sites, with additional generation for storing electricity via battery storage. As with Option B, the selected solar vendor will take the lead on the refinement of the layout and technical design of the PV structures. Table 16, Table 17 and Table 18 highlight the estimated performance and financial metrics for the solar PV systems.

TABLE 16 – OPTION C SOLAR GENERATION METRICS

Site Name	System Size (kW DC)	Annual Load (kWh)	Annual Production (kWh)	% Offset
Full Meter Consolidation (SC & VM Max Solar)	751	1,031,073	1,224,731	119%

TABLE 17 – OPTION C SOLAR FINANCIAL METRICS

Physical Interconnection ($)	Energy Efficiency ($)	Solar ($)	Battery ($)	Total ($)	Annual Bill Savings ($)
382,950	371,500	2,440,750	1,155,700	4,350,900	213,900

Figure 15 shows a normal winter day where excess PV generation is utilized to charge a battery during the day and the battery is discharged in the evening to avoid expensive demand charges. Energy efficiency measures are considered to be applied in this analysis.

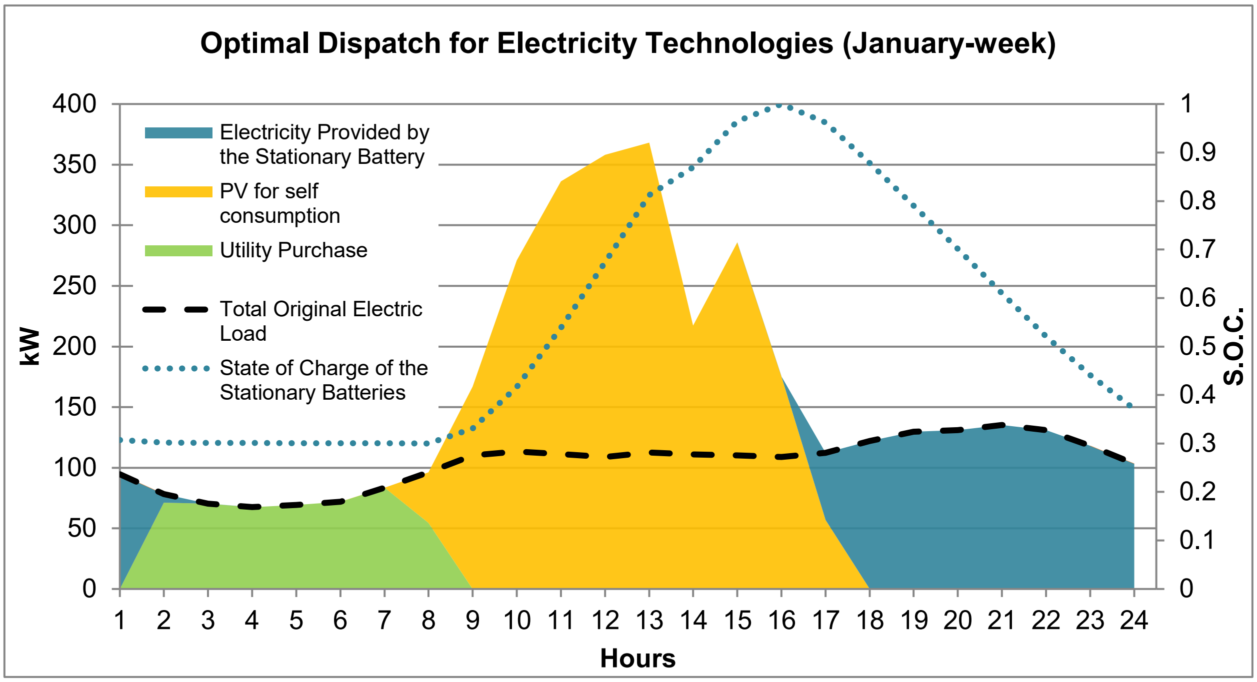

Figure 15. Option C – Economic Dispatch – Winter Normal

The Summer dispatch is showing an average day when an outage may occur. The orange color indicates that a small portion of the electric load is shed, or shut off by building controllers. Critical load and the majority of normal load is served during the day by PV generation and at night by batteries. This scenario would require 5-10% load shedding during the night, which could be achieved by limiting the use of the pool pump. This operation could continue as long as the sun shines on an average day. If there is a period of time with less than average solar generation, such as multiple cloudy or stormy days, existing diesel backup generators can be used as a supplement to the microgrid generation to continue emergency operations.

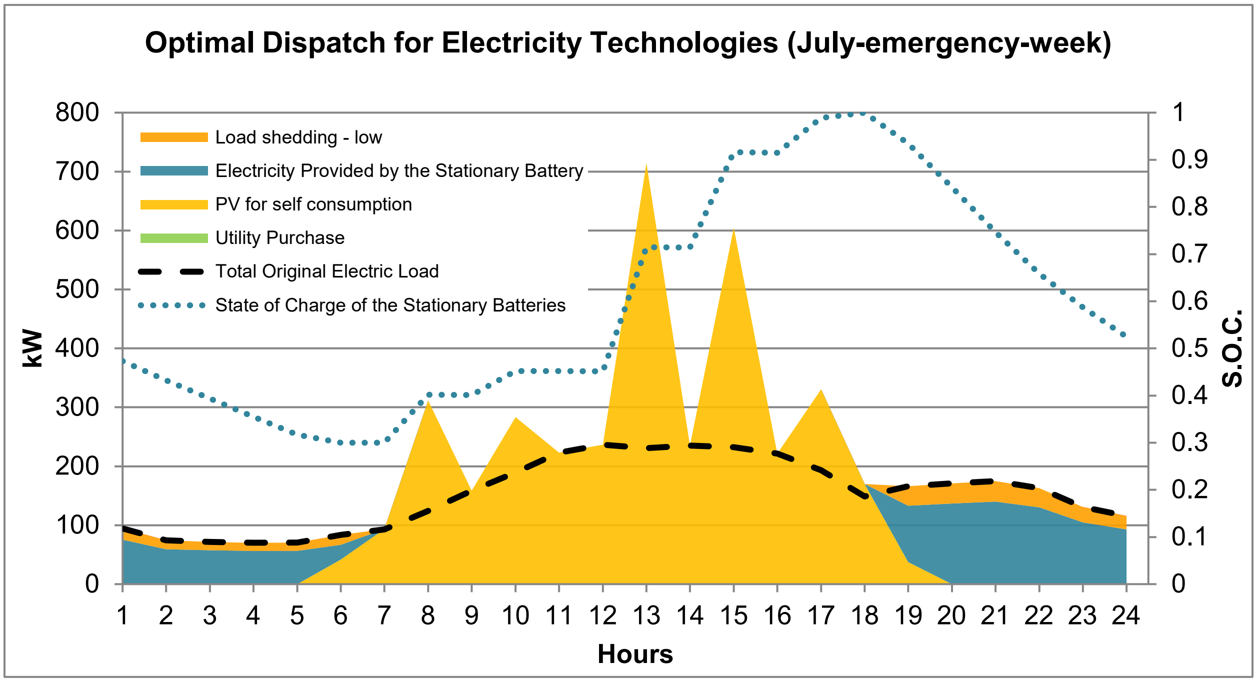

Figure 16. Option C – Economic Dispatch – Summer Emergency

5. Funding

Funding: Grants, Rebates and Incentives and Other Financing

There are many options Culver City can use for implementing the measures identified in this report. Options include direct funding (grants, rebates, and incentives), project financing (debt or equity), or most likely, combinations of both options. Determination of best-fit financing options will include selection of a scenario and evaluation of costs, risks, and flexibility of each option. Willdan can provide additional information on any of the options outlined below that can be reviewed by City finance staff and outside Municipal Financial Advisors.

See the following information about grants, incentives, and rebates that will be evaluated:

Grants

FEMA Hazard Mitigation Grant Program

The City identified FEMA funds available through The Governor's Office of Emergency Services (Cal OES) Hazard Mitigation Grants Program (HMGP) as a potential source of funding for its future microgrid. In December 2018, Cal OES provided Willdan information about solicitation DR4407 with funding related to the November 2018 California Wildfires. Culver City is eligible because it is within LA County, which is considered high priority. The project will be considered in the competitive process and will qualify if it meets cost-effectiveness criteria showing that the lifetime benefits outweigh the project capital costs.

While there is no cap on funding amounts, previous awarded projects were estimated at $3-4 million. There is a 25% local cost share requirement. The project will receive stronger ratings if it can be linked to fire abatement. The Senior Center and Veterans Memorial sites are designated Red Cross emergency shelter sites for over 450 residents in high risk fire areas. Additionally, the Veterans' Memorial site can be used as a staging area and the pool can be used as an emergency water supply for the fire department. Next steps include submitting a Notice of Interest through the web portal articulating the hazard, how the project benefits mitigate the hazard, map/coordinates and other supporting documentation. To meet grant eligibility guidelines, the microgrid project shall be classified as a generator project linked to a critical facility, such as a fire station. Based on communications with the City, hazards mitigated could potentially be power outages as well as fire abatement due to the sites' proximity to severe fire zones flagged by its fire department.

Rebates and Incentives

Midstream Lighting Rebates – Only Available Until March 2019

SCE offers instant rebates on select lighting products purchased from participating lighting distributors. Midstream lighting rebates are paid directly to eligible distributors for a reduced purchase cost to the customer. To participate in this program, customers must complete a Purchase Acknowledgement Form which can be downloaded and completed prior to the purchase or at the time of purchase. These rebates are available for eligible purchases made on or before March 2019.

Self-Generation Incentive Program (SGIP) – For Energy Storage

The Self-Generation Incentive Program (SGIP) is offered by the California Public Utilities Commission (CPUC) and provides incentives to support existing, new, and emerging distributed energy resources. SGIP provides rebates for qualifying distributed energy systems installed on the customer's side of the utility meter. Qualifying technologies include wind turbines, waste heat to power technologies, pressure reduction turbines, internal combustion engines, microturbines, gas turbines, fuel cells, and advanced energy storage systems. Additional information can be found at https://www.selfgenca.com/. For Culver City's project, this would be applicable to offset the costs for its energy storage components assuming minimum utilization rates could be met.

Demand Response Programs

SCE's Demand Response Programs pay incentives for measures that provide verified, dispatchable, on-peak load reduction. Culver City indicated that it discontinued previous DR participation due at least partially to increased energy efficiency. In keeping with the State's

Loading Order, Willdan recommends re-evaluating DR potential and program participation only after the maximum energy efficiency potential has been exhausted.

Local Capacity Requirements Program

Because Culver City is located within the LA West Basin, the following "resource type" projects may qualify for incentives through third party Local Capacity Requirement third party sellers. SCE is required by the CPUC to invest in these contracts to ensure increased capacity where the grid is constrained.

TABLE 18 – SUMMARY OF LOCAL CAPACITY REQUIREMENT PROGRAMS AVAILABLE TO THE WEST BASIN

Seller	Resource Type	MW	# of Contracts
AES	Behind-the-Meter Battery Energy Storage	50	4
AES	Combined Cycle Gas Fired Generation	1,284	2
AES	In-Front-of-Meter Battery Energy Storage	100	1
Generate Evaporcool	Energy Efficiency	73	4
NRG	Demand Response	75	7
FSG	Energy Efficiency	30	4
Ice Energy	Behind-the-Meter Thermal Energy Storage	26	16
Onsite Energy Corporation	Energy Efficiency	11	11
Stanton Energy Reliability Center	Peaking Gas Fired Generation	98	1
Stem	Behind-the-Meter Battery Energy Storage	85	2
Sterling Analytics LLC	Energy Efficiency	17	7
SunPower Corp	Behind-the-Meter Renewable	44	4
Stanton Energy Reliability Center	Peaking Gas Fired Generation	98	1
Stem	Behind-the-Meter Battery Energy Storage	85	2
Sterling Analytics LLC	Energy Efficiency	17	7
SunPower Corp	Behind-the-Meter Renewable	44	4
	TOTAL:	**1,892**	**63**

See the following information about the major financing vehicles that will be evaluated:

Loans

California Energy Commission Loans

The California Energy Commission offers 1% interest loans to Cities, Counties, Specials Districts, Public Colleges and Universities for projects including energy efficiency and renewable generation projects. While funding is capped at $3 million per project, it is in high demand and awarded on a first-come, first-served basis. The project (or portion of the project funded by the loan) must show a simple payback of 17 years or less. Terms of up to 20 years are available.

Loan from the California Infrastructure and Economic Development Bank (I-Bank)

The California I-Bank's California Lending for Environmental Energy and Environmental Needs (CLEEN) Center offers direct loans of $500,000 to $30 million through its Statewide Energy Efficiency Program (SWEEP). The application process requires extensive preparation with I-Bank staff and approval by the I-Bank's Board of Directors. Interest rates are determined at time of loan approval but are based on municipal rates and individual borrower/project risk factors.

Municipal Debt (Loans, Leases, and Bonds)

One of the most commonly utilized financing for energy efficiency projects is municipal debt. Whether through bonds, leases, or loans, the municipal market offers a number of cost-effective options for large projects. Interest rates and terms vary, depending on the project being financed, type of municipal debt being utilized, and the public agency's underlying creditworthiness. Usually, a public agency will make decisions about using municipal debt for efficiency projects in concert with its finance group, often utilizing its Independent Registered Municipal Advisor.

Mello-Roos Community Facilities District

It is possible to finance a microgrid by creating a Community Facilities District in which a special parcel tax is assessed to all microgrid beneficiaries. Creation of a Mello-Roos CFD requires approval by 2/3 of impacted voters, so extensive community outreach would be required.

Vendor Financing through Equipment Manufacturers

Some of the manufacturers providing equipment on the project may offer vendor financing, either through a financing partner or on their own. Most vendor financing will offer commercial market (rather than municipal) interest rates. Vendor financing options and pricing will become clear as equipment is specified.

Third-Party Ownership (Power Purchase Agreement, Energy Services Agreement, Public-Private Partnership)

The most commonly-used non-debt options fall into the category of third parties owning energy equipment and paying for its installation, with long-term service contracts for energy benefits delivered. For instance, a solar power purchase agreement (PPA) allows a public agency to pay only for the energy produced by its solar generating system. For a microgrid, a similar agreement can be made with an outside owner/operator. The City and outside microgrid owner can negotiate metrics to calculate payments, or they can simply agree to flat payments with certain baseline operating guarantees.

6. Implementation Roadmap

In conclusion, the City has already made a bold environmental commitment by signing on to the CPA and purchasing 100% clean power for all its facilities. By taking the next step in lowering its energy and carbon footprint and by adding localized generation and storage, it is further bolstering resiliency. This is of particular importance given the sites' function as emergency shelter sites.

While the upfront expenditure is the highest with Option C, the annual savings and benefits make it the clear choice as a 100% clean powered, ZNE microgrid with ability to island from the grid. As depicted in the summary below, Option C will deliver the City with the most resiliency in the case of an emergency with adequate renewable energy generation and island from the grid for 10+ hours. Furthermore, there are several low-risk funding options, when combined, that are available for Option C that, if secured, could offset most, if not all, all of the system cost.

Whatever Culver City's decision, Willdan looks forward to provide customized support in next steps of the funding, procurement and implementation of its desired scenario.

Smart Cities

Figure 17. Willdan's Vision for Smart Cities

The planned Culver City Community Microgrid will integrate renewable energy, storage, and controls to provide resilience to multiple emergency shelter sites that will serve the Culver City community. This is the first step for many cities in a path to a smart city. Integrating city departments and operations with one control and management system lays the ground work to integrate planning and infrastructure that crosses between energy, transportation, water, and emergency services. Willdan looks forward to continue to support the City of Culver City on the innovative journey it has begun, including with its Transportation Electrification study.

TABLE 19 – SUMMARY OF BENEFITS OF MICROGRID OPTIONS

Advantage	Methodology	Benefits	Option A – Economic	Option B – Resilience	Option C – Resilience
Resilience at Emergency Shelters	Solar, Storage, and Demand Response provide microgrid islanding capability	Provide critical cooling and heating and support city operations during emergencies	3 hours*	7 hours*	10+ hours*
Reduced Utility Costs	Reduced energy and demand costs with energy storage and low cost solar generation	More budget availability for city services and resident benefits	$150,000	$200,000	$213,900

Advantage	Methodology	Benefits	Option A – Economic	Option B – Resilience	Option C – Resilience
Reduced Power Outages**	Optimal dispatch of energy resources to meet critical loads	Avoided cost of outage, lost productivity, project delays, or canceled events	$8,000	$20,000	$30,000
Greenhouse Gas Emissions	HVAC electrification	Improved air quality and meeting city and state emissions goals	323 MT CO2	323 MT CO2	323 MT CO2
Revenue Generation	Potential to provide ancillary services to CAISO and sell capacity to SCE	Encourage additional investment opportunities	Varies	Varies	Varies

* Power for Critical Loads based on battery capacity only and no solar availability – much longer with solar PV

** Based on DOE's Interruption Cost Estimator - https://icecalculator.com/

TABLE 1 – SUMMARY OF MICROGRID SCENARIO COSTS

Option	Energy Efficiency Cost ($)*	Infrastructure Costs ($)	Solar Costs ($)	Battery Costs ($)	Total Capital Costs ($)
A - Economic	371,500	0	1,524,250	365,400	2,261,150
B - Resilience 1	371,500	213,900	1,748,500	1,205,400	3,539,300
C - Resilience 2	371,500	382,950	2,440,750	1,155,700	4,350,900

*The capital costs do not factor in potential SCE rebates or incentives. SoCalREN, which is concurrently assisting the City, can offer help at no cost to the District in identifying and applying for rebates or incentives available at the time of installation. As a best practice, Willdan also suggests incorporating language into solicitations requesting vendors secure and apply all available rebate and incentives as part of their proposal and reduce pricing accordingly.

TABLE 2 – SUMMARY OF MICROGRID SCENARIO PERFORMANCE

Option	Solar Capacity (kW)	Storage Capacity (kW)	Storage Output (kWh)	Annual Bill Savings ($)	Added Annual Resiliency Value ($)*	Energy Savings Payback	Total Value Payback
A - Economic	469	404	522	150,000	8,000	15.1	14.3
B - Resilience 1	538	484	1722	200,000	20,000	17.7	16.1
C - Resilience 2	751	676	1651	213,900	30,000	20.3	17.8

*Resiliency is quantified as the estimated avoided cost of power outage, lost productivity, project delays, or canceled events. Estimates are derived from the Interruption Cost Estimating Tool developed by Lawrence Berkeley National Lab.

Willdan recommends the following next steps associated with the implementation of the recommendations of this report:

1. First, compare scenarios and choose a scenario that meets the City's desired goals and needs and seek relevant internal approvals and support (City Council). While Willdan's recommendation is Option C, we will support any decision the City makes and customize its next steps accordingly. Willdan has provided a presentation, which it can deliver in person at the Council meeting and can also contribute to text for a pre-read staff memo for the City Council.
2. Submit funding applications to cover capital costs for desired scenario. Willdan can support with inputs and funding applications. Suggestions to consider include leveraging SoCalREN's assistance in identifying and applying for utility rebates and incentives, submitting a notice of interest (NOI) to FEMA's Hazard Mitigation Grant for funding of a generators linked to a critical facility and/or submitting an application for CEC 1% loan for up to $3 million for energy efficiency and renewable energy projects.
3. Concurrently, prepare and issue technical specs to collect comparable and competitive bids to refine cost estimates and confirm purchase, leasing and financing options, incorporate applying for relevant incentives and rebates, such as midstream lighting, SGIP, etc. into scope of work and pricing. Willdan can provide technical specs and procurement support. It is recommended that O&M terms are determined and written into the technical specs.
4. Lastly, begin to engage with utility to develop master controller and grid integration strategy and the CPA to understand implications of service expansion to City of Culver City. Willdan can assist with writing specifications and facilitating stakeholder processes as desired.