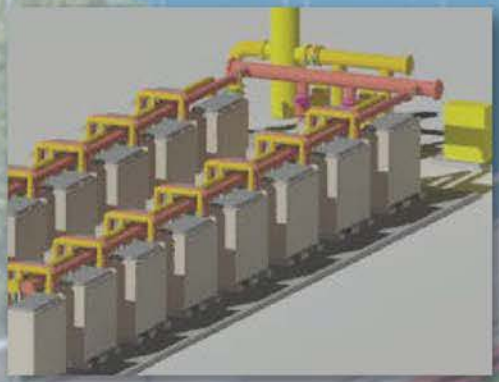
CSU Sacramento

Strategic Energy Plan

SACRAMENTO STATE

September 2021



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1 EXECUTIVE SUMMARY

The California State University Sacramento (CSUS) campus has been educating students since 1947. During 2020, it had an enrollment of over 31,000 students and serves as one of the premier educational institutions as part of the California State University system of campuses. The campus building infrastructure encompasses over 5.8 million square feet of facilities in about 80 structures, which includes five parking structures with a combined size of approximately 2.3 million square feet. Some of the oldest buildings in service today include those that were developed in the mid 1950's. An estimated 1 million square feet of buildings are less than 20 years old and an estimated 1 million square feet of buildings are over 60 years old.

During 2018/1019 period, the campus used approximately 43 million kWh of electricity and 1.2 million Therms of natural gas to operate its buildings. Nearly 72% of the above natural gas use is in the central plant steam boilers that provide steam to campus buildings through a steam distribution system. The 2018/19 Scope 1 and Scope 2 Green House Gas (GHG) emissions corresponding to these energy resources total approximately 13,788 Metric Tons. 65% of the GHG emissions are from State funded buildings and the balance is from non-state buildings including Housing, Parking and UEI buildings.

The campus has successfully led energy efficiency and sustainability programs during the last several decades. In comparison with the 1990 GHG emission levels, the present GHG emissions (2018/19) are 88% of the 1990 emission level of an estimated 15,683 Metric Tons/year. Based on unit emission rates of approximately 0.38 lbs. of GHG per kWh and 11.67 lbs. of GHG per Therm of natural gas, approximately 34% of the overall GHG emissions is directly attributed to the use of natural gas. Going forward, Sac State has the vision and Presidential commitment to go Net Zero in the next 20 years. Specifically, the Climate Action Plan adopted during 2018 has set forth the following vision:

A. **50%** Reduction of GHG emissions by **2030**
B. **80%** Reduction in GHG emissions by **2035**
C. **Net Zero** GHG emissions by **2040**

This Strategic Energy Plan examines the specific projects and programs that can help make the above vision a reality. The projects may be summarized under three categories.

A. Energy efficiency measures that help reduce the energy used by building systems
B. Gas to electric heating conversion measures that help substantially displace use of natural gas on campus with a renewable electricity resource. As part of this measure, the central steam plant and steam distribution system would be replaced with a low temperature heating hot water distribution system.
C. Renewable energy measures, such as Photovoltaic projects or purchase of renewable energy or associated credits to offset the balance that remains after categories A and B are completed.

The following **Table 1.1** summarizes the results of these evaluations.

Table 1.1 – High Level Summary of GHG Reduction Targets & Implementation Costs

Milestone	% Reduction with respect to 1990 Levels	GHG Emissions Reduction (Metric Tons)*	Estimated Cost of Implementation (Million $)	Technology or Measures Required
2030	50%	5,358	$95.7	Building energy efficiency improvements + Shifting 39% natural gas based heating to electric heating
2035	80%	4,610	$73.5	Complete the balance of transition from natural gas heating to electric heating + Renewable energy of approximately 7.4 MWor procurement of approximately 11.8 Million kWh of REC
2040	100%	3,137	$35.9	Renewable energy of approximately 11.4 MW or procurement of approximately 18.2 Million kWh of REC
		13,105	**$205.1**	

FY '18/19 Inventory GHG emissions for reference after accounting for 2.61 MW of photovoltaic system, installed in the summer of year 2020

See Section 5.3 on the high-level cost breakdown at each phase. See Table 2.6 for high energy efficiency measures cost breakdown. Refer to **Figure 1.1** for graphical representation of CSU Sacramento's emission goals and **Figure 1.2** illustrates the funding requirements to realize the emission goals:

Figure 1.1 – Greenhouse Gas Emission Goals

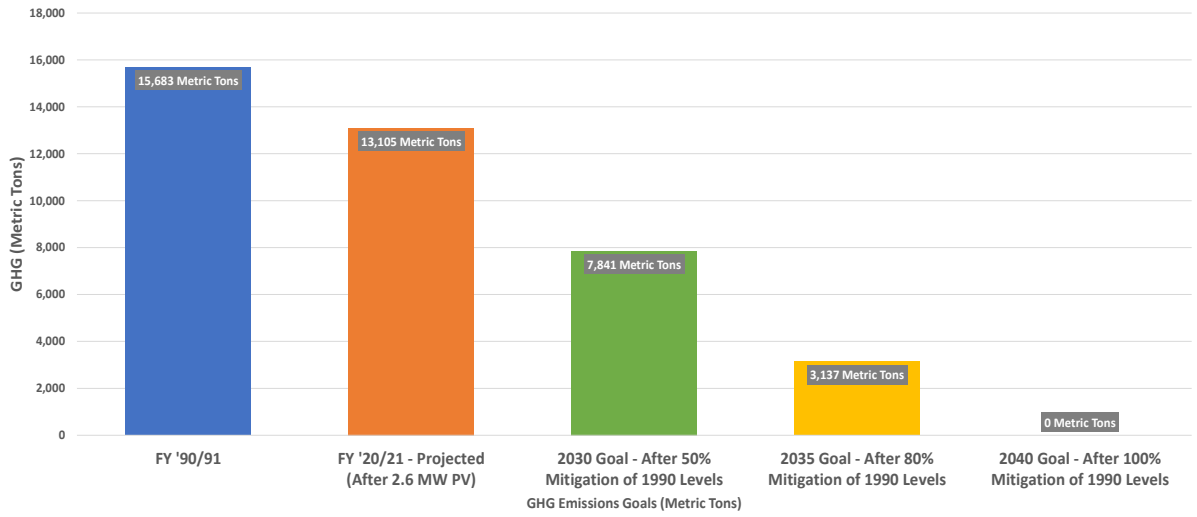
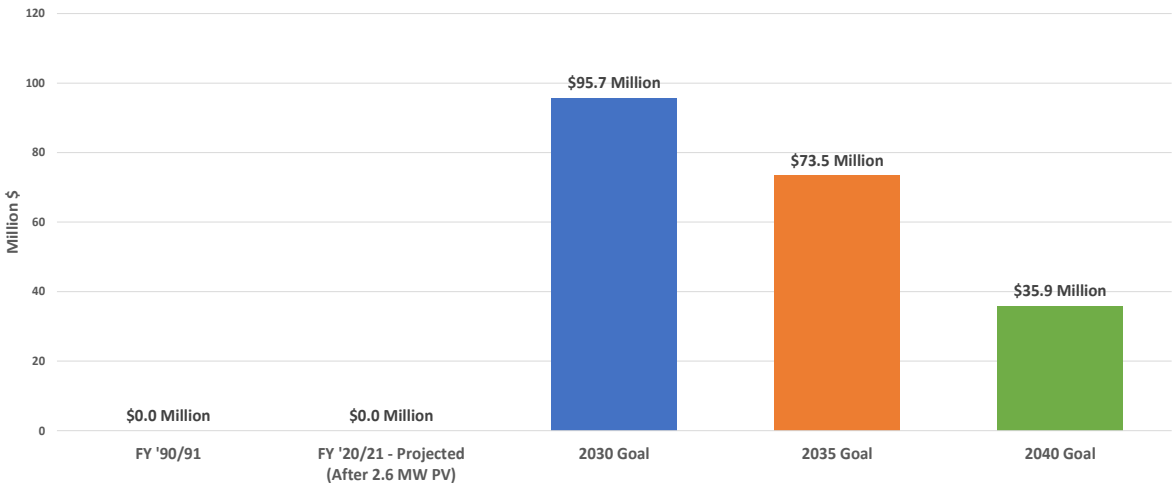


Figure 1.2 – Funding Requirement per Milestone



Based on the above, this Strategic Plan recommends the following path to meet the campus vision.

1. Arrange funding/financing strategy to reflect provide the level of funding summarized above. Funding may involve a variety of mechanisms including:
    - Capital funding
    - Utility financed projects
    - Third-party energy service contracts
    - Lease purchase financing where capital equipment is leased over 20-years and gradually acquired at fair market value
2. Pursue energy efficiency measures campus-wide and make each building as efficient as possible through proven technology measures including LED lighting, Direct digital controls of HVAC systems, improved envelope where possible using high efficiency glazing, and retro-commissioning of buildings using state of the art control sequences.
3. Develop a heating hot water infrastructure that includes a combination of direct buried hot water lines and heat pumps to produce low temperature hot water to ultimately replace the present steam distribution system. The study uses a minimum of 3-5 satellite plants to help minimize the cost of piping infrastructure. A total of 250 Heat pumps, each capable of 30 Tons or 0.28 MMBtuh of heating capacity would be required to accomplish this conversion. These heat pumps would have the combined capacity to provide roughly 20 Btu/SFT of buildings to meet both the space heating and domestic hot water heating load on campus. A total of 3.4 million square feet of buildings that presently use natural gas for heating would use these electric heat pumps for future heating needs.
4. Develop all future buildings to accommodate low temperature hot water at 130 deg. F as opposed to the present design that tends to use 180 deg. F heating hot water.
5. Convert gas based domestic hot water heating systems to electric heat pump based domestic hot water systems at each building.

6. Pursue conversion of gas operating kitchen appliances to all electric kitchens to help minimize use of natural gas on campus.
7. Monitor SMUD renewable energy content closely on an ongoing basis. The campus burden on achieving Net Zero will diminish to the extent that SMUD renewable percentage increases. Current emission rates in the report are based on 0.38 lbs./kWh.
8. Maximize PV generation on campus using available sites including building roof tops. Since achieving net zero will entail far more capacity than what can be realistically built on campus property, consider of site locations, purchase of REC's as other means to offset energy that is otherwise difficult to build on campus property.

2 FACILITY ENERGY USAGE AND GHG EMISSIONS

2.1 CAMPUS ENERGY USE AND GHG EMISSIONS

Records for the latest fiscal year (i.e., FY '18/19: July 1, 2018 to June 30, 2019) show a campus building size of approximately 3.1 million GSF. During this year, the campus used a total of approximately 43.0 million kWh/year of electricity and 1.22 million Therms of natural gas. Over 98.3% of the electricity use during FY '18/19 was purchased from SMUD. The GHG emissions (Direct and Indirect under *Scope 1* and *Scope 2*) is estimated for FY '18/19 as 30.4 million lbs. or approximately 13,788 metric tons.

In 1990, the campus used approximately 30.7 million kWh/year of electricity and 1.01 million Therms of natural gas. The GHG emissions (Direct and Indirect under *Scope 1* and *Scope 2*) is estimated for FY '90/91 as 34.6 million lbs. or approximately 15,683 metric tons.

Table 2.1 presents a comparative summary of the Campus' GHG emissions for FY '18/19 and FY '90/91. Included in the summary are *Scope 1* and *Scope 2* type emissions.[1] As shown, existing levels ('FY '18/19) are approximately 12% lower than the GHG emissions calculated for FY '90/91. Considering that the campus building GSF increased from 2.7 million GSF to 4 million GSF (i.e., 48% increase since FY '90/91), real reduction in GHG emissions represents a noteworthy accomplishment. Refer to **Figures 2.1** and **2.2** for a graphical comparison of Scope 1 vs. Scope 2 emissions for FY '90/91 and FY '18/19.

AB 32's goal[2] of achieving 1990 levels of GHG emissions by 2020 has been successfully met by the Cal State Sacramento campus more than two years ahead of schedule. **Table 1.1** also shows how the campus has successfully reduced the site energy use index from 76.6 kBtu/GSF/year to 67.2 kBtu/SFT/year, a reduction of approximately 12%. The campus is keen on continuing the path of progress in this regard and has set the visionary goal of achieving even greater energy efficiencies and lower carbon footprint in the long term as will be presented later in this document.

[1] Scope 1 (Direct): Natural gas, gasoline, and diesel; Scope 2 (Indirect): Electricity purchased from utility.
[2] California AB 32, California Global Warming Solutions Act of 2006

Table 2.1 – Comparison of Energy Use and GHG Emissions – FY '90/91 vs. FY '18/19 (Campus-Wide)

Item	FY '90/91	FY '18/19	% Change from FY '90/91	Notes
Campus-wide Electricity Use (kWh), Including PV	30,699,296	43,024,229	40%	
PV Produced Electricity (kWh)	0	710,874		[1]
Utility Purchased Electricity (kWh)	30,699,296	42,313,355	38%	[1]
Natural Gas Use (MMBtu)	101,691	122,501	20%	[1]
Gasoline (Gallons)	2,827		0%	[1]
Diesel (Gallons)	9,320		0%	[1]
GHG Emission Rate for:				
Electricity (Metric Tons/kWh)	0.00033	0.00017	-49%	[2]
Natural Gas (Metric Tons/MMtbu)	0.05207	0.05302	2%	[2]
Gasoline (Metric Tons/Gallon)	0.010257085	0.010164759	0%	[2]
Diesel (Metric Tons/Gallon)	0.00890592	0.008586184	0%	[2]
GHG Emission / Fuel:				
Electricity Emission (Metric Tons)	10,276	7,293	-29%	
Natural Gas Emission (Metric Tons)	5,295	6,495	23%	
Gasoline (Metric Tons)	29		-100%	
Diesel (Metric Tons)	83		-100%	
Total GHG Emissions (Metric Tons/Year)	15,683	13,788	-12%	
Building Area (GSF)	2,715,218	4,005,519	48%	[3]
GHG Emission-Normalized (Metric Tons/GSF/Year)	0.006	0.003	-40%	
Building Site Energy Use Index (kBTU/GSF)	76.6	67.2	-12%	[4]

Notes

[1] Based on campus energy records

[2] Emisssion rates are from SIMAP Portal. *See link below:*
https://unhsimap.org/cmap/utility-emission-factors/

[3] Parking structures included in total GSF but with a factor / approximation of 0.007 (e.g., Actual GSF x 0.07 = Equivalent GSF)

[4] Accounts for all building consumption including what is generated by renewables (i.e., PV)

Figure 2.1 – Greenhouse Gas Emission Source Comparison: Metric Tons - Direct Scope vs Indirect Scope (FY '90/91) – Campus Wide

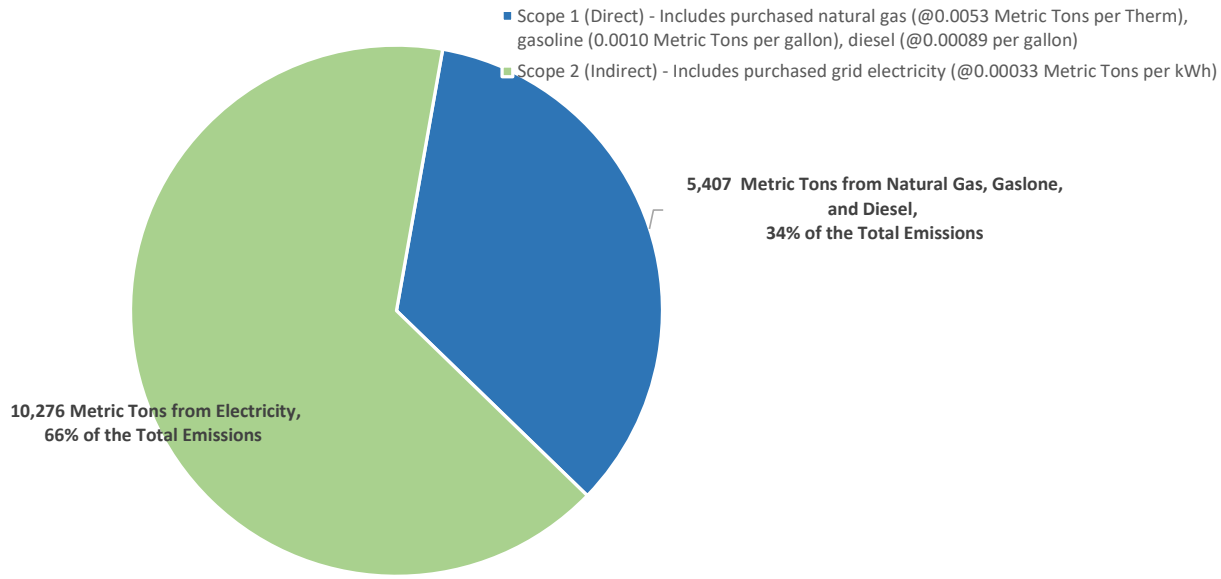
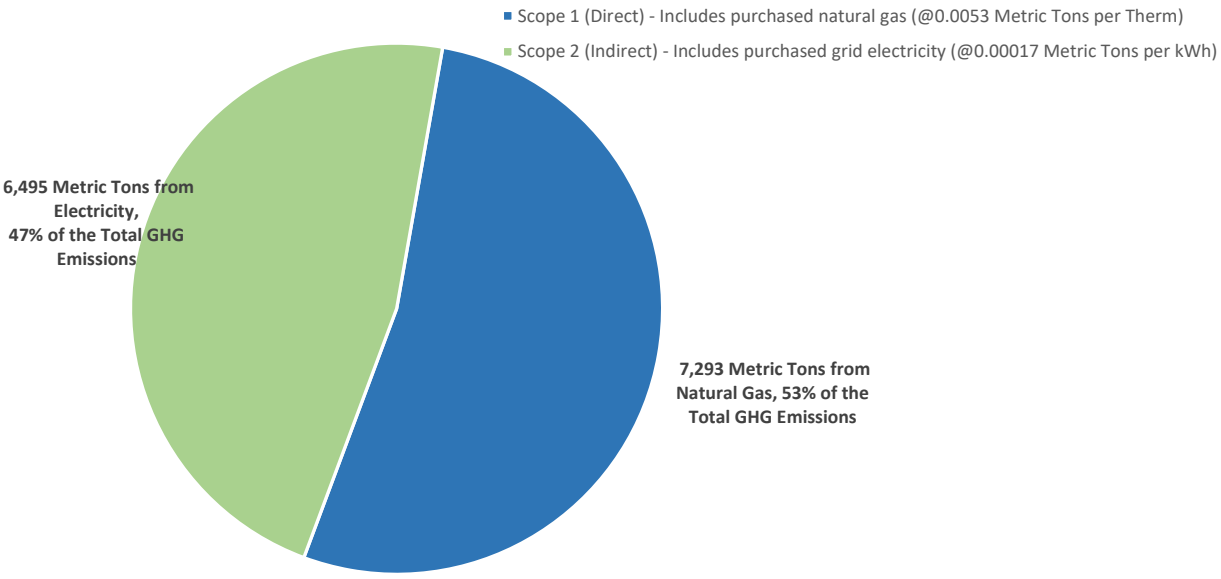


Figure 2.2 – Greenhouse Gas Emission Source Comparison: Metric Tons - Direct Scope vs Indirect Scope (FY '18/19) – Campus Wide

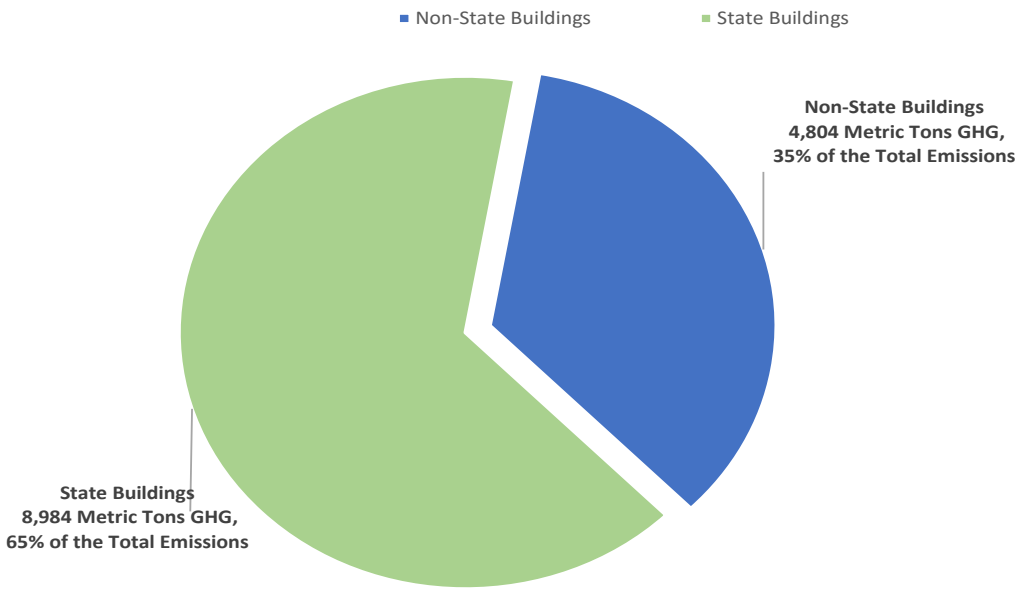


The Table 2.2 presents an itemized comparative summary of the State and Non-State Buildings' electricity, natural gas, and GHG emissions for FY '18/19. Included in the summary are *Scope 1* and *Scope 2* type emissions. Refer to **Figures 2.3** for a graphical comparison of State-Buildings vs. Non-State Buildings emissions for FY '18/19.

Table 2.2 – Comparison of Energy Use and GHG Emissions – FY '18/19 (State vs Non-State Buildings)

#		Building Group	Building Area (GSF)	Annual Electricity Consumption (kWh) -FY' 2018/2019	kWh/GSF	Annual Natural Gas Consumption (Therms) - FY' 2018/2019	Therms/GSF	GHG Emissions (Metric Tons/Year) - FY' 2018/2019	GHG Emissions per GSF (Metric Tons/Year/GSF)
1	Non-State Buildings	Union Well Inc (Student Union & Well Building)	367,845	3,868,272	10.5	56,493	0.15	955	0.0026
2		Housing	546,524	4,461,301	8.2	107,720	0.20	1,327	0.0024
3		Parking Structures	165,504	2,874,651	17.4		-	487	0.0029
4		UEI Buildings	579,243	8,042,124	13.9	126,538	0.22	2,034	0.0035
Sub-Total (Non-State Buildings)			1,659,116	19,246,348	11.6	290,751	0.18	4,804	0.0029
5		State Buildings	2,346,403	23,777,881	10.1	934,263	0.40	8,984	0.0038
Total:			**4,005,519**	**43,024,229**	**10.7**	**1,225,014**	**0.31**	**13,788**	**0.0034**

Figure 2.3 – GHG Emissions Comparison: Metric Tons – State vs Non-State Buildings (FY '18/19)



Note: Direct Scope is Scope-1 GHG Emissions; Indirect Scope is Scope-2 GHG Emissions

2.2 CAMPUS BUILDINGS ENERGY RANKING

Energy meter records show that during a recent 12-month period (July 2018 through June 2019), the University used 43.02 million kWh of electricity and 1.22 million therms of natural gas. Cost of electricity and natural gas during this period averaged $0.090/kWh and $0.702/therm, respectively. Electricity and natural gas are purchased from Sacramento Municipal District (District) and Pacific Gas & Electric, respectively

Appendix A presents a listing of all campus buildings with ranks given by highest energy users (*i.e., ranking by total use, not energy use index*). Data is presented for electricity and natural gas, respectively. Intent of these lists is to provide the campus with a clearer picture of where to focus their energy conservation efforts.

2.3 SCOPE OF GHG ESTIMATES

To understand Cal State Sacramento's carbon footprint contribution, equivalent Greenhouse Gas (GHG) emissions for electricity, natural gas, gasoline, and diesel use were calculated and compared for fiscal years (FY) 1990/1991 vs. FY 2018/2019.

CO2 Equivalent Conversion Rate:[3]

Electricity Use:
1990 – 0.74 lbs. /kWh (0.00033 Metric Tons. /kWh)
2020 – 0.38 lbs. /kWh (0.00017 Metric Tons. /kWh)

Natural Gas Use:
1990 – 11.48 lbs. /Therm (0.005207 Metric Tons. /Therm)
2020 – 11.69 lbs. /Therm (0.005302 Metric Tons. /Therm)

Other Fuels:
Gasoline – 19.634 lbs./Gallon (0.0103 Metric Tons. /Gallon)
Diesel – 22.613 lbs./Gallon (0.0089 Metric Tons. /Gallon)

[3] Emission rates are from SIMAP Portal: https://unhsimap.org/cmap/utility-emission-factors/

Overall GHG Emissions

It is estimated that overall GHG emissions have decreased by approximately **12%** since FY '90/91. **Table 2.3** shows a GHG comparison. Includes *Scope 1* and *Scope 2* GHG emissions only (i.e., electricity, natural gas, gasoline, and diesel). **Figure 2.4** presents a graphical summary of the same.

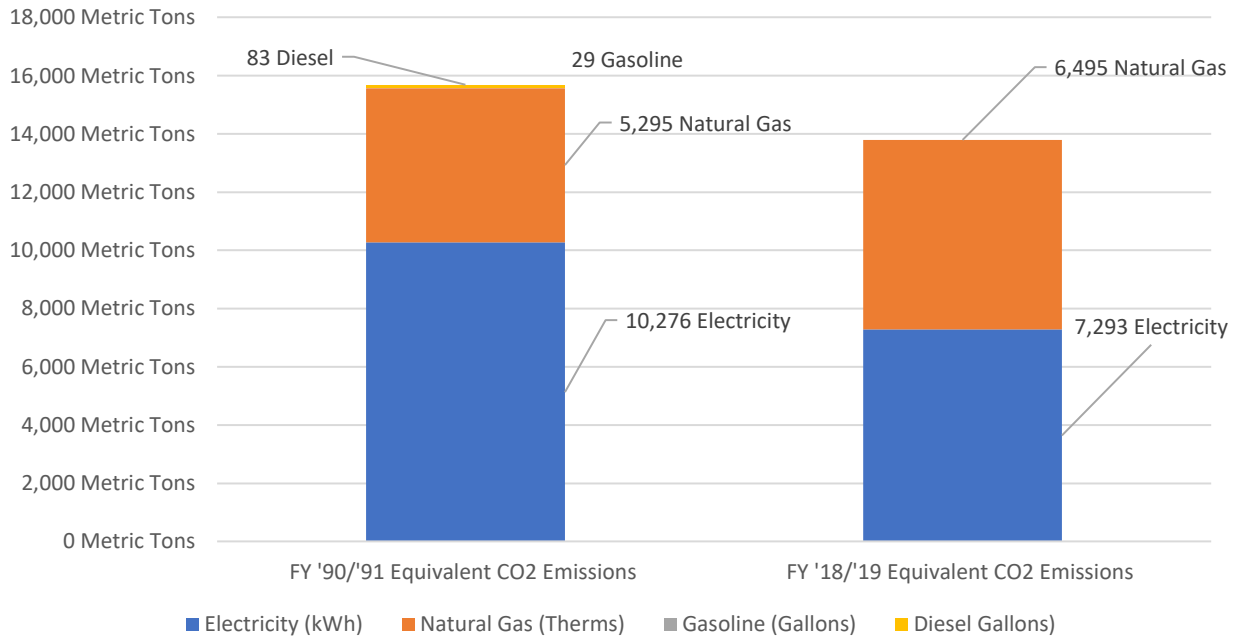
Table 2.3 – Overall GHG Emissions Comparison (Campu-Wide)

	FY '90/'91 Utility Purchases (by Unit Measure)	FY '18/'19 Utility Purchases (by Unit Measure)	FY '90/'91 Equivalent CO2 Emissions	FY '18/'19 Equivalent CO2 Emissions (Metric Tons)	% Reduction
Electricity (kWh)*	30,699,296	42,313,355	10,276	7,293	29%
Natural Gas (Therms)	1,016,905	1,225,014	5,295	6,495	-23%
Gasoline (Gallons)	2,827		29	-	100%
Diesel Gallons)	9,320		83	-	100%
Total (Metric Tons)			**15,683**	**13,788**	**12%**

* *Data is for utility purchased electricity (not including renewables). Total bldg. consumption for FY '18/19 is 42,313,355 kWh*

* * Gasoline and Diesel *consumption is zero for the recent period (FY '18/'19).*

Figure 2.4 – Energy Use Equivalent CO2 Emissions Comparison (FY '90/91 vs. FY '18/19)



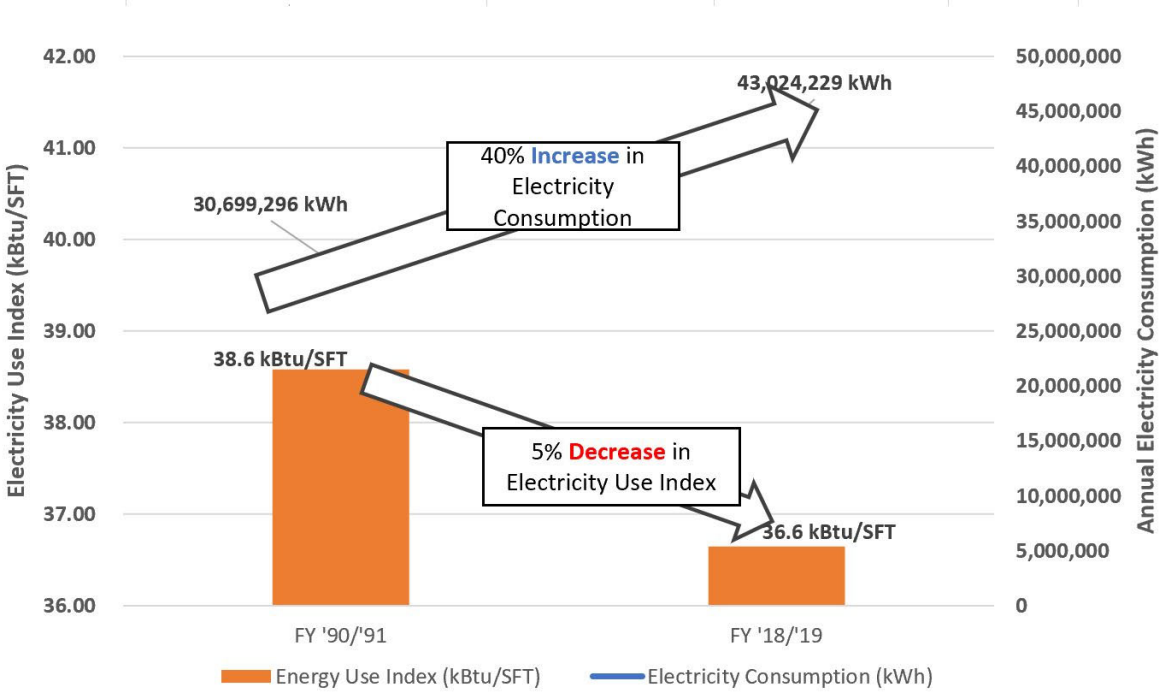
2.4 SUMMARY OF REDUCTIONS

Energy use index represents the rate at which electricity or gas is used at a building on a square foot area basis. This measure provides a relative understanding of building performance through time in terms of utility usage. Note that these measurements include both utility purchases and on-site generation as they are a measure of building efficiency.

Electricity

Even though the campus footprint increased by **48%** square feet and electricity use increased by **40%** from **30.7** million kWh in FY '90/91 to **43.0** Million kWh in FY '18/19, the electricity use index decreased by **5%** from **38.6** kBtu/Sq. ft. to **36.6** kBtu/Sq. ft. in the same time span. A multitude of factors have contributed to the downward trend in electricity use index. These include technology advancements, building modernizations, stricter building codes, and the continuous efforts by campus administration to enhance energy efficiency as is outlined in Section 1.3 of this SEP. **Figure 2.5** shows the annual electricity use index and total use comparison.

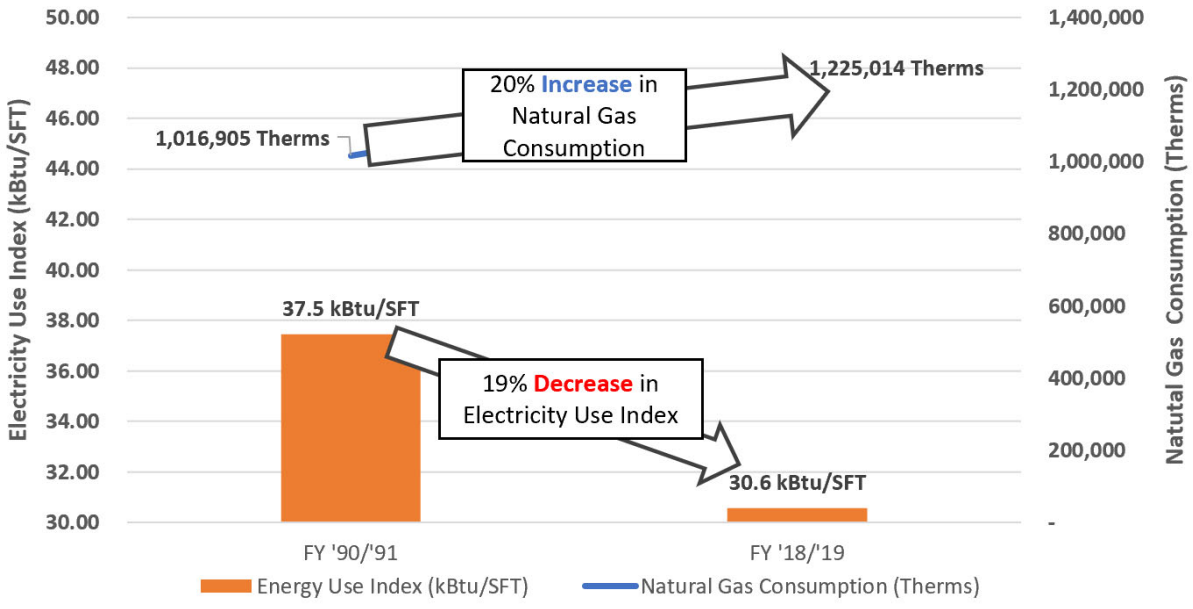
Figure 2.5 – Electricity Use and Use Index Comparison (FY '90/91 vs. FY '18/19)



Natural Gas

A similar comparison was performed for natural gas use. Analysis shows a decrease of approximately 19% in gas use index from FY '90/91 to FY '18/19. **Figure 2.6** shows the annual Gas Use Index comparison.

Figure 2.6 – Gas Use and Use Index Comparison (FY '90/91 vs. FY '18/19)



Energy Use Index Comparisons

Tables 2.4 and **2.5** show detailed analysis on electricity, gas, gasoline, and diesel use indices comparison. As shown, even though the building area has increased by **48%** since FY '90/91, utility use index has decreased considerably leading to the fact that during later years, energy efficiency concepts have been aggressively adapted to new and existing systems.

Table 2.4 – Use Index Comparison

		Electricity		Natural Gas		Gasoline		Diesel	
Year	Building Area (SFT)	Electricity Consumption (kWh)	Energy Use Index (kBtu/SFT)	Natural Gas Consumption (Therms)	Energy Use Index (kBtu/SFT)	Gasoline Consumption (Gallons)	Energy Use Index (kBtu/SFT)	Diesel Consumption (Gallons)	Energy Use Index (kBtu/SFT)
FY '90/'91	2,715,218	30,699,296	38.6	1,016,905	37.5	2,827	0.1	9,320	0.5
FY '18/'19	4,005,519	43,024,229	36.6	1,225,014	30.6		-		-
% Reduction		40%	5%		18%	100%	100%	100%	100%
% Increase	48%			20%					

Table 2.5 – Overall Utility Use Index Comparison

	Year	Energy Usage Index (kBtu/SFT)	% Reduction
Total	FY '90/'91	76.62	12.3%
	FY '18/'19	67.23	

Note: Includes Electricity, Natural Gas, Gasoline, and Diesel (i.e., Scope 1 and Scope 2)

2.5 LONG TERM VISION AND ASPIRATIONAL GOALS

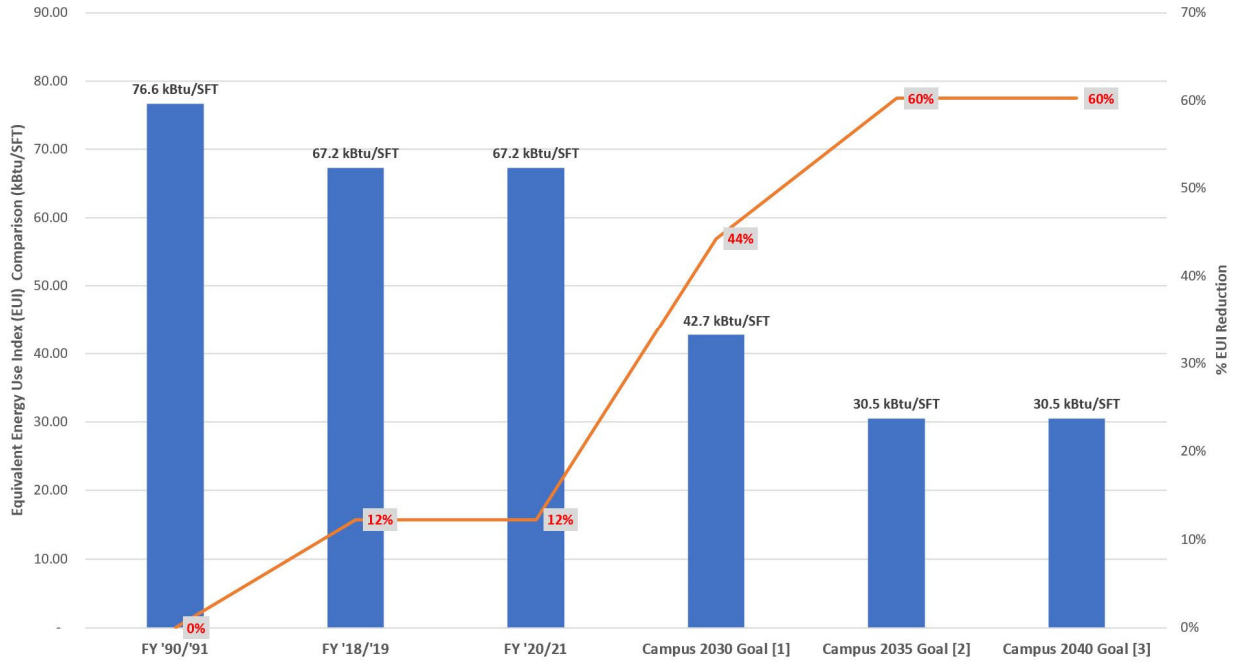
As of FY '18/19, Cal State Sacramento has successfully reduced its GHG emissions to below 1990 levels, an AB 32 goal which was originally set for 2020. This is a result of the campus's continuous efforts and planning; some of the campus accomplishments are presented in the **Section 2.5**.

While this is a great accomplishment, it's only the first step towards bolder emission goals. The State policy states that California is to reduce its Greenhouse Gas (GHG) emissions to 80% below 1990 levels by 2050. Even more challenging is the 2018 Cal State Sacramento's Climate Action Plan which goes beyond the state's goal and accelerates by 10 years – reducing GHG emissions to net zero by 2040.

Future Projections

The following charts below present the comparison of Energy Use Index (EUI) and equivalent GHG emissions (lbs.) between FY '90/91 and FY '18/19. Also shown is the projected index after all energy measures proposed in this SEP are implemented. These measures are discussed in more detail in Section 5 of this SEP. Also shown is projected index if the 2040 goal of Net Zero is met. A high-level summary of what it would take to achieve the Net Zero goal is presented in **Section 5**.

Figure 2.7 – Energy Use Index (EUI) Comparison

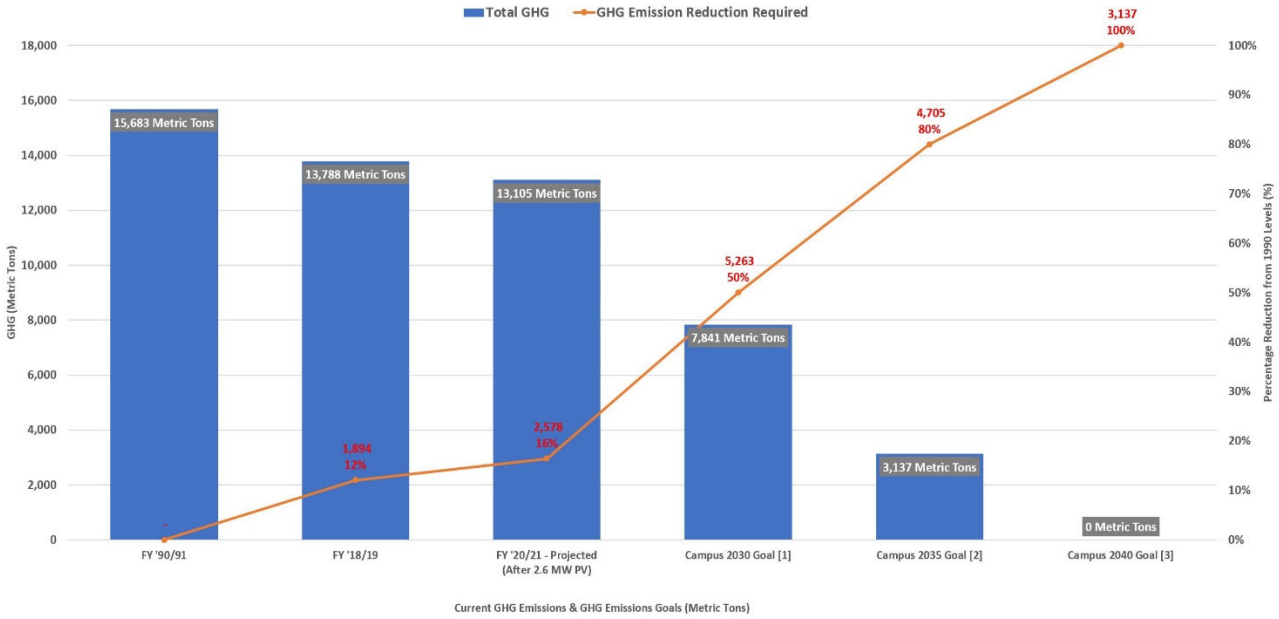


[1] Campus 2030 Goal – 50% Mitigation of 1990 Levels (SB 350) – Energy conservation measures, heating system electrification (39.2 % shift to electric systems: Satellite Plant A, B, & C)

[2] Campus 2035 Goal – 80% Mitigation of 1990 Levels – Heating system electrification (60.8% shift to electric systems: Satellite Plant D, E, and additional plant capacity/complete electrification), photovoltaics or REC (install 7.4 mega-watt photovoltaics or purchase 11.8 million kWh REC)

[3] Campus 2040 Goal – 100% Mitigation of 1990 Levels – Photovoltaics or REC (install 11.4 mega-watt photovoltaics or purchase 18.2 million kWh REC)

Figure 2.8 – Equivalent GHG Emissions Comparison



[1] Campus 2030 Goal – 50% Mitigation of 1990 Levels (SB 350) – Energy conservation measures, heating system electrification (39.2 % shift to electric systems: Satellite Plant A, B, & C)

[2] Campus 2035 Goal – 80% Mitigation of 1990 Levels – Heating system electrification (60.8% shift to electric systems: Satellite Plant D, E, and additional plant capacity/complete electrification), photovoltaics or REC (install 7.4 mega-watt photovoltaics or purchase 11.8 million kWh REC)

[3] Campus 2040 Goal – 100% Mitigation of 1990 Levels – Photovoltaics or REC (install 11.4 mega-watt photovoltaics or purchase 18.2 million kWh REC)

2.6 ACCOMPLISHMENTS

Cal State Sacramento has consistently demonstrated leadership in energy and sustainability. Details of these and other achievements are listed below:

- In 2016, campus signed carbon footprint mitigation commitment with Second Nature (50% GHG emissions below 1990 levels by 2030, 80% GHG emissions below 1900 levels by 2035, and Carbon neutral by 2040).

- The campus uses a central chilled plant with a thermal energy (chilled water) storage tank to offset peak electric loads. Cal State Sacramento installed a 2.61 Mega-watt solar photovoltaic (PV) system atop the Engineering and Technology Building in Summer 2020 that could produces approximately 3.8 million kWh to 4.0 million kWh annually, which translated to approximately 660 to 685 Metric Tons GHG emissions mitigation.

- In last five years, Interior LED lighting has been employed in the Well, Mendocino Hall, and the library. Additionally, the web base integrated lighting control systems were installed at the Mendocino Hall and the Library. These lighting measures resulted in approximately 80% electricity savings at the respective buildings. The lighting project act as a pilot model and campus intends to expand the LEDs with integrated smart controls to campus wide facilities.

- In 2018, a lighting upgrade project was completed to retrofit a major portion of campus exterior lighting. The campus recognizes that there is now opportunity to make it more efficient by use of LED technology. In recent years, the campus has retrofitted approximately 35 exterior light fixtures at Lot 10 and replaced exterior HID fixtures at the Tahoe Hall. These retrofits along with the integrated smart controls (such as two stage motion sensing, i.e. reduce the lighting power to 50% when no occupancy is detected) have resulted in 75% lighting electricity energy savings at the respective sites.

- For all new building construction projects, the campus has incorporated energy efficient features in the Welcome Center and Tschannen Science Complex. These features include daylighting, high efficiency light fixtures, direct digital controls for HVAC systems, and low emission glazed windows.

- Majority of the buildings at campus utilizes Direct Digital Control Building Automation System to track, control, and improve building performance through better detection of events that waste energy or adversely affect occupant comfort. These building efficiency monitoring services provide the basis of a continuous commissioning process

2.7 PAST, PRESENT, AND LONG-TERM CARBON IMPACT

Tables 2.6 below show the combined impact of all the energy efficiency measures (EEMs) analyzed in this Strategic Energy Plan (SEP) as well as building heat electrification, and additional renewable energy. **Figure 2.9** presents a graphical summary of the same.

Table 2.6 assumes that emission rates remain constant (i.e., FY '18/19 equivalent); additionally, it is assumed all of the future building growth will be Zero Net Energy "ZNE". Note: California Public Utilities Commission's (CPUC) in their "Big Bold Energy Efficiency Strategies" (BBEES) states the following: 1) all new residential construction will be Zero Net Energy (ZNE) by 2020, 2) all new commercial construction will be ZNE by 2030, and 3) 50% of the existing commercial buildings will be retrofit to ZNE by 2030. To support these goals, the university has various construction projects (presently in planning stages) that are aiming for ZNE.

As noted in both tables, there is potential to drop the overall site energy use index by **56%** over FY '18/19 levels or **61%** over FY '90/91 levels using aggressive energy conservation measures and fuel source change (building heating electrification). **Section 4** of this SEP details the Energy Efficiency Measures (EEMs) analyzed. Note that emission factors have no impact on the calculated site energy use index.

Without accounting for potential improved SMUD emission rates in future, the overall GHG footprint would reduce by 25% vs. FY '90/91 levels if the campus implements all EEMs. Even after all of the identified EEMs are implemented, the campus still has approximately **9,405** metric tons of GHG emissions that would need to be offset through additional energy conservation measures, switching to low GHG emission fuel (natural gas to electricity for heating), and renewable energy generation should it aspire to become a Zero Net Energy Campus by 2040. **Section 4** of this SEP provides a high-level overview of the measures necessary to achieve this goal.

Note: Clearly, future SMUD emission rates will have a significant impact on the campus' GHG reduction goals. As such, campus shall track updates made to SMUD's Power Integrated Resource Plan and adjust the campus Strategic Energy Plan (SEP) accordingly.

Table 2.6 – Estimated Impact of Recommended Projects (assuming constant SMUD Emission Factors)

				Individual Changes/Improvements							% Change				
Item	FY '90/91	FY '18/19	FY '20/21[4]	Lighting EEMs	Mechanical EEMs	Building Envelope	Plug/Process Load EEMs	Building Heating Electrification	Impact of Future PV (kWh) / PV Offset [5], [6]	Net Final after Conservation and Renewables	FY'18/19 vs. FY'90/91 (As is)	FY'20/21 vs. FY'90/91 (As is)	Net Final Post Measures vs. FY'90/91	Net Final Post Measures vs. FY'18/19	Net Final Post Measures vs. FY'20/21
Campus-wide Electricity Use (kWh), including PV [1]	30,699,296	43,024,229	43,024,229	(9,076,354)	(4,951,965)	(161,968)	(27,291)	5,869,384		34,676,035	40%	40%	13%	-19%	-19%
Solar PV Contribution Electricity (kWh)	0	-710,874	*-4,678,074*						*(29,997,961)*	*(34,676,035)*					
Utility Purchased Electricity (kWh)	30,699,296	42,313,355	*38,346,155*	(9,076,354)	(4,951,965)	(161,968)	(27,291)	5,869,384	(29,997,961)	*0*	38%	25%	-100%	-100%	-100%
Natural Gas use (Therms) - Annual [1]	1,016,905	1,225,014	1,225,014	-	(196,288)	(39,323)	-	(989,404)	-	0	20%	20%	-100%	-100%	-100%
Gasoline (Gallons) [1]	2,827	0	0	-	-		-		-	0	n/a	n/a	n/a	n/a	n/a
Diesel (Gallons) [1]	9,320	0	0	-	-		-		-	0	n/a	n/a	n/a	n/a	n/a
GHG Emission Rate for Electricity (Metric Tons/kWh) [2], [6]	0.00033	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	-49%	-49%	-49%	0%	0%
GHG Emission rate for Natural gas (Metric Tons/Therm) [2], [6]	0.00521	0.00530	0.00530	0.00530	0.00530	0.00530	0.00530	0.00530	0.00530	0.00530	2%	0%	2%	0%	0%
GHG Emission rate for Gasoline (Metric Tons/Gallon) [2], [6]	0.01026	0.01016	0.01016	0.01016	0.01016	0.01016	0.01016	0.01016	0.01016	0.01016	-1%	-1%	-1%	0%	0%
GHG Emission rate for Diesel (Metric Tons/Gallon) [2], [6]	0.00891	0.00859	0.00859	0.00859	0.00859	0.00859	0.00859	0.00859	0.00859	0.00859	-4%	-4%	-4%	0%	0%
GHG Emissions (Metric Tons/Year)	15,683	13,788	13,105	(1,564)	(1,894)	(236)	(5)	(4,234)	(5,171)	(0)	-12%	-16%	-100%	-100%	-100%
GHG Emissions (Lbs./Year)	34,574,166	30,398,135	28,890,599	(3,449,015)	(4,176,136)	(521,185)	(10,371)	(9,334,669)	(11,399,225)	(0)					
Building GSF On Line [1]	2,715,218	4,005,519	4,005,519							4,005,519	48%	48%	48%	0%	0%
Building Site Energy Use Index (kBTU/GSF) [3], [5]	76.6	67.2	67.2	-7.7	-9.1	-1.1	0.0	-19.7	0.0	29.5	-12%	-12%	-61%	-56%	-56%
Building Utility Use Index (kBTU/GSF)	76.6	66.6	63.2	-7.7	-9.1	-1.1	0.0	-19.7	-25.6	0.0	-13%	-17%	-100%	-100%	-100%
Project Cost ($)				$16,790,854	$16,227,026	$948,146	$7,425	$111,941,008	$59,206,501	$205,120,960					
Cost per Metric Ton of GHG Reduction ($/Metric Ton GHG/Year)				$10,733	$8,566	$4,011	$1,578	$26,438	$11,451	$15,653					

Notes

[1] Based on campus records

[2] Emisssion rates are from SIMAP Portal. *See link below:*

https://unhsimap.org/cmap/utility-emission-factors/

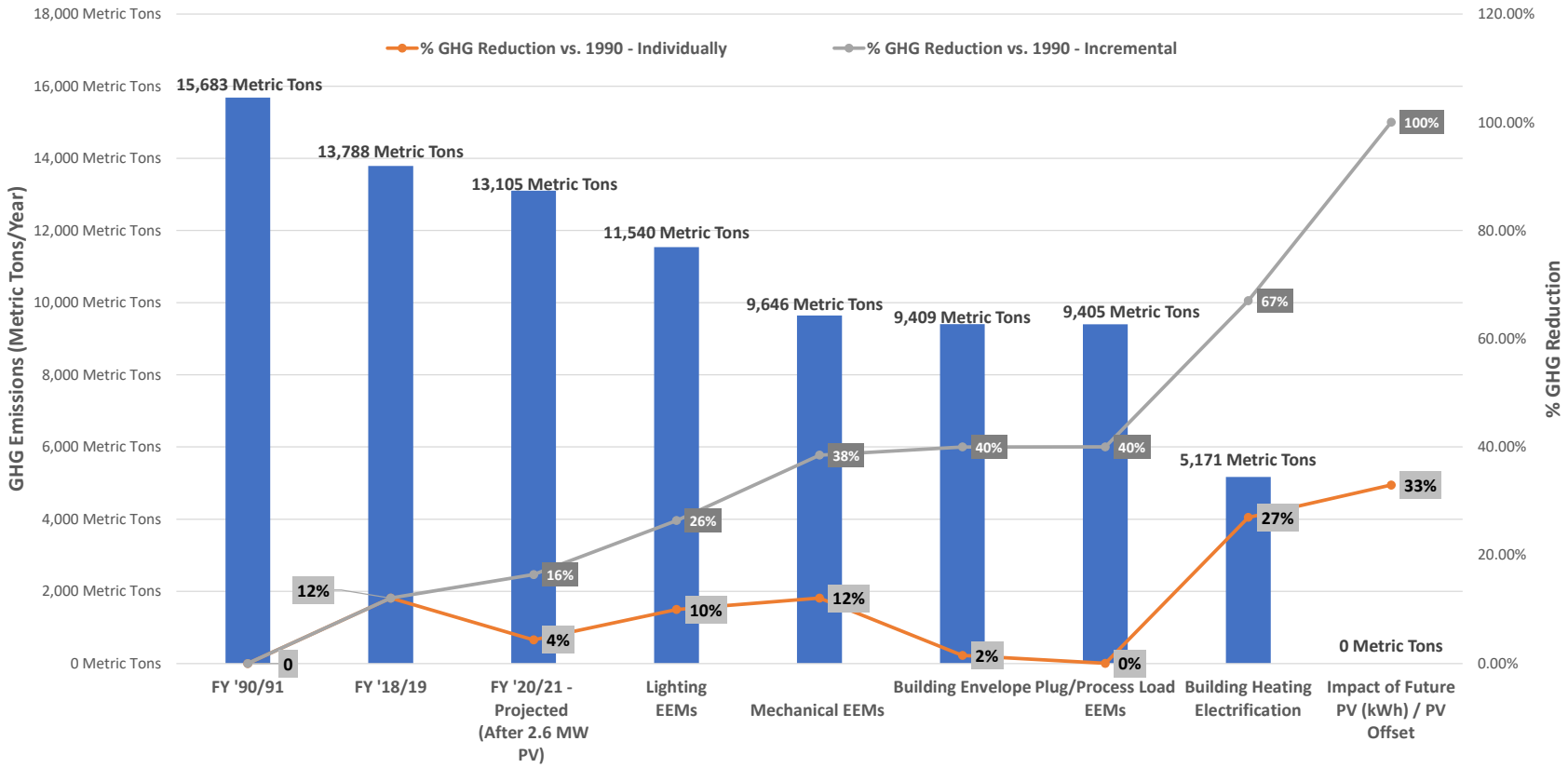
[3] kBtu = 1000 Btu. Accounts for all building consumption including what is generated by renewables (i.e., PV)

[4] Takes into account kWh production from newly installed 2.61 Mega-watt solar project.

[5] Parking structures included in total GSF but with a factor / approximation of 0.007 (e.g., Actual GSF x 0.07 = Equivalent GSF)

[6] Assuming constant emission factors.

Figure 2.9 – Estimated Impact of Strategic Energy Plan (Not Assuming Improved SMUD Emission Factors)



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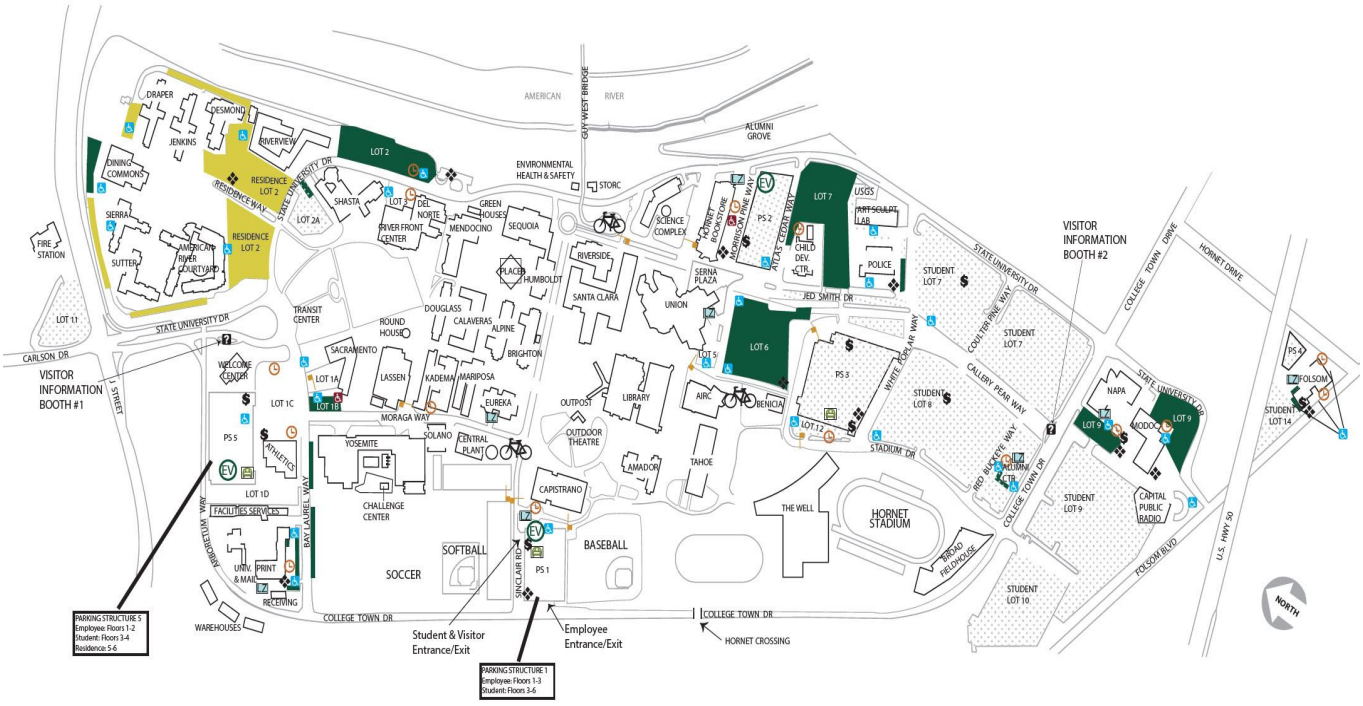
3 EXISTING SYSTEMS

3.1 BUILDINGS

California State University Sacramento (CSUS) is a 305-Acre campus located in middle of Sacramento that houses close to 60 major buildings. In achieving its primary mission of educating nearly students each year (FY '20/21), Cal State Sacramento operates and maintains more than **4.0** million square feet of buildings and land, has approximately 31,451 students enrolled, employs about 3,041 staff, and provides administrative, safety, health, recreational, commercial, food service and many other support functions. **Figure 3.1** below presents a campus map.

Figure 3.1 – Campus Map



Refer to **Table 3.1** of this report complete list of buildings.

3.2 HEATING & COOLING INFRASTRUCTURE

Cooling at California State University Sacramento (CSUS) is primarily provided by a central chilled water plant with a distribution system that serves a majority (**56%** of the building area) of buildings on campus. Chilled water plant details are outlined below:

1. The Central Plant has three 1,250 Ton electric centrifugal chillers intended to provide chilled water to the campus buildings for space cooling. In addition, the plant utilizes a Thermal Energy Storage (TES) tank. Chillers are connected a 2-cell, cooling tower designed to supply condenser water at 85 deg. F. There are two condenser water pumps connected in parallel, each rated at 5,625GPM and 60' head.

2. The plant's cooling hydronic design incorporates the traditional primary/secondary pumping loops. On the primary side, there are three pumps (connected in parallel), each rated at 1,875 GPM and 35 ft. design head. Generally, one primary pump will operate per each chiller that is staged on; the third pump serves as back-up/redundancy. For secondary distribution to the campus buildings, there are three chilled water pumps, each rated at 4,000 GPM and 120 ft. design head.

3. Main Plant equipment is controlled via Direct Digital Controls (DDC).

Infrastructure steam provides thermal energy for heating majority (**58%** of the building area) of the buildings. On the building side, once pressures have been reduced by pressure reducing valves, steam then is passed through.
shell-and-tube heat exchangers to generator heating hot water for use in air handler coils and reheat coils, where applicable. The steam condensate is accumulated and returned to the infrastructure piping system.

All the buildings on the campus are listed in **Table 3.1**. Specifically highlighted on the table are those buildings connected to the central chilled water (CHW) plant and those served by the central plant steam. A campus map view of the same is presented in **Figures 3.2** and **3.3.** Also, noted in the table are the buildings that are audited in this SEP.

Approximately **42%** of the buildings' cooling and heating demands are met by standalone systems (mostly chillers and boilers and few gas-electric package and air source heat pumps) located the building level. These include the Well, University Union, and most of the residence halls.

3.3 ENERGY MANAGEMENT SYSTEM

Various buildings at Cal State Sacramento are connected to the Energy Management System (EMS). The system has a multitude of control types ranging from generic pneumatic systems to high end DDC controllers with remote monitoring and controlling capabilities. Additionally, some buildings like Sequoia Hall, Shasta Hall, Santa Clara Hall, and Douglas Hall have pneumatic-DDC hybrid controls. There are 14 major buildings with part or full pneumatic systems that need to be upgraded. Section 4 of this SEP provides a cost/benefit analysis of upgrading pneumatic controls to DDC.

Table 3.1 – Buildings Connected to Central Chiller Plant and Hot Water Boilers

#	Building	Category	GSF	Served by Central Plant Chiller (YES/NO)	Served by Central Plant Steam (YES/NO)	State	Non-State	Housing	UEI	Union Well Inc.	Parking Structure
1	Academic Information Resource Center	Offices/Classrooms/Computer Labs	97,923	YES	YES	YES	-				
2	Alpine Hall	Lecture Rooms/Faculty Offices	30,550	YES	YES	YES	-				
3	Alumni Center	Offices/Multipurpose Room	10,800	NO	NO	-	YES				
4	Amador Hall	Offices/Classrooms	67,138	YES	YES	YES	-				
5	American River Courtyard	Dormitory	209,050	NO	NO	-	YES	YES			
6	Athletics Center	Offices	27,313	YES	YES	YES	-				
7	Benicia Hall	Lecture Rooms/Offices	7,203	NO	NO	YES	-				
8	Brighton Hall	Lecture Rooms/Faculty Offices	30,000	YES	YES	YES	-				
9	Broad Field House	Gymnasium	26,013	YES	YES	YES	-				
10	Calaveras Hall	Lecture Rooms/Faculty Offices	21,630	YES	YES	YES	-				
11	Capistrano Hall	Lecture Rooms/Offices	84,722	YES	YES	YES	-				
12	Central Plant	Central Plant	13,569	YES	YES	YES	-				
13	Child Development Center	Offices/Classrooms	13,704	NO	NO	-	YES				
14	Del Norte Hall	Lecture Rooms/Offices	54,000	YES	YES	-	YES				
15	Desmond Hall	Dormitory	50,134	NO	NO	-	YES	YES			
16	Dining Commons	Dining/Kitchen	22,747	NO	NO	-	YES		YES		
17	Douglass Hall	Lecture Rooms/Faculty Offices	22,700	YES	YES	YES	-				
18	Draper Hall	Dormitory	38,212	NO	NO	-	YES	YES			
19	Eureka Hall	Lecture Rooms/Faculty Offices	59,488	YES	YES	YES	-				
20	Exterior Lights	Exterior Lightts	9,300,060	NO	NO	-	YES				
21	Facilities Management	Offices/Workshops	38,872	NO	NO	YES	-				
22	Handball Courts	0	2,500	0	0	YES	-				
23	Hornet Bookstore	Bookstore	93,170	YES	NO	-	YES				
24	Jenkins Hall	Dormitory	38,212	NO	NO	-	YES	YES			
25	Kadema Hall	Lecture Rooms/Art Workshops	46,184	YES	YES	YES	-				
26	Lassen Hall	Offices	80,445	YES	YES	YES	-				
27	Library I & II	Library	377,074	YES	YES	YES	-				
28	Mariposa Hall	Lecture Rooms/Faculty Offices	78,079	YES	YES	YES	-				
29	Mendocino Hall	Lecture Rooms/Labs/Faculty Offices	77,000	YES	YES	YES	-				
30	Modoc Hall	Offices/Training Room	85,402	NO	NO	-	YES				

Table 3.1– Buildings Connected to Central Chiller Plant and Hot Water Boilers *(Continued)*

#	Building	Category	GSF	Served by Central Plant Chiller (YES/NO)	Served by Central Plant Steam (YES/NO)	State	Non-State	Housing	UEI	Union Well Inc.	Parking Structure
31	Napa Hall	Offices/Lecture Rooms	33,392	NO	NO	-	YES				
32	Parking Structure (All)	Parking Structure	165,504	NO	NO	-	YES				YES
33	Placer Hall	Lecture Rooms/Labs/Faculty Offices	67,101	YES	YES	YES	-				
34	Public Safety Building	Offices	11,892	NO	NO	-	YES				
35	Riverfront Center	0	40,198	YES	YES	-	YES				
36	Riverside Hall	Lecture Rooms/Offices	83,316	YES	YES	YES	-				
37	Riverview Hall	Dormitory	128,000	YES	YES	-	YES	YES			
38	Sacramento Hall	Offices	38,090	YES	YES	YES	-				
39	Santa Clara Hall	Classroom / Workshop/Computer Lab	66,391	YES	YES	YES	-				
40	Sequoia Hall	Lecture Rooms/Labs/Faculty Offices	201,527	YES	YES	YES	-				
41	Shasta Hall	Offices/Classrooms	62,667	YES	YES	YES	-				
42	Sierra Hall	Dormitory	41,662	NO	NO	-	YES	YES			
43	Solano Hall	Offices/Classrooms/Auditorium	67,710	YES	YES	YES	-				
44	Sutter Hall	Dormitory	40,102	YES	NO	-	YES	YES			
45	Tahoe Hall	Offices/Classrooms	64,764	YES	YES	YES	-				
46	The Well	Gymnasium	150,845	NO	NO	-	YES			YES	
47	University Print & Mail	Offices/Workshops	3,500	NO	NO	YES	-				
48	University Union	University Union	217,000	NO	YES	-	YES			YES	
49	Yosemite Hall	Offices/Classrooms/Basketball Courts/Locker Rooms	82,301	YES	YES	YES	-				

Total Campus Building Area (GSF)		4,005,519
Building Area Audited (GSF)		3,369,796
% Campus Building Area Audited	84%	

Total Campus Building Area Connected to CHW Plant (GSF)		2,229,165
% of GSF - Connected to Central Plant CHW	56%	

Total Campus Audited Building Area Connected to Central Steam Plant (GSF)		2,312,893
% of GSF - Connected to Central Plant Steam	58%	

Figure 3.2 – Buildings Served by Central Chilled Water System

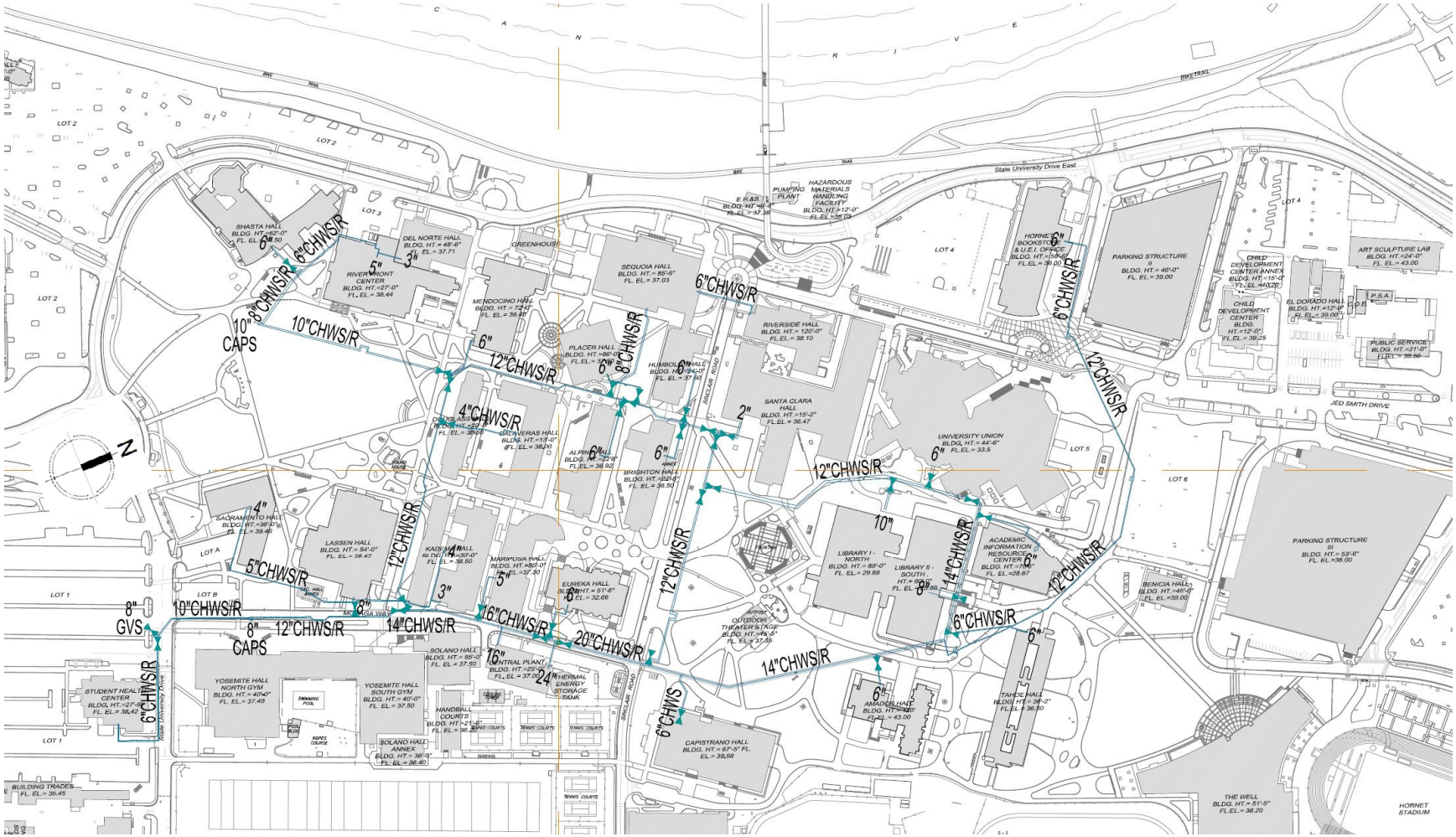
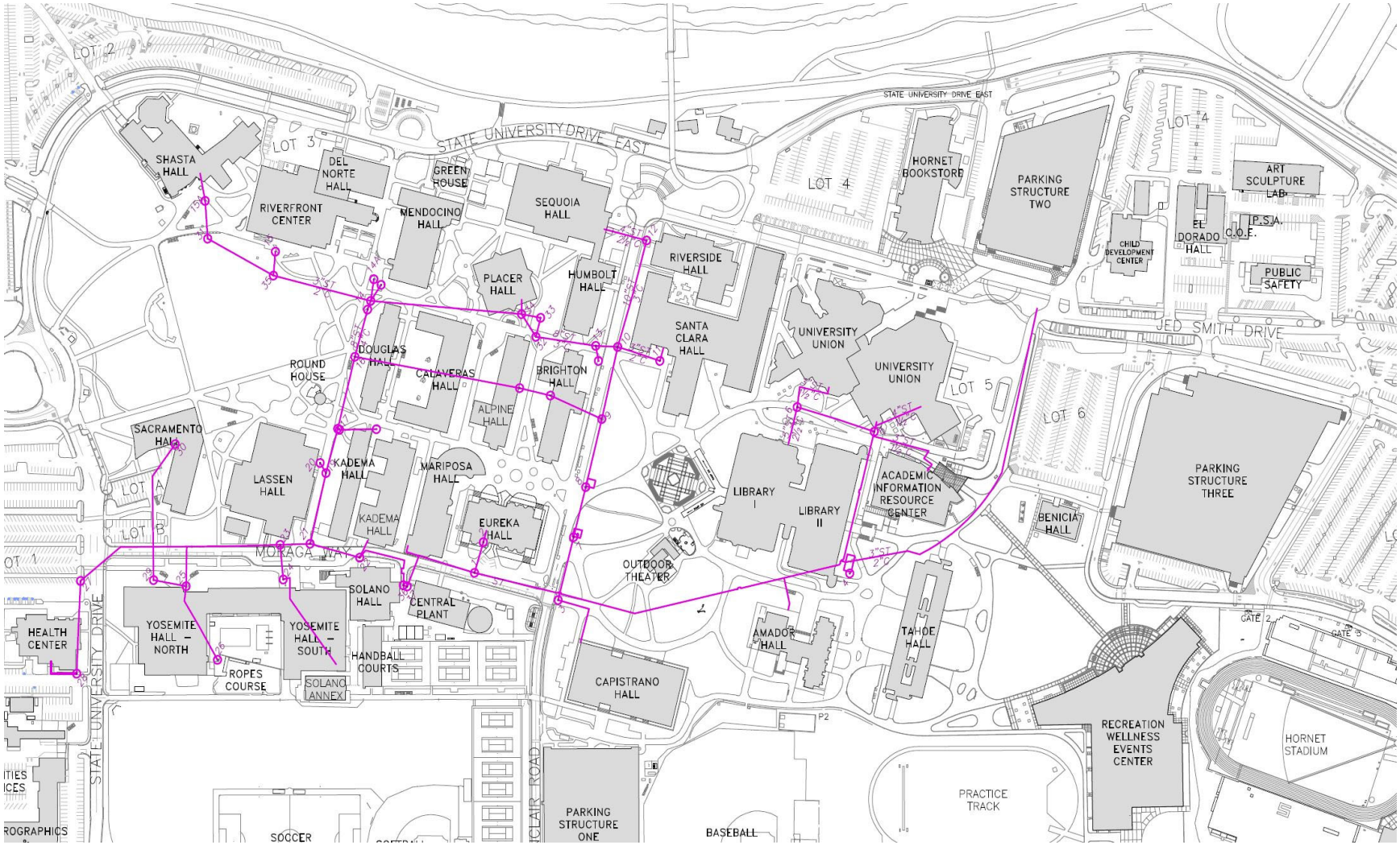


Figure 3.3 – Buildings Served by Central Plant Steam



A high-level summary of existing building conditions (Building Envelope, Lighting and Plug Loads) is presented **Appendix B.**

4 NEAR TERM PLAN / DRIVE TO GREATER EFFICIENCIES AND DECARBONIZATION

4.1 BUILDING ENERGY EFFICIENCY

4.1.1 Building Audit Process

This study identifies Energy Efficiency Measures (EEMs) at selected Cal State Sacramento buildings. EEMs were analyzed based on a preliminary walkthrough/audit of each building served by the campus central plant (i.e., those buildings connected to chilled water and heating hot water loop). Also included were the housing buildings, parking structures, and campus exterior lighting.

The SEP report provides a feasibility analysis of various energy efficiency measures (EEMs) for the majority of main campus buildings. In order to develop a reasonable estimate of the energy conservation potential without doing a room-by-room survey, a methodical but simplified procedure was developed as described below:

- Interior Lighting: For each unique room type within a given building (e.g., classroom, offices, etc.), lighting types, counts, and area square footage was gathered to determine a baseline lighting power index (Watts/SFT). Approximately two samples (i.e., rooms) were collected for each room type in each building. To estimate the installed lighting power (watts) and annual energy use (kWh) for the entire building, the lighting power index calculated from sample room survey was extrapolated using an estimate of total square footage of each room type in the building. Usage hours were estimated based on typical building operational schedules and whether the spaces have existing occupancy sensors installed.

- Plug Loads: For each unique room type (e.g., classroom, offices, etc.), a baseline plug load index (Watts/SFT) was estimated based on observations from the building walkthroughs. Key data gathered were counts on vending machines, use of computers, and other miscellaneous office equipment.

- Process Loads: At each building walkthrough, data for process loads (if any) was gathered. Key data gathered were counts on elevators and other miscellaneous motor loads like those used for pneumatic controls. In the absence of data, an estimated power index of 0.1 Watts/SFT was utilized and extrapolated using the total building area.

- HVAC Systems: Data for HVAC systems was obtained mostly from design and as-built drawings in combination with sample field observations. Key data gathered were system types, number of air handling units, motor horsepower, use of variable frequency drives for variable air volume controls, type of controls (i.e., DDC or pneumatic), use of economizers, use of demand-controlled ventilation (CO_2) controls, and use of occupancy based controls for HVAC.

- Exterior Lighting: A reasonable attempt was made to survey all the campus' exterior lighting fixtures. This was done by a combination of site walkthroughs and available as-built drawings.

- Chiller Plant: Annual chiller plant energy was calculated using the sum of chilled water ton-hours estimated for all buildings served by the plant. It was assumed that the plant operates at average efficiency of **0.7 kW/Ton** (includes chillers, cooling tower, and pumping systems).

With reasonable estimates on load factors, operating efficiencies, and usage hours, the above procedure gave way to establishing a baseline energy use for each building and the plant. **Table 4.1** presents a summary of estimated electricity use balance at each building.

Table 4.1 – Annual Baseline Electricity Use Balance

							Electiricity Load - % of Total		
#	Building Name	State or Non-State	Annual Lighting kWh	Annual HVAC kWh	Annual Plug Loads kWh	Annual Total kWh	Lighting	HVAC	Plug Loads
	0								
1	Academic Information Resource Center	State	265,324	1,543,429	128,351	1,937,105	14%	80%	7%
2	Alpine Hall	State	87,223	142,925	27,118	257,267	34%	56%	11%
3	Alumni Center	Non-State	27,270	71,268	6,441	104,979	26%	68%	6%
4	Amador Hall	State	233,536	257,493	78,078	569,108	41%	45%	14%
5	American River Courtyard	Non-State	1,110,063	1,633,722	146,342	2,890,126	38%	57%	5%
6	Athletics Center	State	98,573	246,529	34,821	379,923	26%	65%	9%
7	Benicia Hall	State	22,932	26,201	11,317	60,449	38%	43%	19%
8	Brighton Hall	State	68,720	183,139	26,779	278,639	25%	66%	10%
9	Broad Field House	State	129,285	203,162	36,938	369,385	35%	55%	10%
10	Calaveras Hall	State	69,785	137,481	12,028	219,294	32%	63%	5%
11	Capistrano Hall	State	302,903	326,710	60,710	690,323	44%	47%	9%
12	Central Plant	State	11,379	40,257	3,513	55,149	21%	73%	6%
13	Child Development Center	Non-State	69,068	138,136	23,023	230,227	30%	60%	10%
14	Del Norte Hall	Non-State	95,462	241,907	29,660	367,029	26%	66%	8%
15	Desmond Hall	Non-State	231,881	958,433	30,278	1,220,592	19%	79%	2%
16	Dining Commons	Non-State	66,642	1,678,189	19,762	1,764,594	4%	95%	1%
17	Douglass Hall	State	55,097	95,046	24,962	175,105	31%	54%	14%
18	Draper Hall	Non-State	162,176	702,200	24,042	888,419	18%	79%	3%
19	Eureka Hall	State	232,353	209,287	52,232	493,871	47%	42%	11%
20	Exterior Lights	Non-State	2,225,000	-		2,225,000	100%	0%	0%
21	Facilities Management	State	65,647	107,186	82,004	254,838	26%	42%	32%
22	Handball Courts	State	115,058	59,830	3,758	178,647	64%	33%	2%
23	Hornet Bookstore	Non-State	265,507	276,588	55,255	597,350	44%	46%	9%
24	Jenkins Hall	Non-State	170,814	509,831	23,825	704,470	24%	72%	3%
25	Kadema Hall	State	181,011	325,420	37,250	543,681	33%	60%	7%
26	Lassen Hall	State	440,460	375,762	111,979	928,200	47%	40%	12%
27	Library I & II	State	1,938,332	869,397	162,905	2,970,634	65%	29%	5%
28	Mariposa Hall	State	265,572	712,486	75,404	1,053,463	25%	68%	7%
29	Mendocino Hall	State	327,561	484,848	77,531	889,939	37%	54%	9%
30	Modoc Hall	Non-State	270,125	1,373,130	50,470	1,693,725	16%	81%	3%
31	Napa Hall	Non-State	159,749	193,583	38,725	392,058	41%	49%	10%
32	Parking Structure (All)	Non-State	1,609,187	-	-	1,609,187	100%	0%	0%
33	Placer Hall	State	192,707	529,091	54,619	776,417	25%	68%	7%
34	Public Safety Building	Non-State	184,957	290,646	52,845	528,448	35%	55%	10%
35	Riverfront Center	Non-State	184,084	104,928	36,971	325,983	56%	32%	11%
36	Riverside Hall	State	291,478	282,911	87,506	661,895	44%	43%	13%
37	Riverview Hall	Non-State	282,805	1,087,716	73,475	1,443,996	20%	75%	5%
38	Sacramento Hall	State	122,037	156,753	54,393	333,184	37%	47%	16%
39	Santa Clara Hall	State	261,726	471,819	163,671	897,216	29%	53%	18%
40	Sequoia Hall	State	658,569	1,418,963	170,777	2,248,310	29%	63%	8%
41	Shasta Hall	State	227,455	373,514	53,083	654,052	35%	57%	8%
42	Sierra Hall	Non-State	185,530	57,237	24,169	266,936	70%	21%	9%
43	Solano Hall	State	300,971	472,954	85,992	859,917	35%	55%	10%
44	Sutter Hall	Non-State	173,254	208,576	25,152	406,982	43%	51%	6%
45	Tahoe Hall	State	209,072	145,263	60,536	414,871	50%	35%	15%
46	The Well	Non-State	586,580	731,903	166,588	1,485,071	39%	49%	11%
47	University Print & Mail	State	37,764	23,602	12,346	73,712	51%	32%	17%
48	University Union	Non-State	911,610	1,002,771	228,132	2,142,513	43%	47%	11%
49	Yosemite Hall	State	304,851	898,906	89,954	1,293,711	24%	69%	7%
Sub-Total:			**16,184,295**	**21,482,225**	**2,845,758**	**40,512,277**	**39.95%**	**53.03%**	**7.02%**
44	Other Electricity Use					2,511,952	0%	0%	0%
Total:			**16,184,295**	**21,482,225**	**2,845,758**	**43,024,229**	**38%**	**50%**	**7%**

Figure 4.2 provides a graphical summary of the electricity usage by end-use.

Figure 4.2 – Campus Baseline Electricity Use Breakdown (By End-Use)

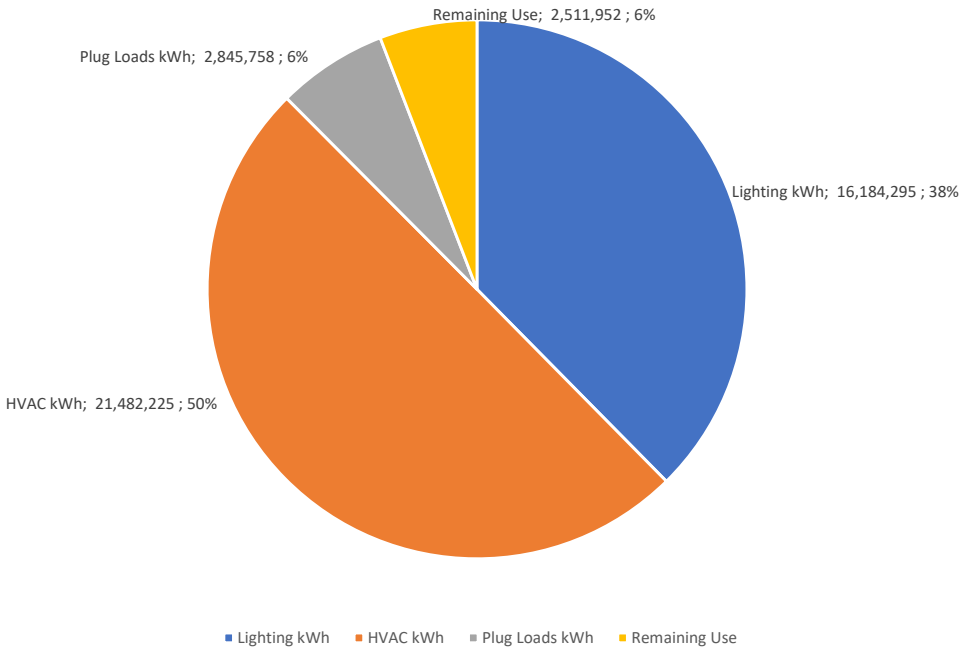
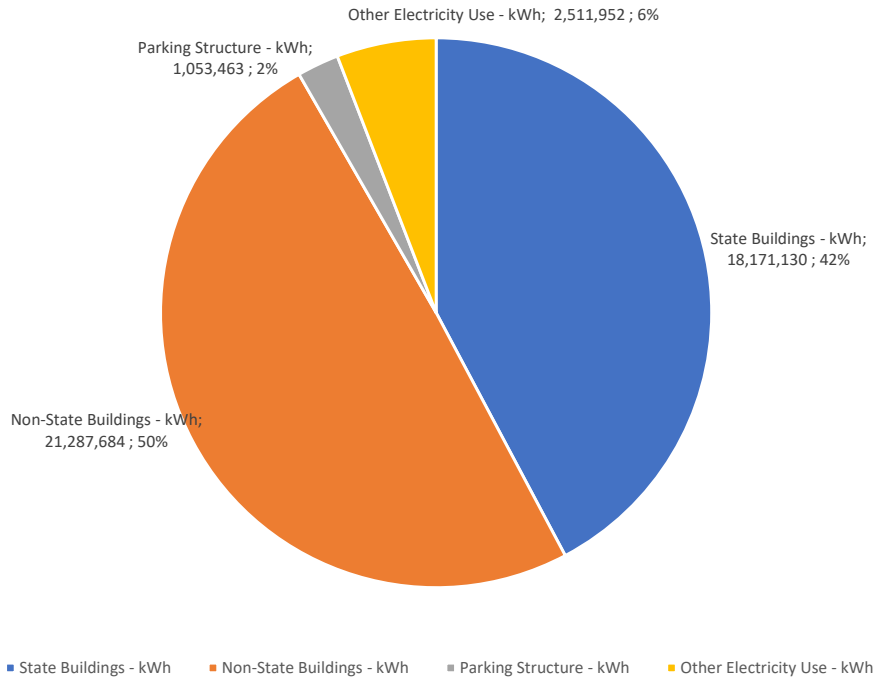


Table 4.2 presents the estimated electricity use balance for the entire campus. Electricity use is categorized by 1) audited state buildings, 2) audited non-state buildings, 3) Parking Structure, 4) Exterior Lighting, and 5) all other remaining use. **Figure 4.3** provides a graphical summary of the same.

Table 4.2 – Campus Baseline Electricity Use Breakdown (Annual)

Category	kWh (Annual)	%
State Buildings - kWh	18,171,130	42%
Non-State Buildings - kWh	21,287,684	49%
Parking Structure - kWh	1,053,463	2%
Other Electricity Use - kWh	2,511,952	6%
Annual Total:	**43,024,229**	**100%**

Figure 4.3 – Campus Baseline Electricity Use Breakdown



4.1.2 Savings Summary

The identified energy efficiency measures (EEMs) have savings potential of over **14.2 million kWh** of electricity and **235,610 Therms** of natural gas. **Table 4.3** shows the savings potential by measure type (i.e., lighting, HVAC, building envelope, plug loads, and process loads). **Appendix D** provides a listing of all EEMs analyzed with a summary of the savings analysis, project costs (rough order of magnitude only), and the buildings where the EEMs are proposed. The section that follows provides additional details on each measure including a break-down of the savings analysis by building. Energy savings calculations have been submitted to the campus in electronic format for future reference.

Table 4.3 – Savings Potential from Identified EEMs

	Electricity (kWh)	Natural Gas (Therms)
Baseline Utility (FY '18/19)	**43,024,229**	**1,225,014**
Potential Savings by Project Type:		
Lighting	9,076,354	-
HVAC	4,951,965	196,288
Building Envelope	161,968	39,323
Plug Loads	27,291	-
Total Savings	14,217,578	235,610
Savings (% of FY '18/19)	**33.0%**	**19.2%**

4.1.3 Energy Cost Savings Assumptions

Energy costs savings for the EEMs presented in this report are estimated based on campus historical energy rates from FY '18/19. For those measures that result in both electricity use (kWh) and electric demand (kW) savings, the historical average rate of **$0.090** per kWh was applied. For those measures that don't save electric demand (e.g., occupancy sensor for lighting control, occupancy-based HVAC controls, etc.), a lower electricity rate of **$0.072** per kWh was applied. This assumes that 25% of total electricity costs are attributed to demand. For natural gas, the historical average rate was **$0.703** per therm was applied.

4.1.4 Low Hanging Fruit

Projects outlined in this SEP vary widely in terms of projects costs, return on investment, and ease of installation. Naturally, there are projects that the campus would find easier and more feasible to implement than others. For purposes of this report, we'll call these projects "low hanging fruit". The list provided below summarizes all "low hanging fruit" projects that should be considered for immediate implementation. It should be noted that these recommendations are based on high-level observations; because of varying conditions building-to-building, project complexities are expected to be different at each building.

Table 4.4A – Projects to be Considered for Immediate Implementation

Project ID	Project Description	Comments
L-1	LED lighting for interior spaces and Integrated Smart Controls	While this project has high implementation costs, it has the potential for large energy savings. Costs could possibly be reduced via LED tube retrofits instead of full fixture conversions; however, compatibility with proposed control system should be investigated. Also, cost could be further reduced by using standalone sensors (occupancy and daylight harvesting) instead of integrated sensors.
M-4	Occupancy Based HVAC Reset	Low-cost measure to replace inefficient to setback when no occupancy is detected. Link existing occupancy sensors (where available) to the EMS system so zone temperatures can be reset.
M-5	Retro-commission HVAC System & Optimize HVAC Controls	Project has potential to generate significant energy savings. With a phased approach and use of existing monitoring tools, costs can be minimized

Table 4.4B – Notable Mentions for "Low Hanging Fruit"

Project ID	Project Description	Comments
L-2	LED EXIT signs	Low-cost measure to replace inefficient compact-fluorescent or incandescent based EXIT sign fixtures.
E-1	Vending misers for vending machines	Simple plug and play devices which can possibly be installed in-house

4.1.5 Description of EEMs

Lighting Project L-1: LED lighting for interior spaces and integrated controls

Complete interior lighting modernization to LED technology. Existing interior lighting is primarily composed of linear fluorescent and compact fluorescent fixtures. This project proposes replacing existing fixtures with LED fixtures embedded with integrated controls. The integrated controls with simplified daylight harvesting, occupancy sensing and task tuning which, when combined with the efficiency of LED technology, slash energy costs up to 75%.

Assumptions:

- Analysis assumes approximately 50% power savings with LED and additional 25% attributed to the embedded controls. A cap on the proposed lighting power density is used depending on the room type (e.g., Classrooms: 0.80 watts/SFT, Offices: 0.7 watts/SFT, Hallways: 0.4 watts/SFT, etc.).

Project costs estimated at $4.4 per square feet for the LED Fixtures, additional $2.8 per square feet for the controls.

Table 4.5A and Table 4.5B below summarizes measure economics by building. A similar table is presented for all measures in this section.

Table 4.5A – Summary of Measure L-1 by Building (State Buildings)

#	Building	Project Cost ($)	Annual Electricity Savings (kWh)	Annual Natural Gas Savings (Therms)	Annual Energy Cost Savings ($)	Annual Maintenance Cost Savings ($)	GHG Reduction (Tons/Year)	Simple Pay Back (Years)
1	Academic Information Resource Center	$493,984	117,170	0	$10,016	$626	20.2	46.4
2	Alpine Hall	$147,541	45,853	0	$3,885	$187	7.9	36.2
3	Amador Hall	$282,765	147,668	0	$12,731	$359	25.5	21.6
4	Athletics Center	$103,105	73,513	0	$6,362	$131	12.7	15.9
5	Benicia Hall	$35,809	10,657	0	$952	$45	1.8	35.9
6	Brighton Hall	$139,136	32,907	0	$2,909	$176	5.7	45.1
7	Calaveras Hall	$96,372	40,888	0	$3,577	$122	7.0	26.0
8	Capistrano Hall	$328,493	206,139	0	$17,665	$416	35.5	18.2
9	Central Plant	$10,535	4,598	0	$382	$16	0.8	26.4
10	Douglass Hall	$63,423	33,659	0	$2,862	$106	5.8	21.4
11	Eureka Hall	$244,720	135,234	0	$12,142	$341	23.3	19.6
12	Facilities Management	$155,566	18,011	0	$1,549	$18	3.1	99.2
13	Kadema Hall	$211,629	116,895	0	$9,917	$268	20.1	20.8
14	Lassen Hall	$431,899	322,603	0	$28,586	$548	55.6	14.8
15	Mariposa Hall	$291,609	160,386	0	$13,903	$407	27.6	20.4
16	Mendocino Hall	$372,907	223,800	0	$18,851	$473	38.6	19.3
17	Placer Hall	$311,769	92,973	0	$8,221	$395	16.0	36.2
18	University Print & Mail	$35,888	30,651	0	$2,698	$46	5.3	13.1
19	Riverside Hall	$397,691	212,932	0	$18,203	$504	36.7	21.3
20	Sacramento Hall	$176,322	86,710	0	$7,454	$224	14.9	23.0
21	Shasta Hall	$286,892	153,744	0	$13,414	$364	26.5	20.8
22	Tahoe Hall	$272,853	105,348	0	$8,861	$346	18.2	29.6
23	Yosemite Hall	$373,027	207,051	0	$17,504	$578	35.7	20.6
24	Library I & II	$1,864,406	1,336,524	0	$116,131	$2,364	230.4	15.7
25	Sequoia Hall	$803,614	491,015	0	$42,137	$1,019	84.6	18.6
26	Public Safety Building	$46,058	17,728	0	$1,533	$58	3.1	30.0
27	Solano Hall	$324,287	219,173	0	$19,320	$411	37.8	16.4
Total:		**$ 8,302,298**	**4,643,831**	**0**	**$ 401,767**	**$ 10,549**	**800.4**	**20.1**

Table 4.5B – Summary of Measure L-1 by Building (Non-State Buildings)

#	Building	Project Cost ($)	Annual Electricity Savings (kWh)	Annual Natural Gas Savings (Therms)	Annual Energy Cost Savings ($)	Annual Maintenance Cost Savings ($)	GHG Reduction (Tons/Year)	Simple Pay Back (Years)
1	Alumni Center	$72,277	16,483	-	$1,434	$92	3	47.4
2	American River Courtyard	$1,083,494	580,451	-	$52,247	$1,374	100	20.2
3	Del Norte Hall	$0	-	-	$0	$0	-	-
4	Desmond Hall	$123,514	121,432	-	$10,930	$258	21	11.0
5	Dining Commons	$48,285	22,459	-	$2,022	$155	4	22.2
6	Draper Hall	$64,925	80,627	-	$7,257	$209	14	8.7
7	Hornet Bookstore	$366,253	120,368	-	$10,811	$464	21	32.5
8	Jenkins Hall	$64,925	85,972	-	$7,738	$209	15	8.2
9	Modoc Hall	$378,406	115,709	-	$10,082	$546	20	35.6
10	Napa Hall	$175,964	103,104	-	$8,919	$223	18	19.2
11	Parking Structure (ALL)	$0	-	-	$0	$0	-	-
12	Riverfront Center	$136,538	127,920	-	$11,242	$286	22	11.8
13	Riverview Hall	$0	-	-	$0	$0	-	-
14	Sierra Hall	$66,206	95,429	-	$8,590	$213	16	7.5
15	Sutter Hall	$66,206	84,838	-	$7,636	$213	15	8.4
16	The Well	$0	-	-	$0	$0	-	-
17	University Union	$565,500	591,675	-	$51,853	$1,820	102	10.5
18	Child Development Center	$77,273	20,669	-	$1,775	$98	4	43.5
19	Exterior Lights							
Total:		**$3,289,766**	**$ 2,167,137**	**$ -**	**$192,535**	**$6,160**	**374**	**16.6**

Lighting Project L-2: LED EXIT Signs

Various building on-campus make use of older incandescent or compact-fluorescent type EXIT signs. These can be easily replaced with new LED-based EXIT signs for a reduction in electricity use.

Assumptions:

- A typical incandescent EXIT sign uses 70 watts; a compact fluorescent EXIT sign uses 30 watts; and a LED EXIT sign uses 5 watts. All EXIT signs are assumed to operate 8760 hours annually.
- Project costs estimated as $250 per unit.

Table 4.6 – Summary of Measure L-2 by Building (State Buildings) *

#	Building	Project Cost ($)	Annual Elecrticity Savings (kWh)	Annual Natural Gas Savings (Therms)	Annual Energy Cost Savings ($)	GHG Reduction (Tons/Year)	Simple Pay Back (Years)
1	Academic Information Resource Center	$0	-	-	$ -	-	-
2	Alpine Hall	$0	-	-	$ -	-	-
3	Amador Hall	$0	-	-	$ -	-	-
4	Athletics Center	$0	-	-	$ -	-	-
5	Benicia Hall	$0	-	-	$ -	-	-
6	Brighton Hall	$0	-	-	$ -	-	-
7	Calaveras Hall	$0	-	-	$ -	-	-
8	Capistrano Hall	$0	-	-	$ -	-	-
9	Central Plant	$0	-	-	$ -	-	-
10	Douglass Hall	$0	-	-	$ -	-	-
11	Eureka Hall	$0	-	-	$ -	-	-
12	Facilities Management	$0	-	-	$ -	-	-
13	Kadema Hall	$1,500	1,314	-	$ 363	0	4.1
14	Lassen Hall	$0	-	-	$ -	-	-
15	Mariposa Hall	$0	-	-	$ -	-	-
16	Mendocino Hall	$0	-	-	$ -	-	-
17	Placer Hall	$0	-	-	$ -	-	-
18	University Print & Mail	$0	-	-	$ -	-	-
19	Riverside Hall	$2,750	2,409	-	$ 678	0	4.1
20	Sacramento Hall	$0	-	-	$ -	-	-
21	Shasta Hall	$0	-	-	$ -	-	-
22	Tahoe Hall	$0	-	-	$ -	-	-
23	Yosemite Hall	$0	-	-	$ -	-	-
24	Library I & II	$0	-	-	$ -	-	-
25	Sequoia Hall	$5,500	4,818	-	$ 1,366	1	4.0
26	Public Safety Building	$0	-	-	$ -	-	-
27	Solano Hall	$0	-	-	$ -	-	-
Total:		**$9,750**	**8,541**	**-**	**$ 2,406**	**1**	**4.1**

*None for the Non-State Buildings

Lighting Project L-3: LED lighting & bi-level controls for exterior

Various exterior areas throughout the campus are lighted by combination of HID fixtures, i.e., high pressure sodium (HPS) and metal halide (MH), compact fluorescent (CF), and halogen/incandescent lamps fixtures. These are located at building perimeters, walkways, parking structures, parking lots, and roadways. This project proposes replacement of all exterior fixtures (not already LED) with new LED-based fixtures. For enhanced energy savings and to meet Title 24's mandated controls compliance, this project also proposes multi-level lighting controls. The multilevel lighting control system generally consists of "smart sensors" at each fixture. Each luminaire with embedded control technology is designed with an intelligent microprocessor directly integrated into the LED fixture's driver. This design eliminates the need for additional interfaces, enabling the fixture and controls to communicate directly with each other for seamless interoperability. The control system offers occupancy sensing, daylight harvesting, light level scheduling, and demand response controls.

Assumptions:

- Analysis assumes 40% power reduction with conversion to LED. An additional 50% power reduction is assumed when space is unoccupied. It is estimated that 30% of baseline operational hours have actual occupancy; remaining 70% of the time the space can benefit from the 50% power reduction.
- Project costs estimated as $21 per installed LED watt.

Table 4.7 – Summary of Measure L-3

#	Building	Project Cost ($)	Annual Elecrticity Savings (kWh)	Annual Natural Gas Savings (Therms)	Annual Energy Cost Savings ($)	GHG Reduction (Tons/Year)	Simple Pay Back (Years)
1	Alumni Center	$0	-	-	$0	-	-
2	American River Courtyard	$0	-	-	$0	-	-
3	Del Norte Hall	$0	-	-	$0	-	-
4	Desmond Hall	$0	-	-	$0	-	-
5	Dining Commons	$15,372	2,988	-	$371	1	41.5
6	Draper Hall	$0	-	-	$0	-	-
7	Hornet Bookstore	$0	-	-	$0	-	-
8	Jenkins Hall	$0	-	-	$0	-	-
9	Modoc Hall	$0	-	-	$0	-	-
10	Napa Hall	$0	-	-	$0	-	-
11	Parking Structure (ALL)	$2,164,993	893,659	-	$64,385	154	33.6
12	Riverfront Center	$0	-	-	$0	-	-
13	Riverview Hall	$0	-	-	$0	-	-
14	Sierra Hall	$0	-	-	$0	-	-
15	Sutter Hall	$0	-	-	$0	-	-
16	The Well	$0	-	-	$0	-	-
17	University Union	$15,170	2,949	-	$2,032	1	7.5
18	Child Development Center	$0	-	-	$0	-	-
19	Exterior Lights	$2,993,505	1,357,250	-	$113,756	234	26.3
Total:		**$5,189,040**	**2,256,846**	**-**	**$180,543**	**389**	**28.7**

Energy Project E-1: Vending misers for vending machines

Install vending machine controllers at all campus vending machines to monitor occupancy and space temperature conditions in the vicinity and to power down the vending machines during periods when the surrounding areas are vacated. The controllers also re-power the cooling system at periodic intervals to ensure that the beverages remain cold.

Assumptions:

- A typical vending machine uses an average of 1582 kWh annually. With a vending miser, the same vending machine will use around 755 kWh annually. This is estimated based on various published studies.
- Campus has approximately 33 vending machines in operation, without vending miser controls.
- Project costs estimated as $225 per unit.

Table 4.8A – Summary of Measure E-1 by Building (State-Buildings)

#	Building	Project Cost ($)	Annual Elecrticity Savings (kWh)	Annual Natural Gas Savings (Therms)	Annual Energy Cost Savings ($)	GHG Reduction (Tons/Year)	Simple Pay Back (Years)
1	Academic Information Resource Center	$1,350	4,962	-	$984	0.9	1.4
2	Alpine Hall	$0	-	-	$0	-	-
3	Amador Hall	$0	-	-	$0	-	-
4	Athletics Center	$0	-	-	$0	-	-
5	Benicia Hall	$450	1,654	-	$165	0.3	2.7
6	Brighton Hall	$0	-	-	$0	-	-
7	Calaveras Hall	$0	-	-	$0	-	-
8	Capistrano Hall	$0	-	-	$0	-	-
9	Central Plant	$0	-	-	$0	-	-
10	Douglass Hall	$0	-	-	$0	-	-
11	Eureka Hall	$0	-	-	$0	-	-
12	Facilities Management	$0	-	-	$0	-	-
13	Kadema Hall	$0	-	-	$0	-	-
14	Lassen Hall	$450	1,654	-	$667	0.3	0.7
15	Mariposa Hall	$675	2,481	-	$585	0.4	1.2
16	Mendocino Hall	$225	827	-	$532	0.1	0.4
17	Placer Hall	$0	-	-	$0	-	-
18	University Print & Mail	$0	-	-	$0	-	-
19	Riverside Hall	$450	1,654	-	$623	0.3	0.7
20	Sacramento Hall	$0	-	-	$0	-	-
21	Shasta Hall	$0	-	-	$0	-	-
22	Tahoe Hall	$225	827	-	$405	0.1	0.6
23	Yosemite Hall	$675	2,481	-	$757	0.4	0.9
24	Library I & II	$0	-	-	$0	-	-
25	Sequoia Hall	$1,125	4,135	-	$1,317	0.7	0.9
26	Public Safety Building	$0	-	-	$0	-	-
27	Solano Hall	$0	-	-	$0	-	-
28	Broad Field House	$0	-	-	$0	-	-
Total:		**$5,625**	**20,675**	**-**	**$6,035**	**3.6**	**0.9**

Table 4.8B – Summary of Measure E-1 by Building (Non-State-Buildings)

#	Building	Project Cost ($)	Annual Elecrticity Savings (kWh)	Annual Natural Gas Savings (Therms)	Annual Energy Cost Savings ($)	GHG Reduction (Tons/Year)	Simple Pay Back (Years)
1	Alumni Center	$0	-	-	$0	-	-
2	American River Courtyard	$0	-	-	$0	-	-
3	Del Norte Hall	$0	-	-	$0	-	-
4	Desmond Hall	$0	-	-	$0	-	-
5	Dining Commons	$0	-	-	$0	-	-
6	Draper Hall	$0	-	-	$0	-	-
7	Hornet Bookstore	$0	-	-	$0	-	-
8	Jenkins Hall	$0	-	-	$0	-	-
9	Modoc Hall	$0	-	-	$0	-	-
10	Napa Hall	$450	1,654	-	$342	0	1.3
11	Parking Structure (ALL)	$0	-	-	$0	-	-
12	Riverfront Center	$0	-	-	$0	-	-
13	Riverview Hall	$0	-	-	$0	-	-
14	Sierra Hall	$0	-	-	$0	-	-
15	Sutter Hall	$0	-	-	$0	-	-
16	The Well	$450	1,654	-	$1,156	0	0.4
17	University Union	$900	3,308	-	$2,058	1	0.4
18	Child Development Center	$0	-	-	$0	-	-
19	Exterior Lights	$0	-	-	$0	-	-
Total:		**$1,800**	**6,616**	**-**	**$3,557**	**1**	**0.5**

Energy Project Env-1: High efficiency windows

Replace existing single-pane windows with double-pane windows at south-facing and west-facing conditioned rooms throughout campus facilities. Windows in buildings are typically responsible for large part of the heat loss during winter and heat gain in the summer. Heat is transferred by direct conduction through the glass and through the frame around the window assembly. Although not fully eliminated, this heat loss can be reduced by various means including converting from single to multiple panes, specialty selective films or coatings, and high-tech framing.

Assumptions:

- All existing single-pane windows facing south and west are proposed to be replaced with double-pane windows.
- Total window area (sq.ft.) determined from observations of % window area, as shown in **Appendix B.**
- Project costs estimated as $35 per square foot of glazing.
- Energy savings estimated based on eQuest computer modeling of sample buildings. Model was used to determine % savings as a function of window area. Energy savings varies from 5% to 10% (i.e., fan, cooling, and heating energy) for window areas in the range of 5% to 30% (i.e., percent of wall area), respectively.
- CHW water plant efficiency of 0.70 kW/Ton & HHW plant efficiency of 75%.

Table 4.9A – Summary of Measure Env-1 by Building (State Buildings)

#	Building	Project Cost ($)	Annual Elecrticity Savings (kWh)	Annual Natural Gas Savings (Therms)	Annual Energy Cost Savings ($)	GHG Reduction (Tons/Year)	Simple Pay Back (Years)
1	Academic Information Resource Center	$0	-	-	$0	-	-
2	Alpine Hall	$101,380	(898)	670	$594	3	170.8
3	Amador Hall	$0	-	-	$0	-	-
4	Athletics Center	$0	-	-	$0	-	-
5	Benicia Hall	$0	-	-	$0	-	-
6	Brighton Hall	$98,450	(650)	632	$574	3	171.5
7	Calaveras Hall	$46,350	4,277	567	$829	4	55.9
8	Capistrano Hall	$128,359	19,155	1,933	$3,155	14	40.7
9	Central Plant	$0	-	-	$0	-	-
10	Douglass Hall	$76,368	3,346	493	$693	3	110.1
11	Eureka Hall	$0	-	-	$0	-	-
12	Facilities Management	$0	-	-	$0	-	-
13	Kadema Hall	$0	-	-	$0	-	-
14	Lassen Hall	$169,952	16,248	2,401	$3,405	16	49.9
15	Mariposa Hall	$0	-	-	$0	-	-
16	Mendocino Hall	$0	-	-	$0	-	-
17	Placer Hall	$0	-	-	$0	-	-
18	University Print & Mail	$0	-	-	$0	-	-
19	Riverside Hall	$0	-	-	$0	-	-
20	Sacramento Hall	$66,497	4,031	870	$1,125	5	59.1
21	Shasta Hall	$0	-	-	$0	-	-
22	Tahoe Hall	$0	-	-	$0	-	-
23	Yosemite Hall	$0	-	-	$0	-	-
24	Library I & II	$0	-	-	$0	-	-
25	Sequoia Hall	$0	-	-	$0	-	-
26	Public Safety Building	$28,000	4,355	5,571	$4,355	30	6.4
27	Solano Hall	$0	-	-	$0	-	-
28	Broad Field House	$0	-	-	$0	-	-
Total:		**$715,357**	**49,864**	**13,137**	**$14,730**	**78**	**48.6**

Table 4.9B – Summary of Measure Env-1 by Building (Non-State Buildings)

#	Building	Project Cost ($)	Annual Elecrticity Savings (kWh)	Annual Natural Gas Savings (Therms)	Annual Energy Cost Savings ($)	GHG Reduction (Tons/Year)	Simple Pay Back (Years)
1	Alumni Center	$0	-	-	$0	-	-
2	American River Courtyard	$0	-	-	$0	-	-
3	Del Norte Hall	$0	-	-	$0	-	-
4	Desmond Hall	$0	-	-	$0	-	-
5	Dining Commons	$0	-	-	$0	-	-
6	Draper Hall	$52,492	45,004	394	$3,726	10	14.1
7	Hornet Bookstore	$0	-	-	$0	-	-
8	Jenkins Hall	$52,492	36,491	(181)	$2,709	5	19.4
9	Modoc Hall	$0	-	-	$0	-	-
10	Napa Hall	$0	-	-	$0	-	-
11	Parking Structure (ALL)	$0	-	-	$0	-	-
12	Riverfront Center	$0	-	-	$0	-	-
13	Riverview Hall	$0	-	-	$0	-	-
14	Sierra Hall	$53,008	6,831	4,810	$4,086	27	13.0
15	Sutter Hall	$53,008	3,576	21,163	$15,347	113	3.5
16	The Well	$0	-	-	$0	-	-
17	University Union	$0	-	-	$0	-	-
18	Child Development Center	$21,789	20,201	-	$1,818	3	12.0
19	Exterior Lights						
Total:		**$232,789**	**112,104**	**26,185**	**$27,687**	**158**	**8.4**

HVAC Project M-1: New VAV AHUs w/ economizers

Many buildings on campus have original HVAC equipment (+50 years) that are reaching or have passed the end of their useful life (i.e., 15-30 years). Specifically, this includes existing constant volume air handlers (i.e., multi-zone units and dual-duct systems) without existing Variable Frequency Drives (VFDs) to control fans or air-side economizers to control outside air. This project proposes replacement of existing air handlers with new air handlers of the same capacity, VFDs to modulate fan speed, air-side economizers for free cooling, high delta-T water coils to improve central plant efficiency, and integrated evaporator cooler. Also, in buildings with constant volume air distribution, zones shall be converted to Variable Air Volume (VAV).

Assumptions:

- All existing constant volume AHUs without existing variable frequency drives (VFDs) to control fans or air-side economizers to control outside air are proposed for replacement.
- **Appendix B** provides a listing of AHU counts by building, total fan horsepower, and whether the systems have existing VFDs and economizers.
- Project costs estimated as $70 per AHU CFM.
- Energy savings primarily attributed to a fan energy reduction via the VFD and conversion from constant volume to variable volume. Assumption is that the fan motor load factor reduces from a base of 0.8 to 0.55. A/C load factor reduces from a base of 0.180 to 0.155. Heating load factor reduces from a base of 0.050 to 0.042.
- With addition of an economizer and integrated evaporator cooler, the A/C load factor reduces from 0.155 to 0.140.
- CHW water plant efficiency of 0.70 kW/Ton & HHW plant efficiency of 75%.

Table 4.10 – Summary of Measure M-1 by Building (State Buildings) *

#	Building	Project Cost ($)	Annual Elecrticity Savings (kWh)	Annual Natural Gas Savings (Therms)	Annual Energy Cost Savings ($)	GHG Reduction (Tons/Year)	Simple Pay Back (Years)
1	Academic Information Resource Center	$0	-	-	$0	-	-
2	Alpine Hall	$1,438,920	61,097	1,633	$6,834	19	210.5
3	Amador Hall	$0	-	-	$0	-	-
4	Athletics Center	$1,005,550	94,583	2,859	$10,654	31	94.4
5	Benicia Hall	$0	-	-	$0	-	-
6	Brighton Hall	$0	-	-	$0	-	-
7	Calaveras Hall	$0	-	-	$0	-	-
8	Capistrano Hall	$0	-	-	$0	-	-
9	Central Plant	$0	-	-	$0	-	-
10	Douglass Hall	$816,480	35,024	1,395	$4,239	13	192.6
11	Eureka Hall	$0	-	-	$0	-	-
12	Facilities Management	$0	-	-	$0	-	-
13	Kadema Hall	$2,063,950	103,618	2,342	$11,241	30	183.6
14	Lassen Hall	$0	-	-	$0	-	-
15	Mariposa Hall	$0	-	-	$0	-	-
16	Mendocino Hall	$0	-	-	$0	-	-
17	Placer Hall	$0	-	-	$0	-	-
18	University Print & Mail	$0	-	-	$0	-	-
19	Riverside Hall	$0	-	-	$0	-	-
20	Sacramento Hall	$0	-	-	$0	-	-
21	Shasta Hall	$0	-	-	$0	-	-
22	Tahoe Hall	$0	-	-	$0	-	-
23	Yosemite Hall	$0	-	-	$0	-	-
24	Library I & II	$0	-	-	$0	-	-
25	Sequoia Hall	$0	-	-	$0	-	-
26	Public Safety Building	$0	-	-	$0	-	-
27	Solano Hall	$0	-	-	$0	-	-
Total:		**$5,324,900**	**294,322**	**8,229**	**$32,969**	**94**	**161.5**

* As part of a building modernization projects, the campus has already upgraded airside system at majority of the buildings. The upgrade included conversion from constant-volume dual-duct boxes to dual-damper VAV boxes. The above recommended project targets the existing building with constant volume dual-duct boxes. None for the Non-State buildings.

HVAC Project M-2: Pneumatic to DDC controls

Although most of the campus buildings utilize a Energy Management System (EMS) system with Direct Digital Control (DDC) controls, some building systems still depend on the combination of pneumatic and pneumatic-hybrid DDC HVAC controls. This project proposes replacement existing pneumatic controls with state-of-the-art DDC controls. DDC systems allow a maintenance technician to remotely monitor room temperature conditions, maintain and change setpoints, schedule equipment On/Off periods, track energy use, and detect potential problems before the space users generate a complaint. In addition to cooling and heating energy savings, there would be added savings from elimination of compressed air systems and reduced maintenance.

Assumptions:

- All existing control systems without existing DDC controls are proposed for conversion.
- **Appendix B** provides a listing of AHU counts by building, total fan horsepower, and whether the systems have existing DDC controls.
- Project costs estimated as $7.00 per square feet for hybrid pneumatic-DDC to DDC conversion and $10.00 per square feet for full DDC conversion.
- Assumption is that the fan motor load factor reduces from a base of 0.55 (post Measure M-1) to 0.45. The A/C load factor reduces from a base of 0.140 (post Measure M-1) to 0.125. Heating load factor reduces from a base of 0.042 to 0.036.
- CHW water plant efficiency of 0.70 kW/Ton & HHW plant efficiency of 75%.

Table 4.11 – Summary of Measure M-2 by Building (State Buildings) *

#	Building	Project Cost ($)	Annual Elecrticity Savings (kWh)	Annual Natural Gas Savings (Therms)	Annual Energy Cost Savings ($)	GHG Reduction (Tons/Year)	Simple Pay Back (Years)
1	Academic Information Resource Center	$0	-	-	$0	-	-
2	Alpine Hall	$143,892	21,987	1,056	$2,513	9	57.3
3	Amador Hall	$275,772	75,236	2,025	$7,199	24	38.3
4	Athletics Center	$100,555	25,549	738	$2,489	8	40.4
5	Benicia Hall	$0	-	-	$0	-	-
6	Brighton Hall	$135,695	27,447	996	$2,853	10	47.6
7	Calaveras Hall	$93,989	20,952	690	$2,116	7	44.4
8	Capistrano Hall	$0	-	-	$0	-	-
9	Central Plant	$0	-	-	$0	-	-
10	Douglass Hall	$81,648	13,518	599	$1,501	6	54.4
11	Eureka Hall	$0	-	-	$0	-	-
12	Facilities Management	$0	-	-	$0	-	-
13	Kadema Hall	$206,395	46,794	1,515	$4,703	16	43.9
14	Lassen Hall	$421,218	78,954	3,092	$8,407	30	50.1
15	Mariposa Hall	$0	-	-	$0	-	-
16	Mendocino Hall	$0	-	-	$0	-	-
17	Placer Hall	$0	-	-	$0	-	-
18	University Print & Mail	$0	-	-	$0	-	-
19	Riverside Hall	$387,856	118,368	1,496	$10,079	28	38.5
20	Sacramento Hall	$171,962	33,016	1,262	$3,488	12	49.3
21	Shasta Hall	$279,797	60,746	2,054	$6,182	21	45.3
22	Tahoe Hall	$0	-	-	$0	-	-
23	Yosemite Hall	$0	-	-	$0	-	-
24	Library I & II	$1,818,299	494,655	10,012	$45,021	138	40.4
25	Sequoia Hall	$783,741	175,826	5,754	$17,725	61	44.2
26	Public Safety Building	$22,460	53,222	6,128	$9,099	42	2.5
27	Solano Hall	$0	-	-	$0	-	-
28	Broad Field House	$0	-	-	$0	-	-
Total:		**$4,923,279**	**1,246,271**	**37,420**	**$123,375**	**413**	**39.9**

*None for the Non-State Buildings

HVAC Project M-3: Demand Controlled Ventilation (DCV)

Install CO2 sensors at all zones with variable occupancy for Demand Controlled Ventilation (DCV) HVAC controls. Building ventilation rates are typically designed for 15 CFM per person, so as to maintain indoor CO2 concentrations below 1000 PPM (or 700 PPM above the ambient level of 300-400 PPM). Fan systems are typically designed to provide a ventilation rate large enough that can handle the peak occupancy conditions of a given space. Since no space is ever loaded to 100% capacity at all times, there is the opportunity to modulate the outside air dampers during partial occupancy periods while continually meeting the design intent of having a CO2 level under 1000 PPM. Reducing the fresh airflow at lower occupancy conditions enables a reduction in heating energy and cooling energy. Under this measure, the CO2 sensor would signal the need for more or less fresh outside air and the controls would operate so that the OSA damper adjusts to maintain a CO2 level below 1000 PPM.

Assumptions:

- All existing control systems without existing DCV controls are proposed for conversion.
- **Appendix B** provides a listing of AHU counts by building, total fan horsepower, and whether the systems have existing DCV controls.
- Project costs estimated as $2.00 per square feet.
- Assumption is that the A/C load factor reduces from a base of 0.125 (post Measures M-1 & M-2) to 0.120. Heating load factor reduces from a base of 0.036 (post Measures M-1 & M-2) to 0.033.
- CHW water plant efficiency of 0.70 kW/Ton & HHW plant efficiency of 75%.

Table 4.12 – Summary of Measure M-3 by Building (State-Buildings) *

#	Building	Project Cost ($)	Annual Elecrticity Savings (kWh)	Annual Natural Gas Savings (Therms)	Annual Energy Cost Savings ($)	GHG Reduction (Tons/Year)	Simple Pay Back (Years)
1	Academic Information Resource Center	$0	-	-	$0	-	-
2	Alpine Hall	$41,112	10,504	1,056	$1,686	7	24.4
3	Amador Hall	$0	-	-	$0	-	-
4	Athletics Center	$28,730	7,341	738	$1,178	5	24.4
5	Benicia Hall	$0	-	-	$0	-	-
6	Brighton Hall	$38,770	-	996	$877	5	44.2
7	Calaveras Hall	$26,854	6,861	690	$1,101	5	24.4
8	Capistrano Hall	$0	-	-	$0	-	-
9	Central Plant	$0	-	-	$0	-	-
10	Douglass Hall	$23,328	5,960	599	$957	4	24.4
11	Eureka Hall	$0	-	-	$0	-	-
12	Facilities Management	$0	-	-	$0	-	-
13	Kadema Hall	$0	-	-	$0	-	-
14	Lassen Hall	$0	-	-	$0	-	-
15	Mariposa Hall	$0	-	-	$0	-	-
16	Mendocino Hall	$0	-	-	$0	-	-
17	Placer Hall	$0	-	-	$0	-	-
18	University Print & Mail	$0	-	-	$0	-	-
19	Riverside Hall	$0	-	-	$0	-	-
20	Sacramento Hall	$0	-	-	$0	-	-
21	Shasta Hall	$79,942	20,425	2,054	$3,279	14	24.4
22	Tahoe Hall	$0	-	-	$0	-	-
23	Yosemite Hall	$0	-	-	$0	-	-
24	Library I & II	$0	-	-	$0	-	-
25	Sequoia Hall	$223,926	57,213	13,077	$14,331	79	15.6
26	Public Safety Building	$0	-	-	$0	-	-
27	Solano Hall	$0	-	-	$0	-	-
28	Broad Field House	$0	-	-	$0	-	-
Total:		**$462,662**	**108,304**	**19,212**	**$23,409**	**120**	**19.8**

*None for the Non-State Buildings

HVAC Project M-4: Occupancy Based HVAC Control

Link existing occupancy sensors to the EMS system so zone temperatures can be reset when no occupancy is detected. When there are no occupants, the EMS will automatically set back zone temperatures to a more efficient setting. This can be accomplished by simply providing low-voltage wiring from the sensor to the EMS controller input. Also, in buildings with advanced lighting technology installations (e.g., Lutron Vive, or similar), a wireless occupancy sensor should be capable of sending its occupancy status signal to the building EMS via BACnet or other open protocol.

Assumptions:

- All existing control systems without existing occupancy-based controls are proposed for conversion.
- **Appendix B** provides a listing of AHU counts by building, total fan horsepower, and whether the systems have existing occupancy-based controls.
- Project costs estimated as $1.00 per square feet.
- Assumption is that the fan load factor reduces from a base of 0.50 (post Measures M-1 to M-3) to 0.45. A/C load factor reduces from a base of 0.120 (post Measures M-1 to M-3) to 0.110. Heating load factor reduces from a base of 0.033 (post Measures M-1 to M-3) to 0.030.
- CHW water plant efficiency of 0.70 kW/Ton & HHW plant efficiency of 75%.

Table 4.13A – Summary of Measure M-4 by Building (State Buildings)

#	Building	Project Cost ($)	Annual Elecrticity Savings (kWh)	Annual Natural Gas Savings (Therms)	Annual Energy Cost Savings ($)	GHG Reduction (Tons/Year)	Simple Pay Back (Years)
1	Academic Information Resource Center	$68,824	97,403	3,976	$10,435	38	6.6
2	Alpine Hall	$20,556	10,824	1,056	$1,709	7	12.0
3	Amador Hall	$39,396	41,430	2,025	$4,765	18	8.3
4	Athletics Center	$14,365	13,177	738	$1,599	6	9.0
5	Benicia Hall	$0	-	-	$0	-	-
6	Brighton Hall	$19,385	6,234	996	$1,326	6	14.6
7	Calaveras Hall	$13,427	11,189	690	$1,413	6	9.5
8	Capistrano Hall	$0	-	-	$0	-	-
9	Central Plant	$0	-	-	$0	-	-
10	Douglass Hall	$11,664	6,182	599	$973	4	12.0
11	Eureka Hall	$37,505	7,854	6,328	$5,355	35	7.0
12	Facilities Management	$31,098	7,300	-	$809	1	38.5
13	Kadema Hall	$29,485	23,517	-	$1,962	4	15.0
14	Lassen Hall	$60,174	37,879	3,092	$5,449	23	11.0
15	Mariposa Hall	$44,691	98,036	1,304	$8,383	24	5.3
16	Mendocino Hall	$51,955	39,220	1,113	$4,079	13	12.7
17	Placer Hall	$43,437	101,531	5,195	$11,358	45	3.8
18	University Print & Mail	$0	-	-	$0	-	-
19	Riverside Hall	$55,408	55,083	1,496	$5,522	17	10.0
20	Sacramento Hall	$24,566	15,862	1,262	$2,253	9	10.9
21	Shasta Hall	$39,971	30,200	2,054	$3,982	16	10.0
22	Tahoe Hall	$38,015	19,954	1,954	$3,156	14	12.0
23	Yosemite Hall	$63,521	86,739	3,264	$9,119	32	7.0
24	Library I & II	$259,757	135,502	10,012	$19,159	76	13.6
25	Sequoia Hall	$111,963	88,555	18,889	$20,674	115	5.4
26	Public Safety Building	$0	-	-	$0	-	-
27	Solano Hall	$0	-	-	$0	-	-
28	Broad Field House	$0	-	-	$0	-	-
Total:		**$1,079,163**	**933,671**	**66,045**	**$123,479**	**510**	**8.7**

Table 4.13B – Summary of Measure M-4 by Building (Non-State Buildings)

#	Building	Project Cost ($)	Annual Elecrticity Savings (kWh)	Annual Natural Gas Savings (Therms)	Annual Energy Cost Savings ($)	GHG Reduction (Tons/Year)	Simple Pay Back (Years)
1	Alumni Center	$10,070	1,986	-	$235	0	42.9
2	American River Courtyard	$0	-	-	$0	-	-
3	Del Norte Hall	$17,140	16,600	881	$1,971	8	8.7
4	Desmond Hall	$0	-	-	$0	-	-
5	Dining Commons	$0	-	-	$0	-	-
6	Draper Hall	$0	-	-	$0	-	-
7	Hornet Bookstore	$51,028	81,014	1,464	$7,327	22	7.0
8	Jenkins Hall	$0	-	-	$0	-	-
9	Modoc Hall	$0	-	-	$0	-	-
10	Napa Hall	$24,516	9,559	608	$1,339	5	18.3
11	Parking Structure (ALL)	$0	-	-	$0	-	-
12	Riverfront Center	$0	-	-	$0	-	-
13	Riverview Hall	$0	-	-	$0	-	-
14	Sierra Hall	$0	-	-	$0	-	-
15	Sutter Hall	$0	-	-	$0	-	-
16	The Well	$0	-	-	$0	-	-
17	University Union	$0	-	-	$0	-	-
18	Child Development Center	$0	-	-	$0	-	-
19	Exterior Lights	$0	-	-	$0	-	-
Total:		**$102,754**	**109,159**	**2,953**	**$10,871**	**34**	**9.5**

HVAC Project M-5: Provide Retro-Commissioning & HVAC Optimization

The HVAC systems are controlled by the building automation systems (DDC, Pneumatic, Pneumatic-DDC Hybrid). Facilities staff can schedule equipment, monitor the zone temperatures, monitor alarms, and set or reset various set points using the present system.

To improve building and capture the sizable energy opportunities that exist within them, commissioning principles (often called re-commissioning) can be applied to existing buildings. Building re-commissioning is a systematic process of ensuring that all of the building systems perform interactively according to the building intent and the owner's operational requirements. When appropriately applied, these principles go beyond 'quick-fix' solutions to systematically optimize building systems so that they operate efficiently and effectively, often eliminating the need for costly capital improvements.

The most common energy problems in institutional buildings include the incorrect scheduling of HVAC and lighting systems or incorrect calibration of the sensors/instrumentation. Re-commissioning ensures that these systems are adjusted and verifies that the other systems continue to function at optimum efficiency and effectiveness throughout their lives.

The most frequently mentioned benefit of re-commissioning is its energy-related value. However, it has other benefits such as improved air quality, occupant comfort and productivity. Also, re-commissioning helps in reducing operation, maintenance, and equipment replacement costs.

Assumptions:

- Project costs estimated as $1.0 per square foot.
- Savings from commissioning can vary widely from building to building. For purposes of this SEP, the savings are estimated as 10% for both electricity and natural gas.

Table 4.14A – Summary of Measure M-5 by Building (State Buildings)

#	Building	Project Cost ($)	Annual Elecrticity Savings (kWh)	Annual Natural Gas Savings (Therms)	Annual Energy Cost Savings ($)	GHG Reduction (Tons/Year)	Simple Pay Back (Years)
1	Academic Information Resource Center	$97,923	154,343	2,140	$12,618	38	7.8
2	Alpine Hall	$30,550	14,293	674	$1,503	6	20.3
3	Amador Hall	$67,138	25,749	832	$2,439	9	27.5
4	Athletics Center	$27,313	24,653	557	$2,167	7	12.6
5	Benicia Hall	$7,203	2,620	45	$220	1	32.7
6	Brighton Hall	$30,000	18,314	636	$1,766	7	17.0
7	Calaveras Hall	$21,630	13,748	440	$1,300	5	16.6
8	Capistrano Hall	$84,722	32,671	1,266	$3,242	12	26.1
9	Central Plant	$13,569	4,026	56	$329	1	41.2
10	Douglass Hall	$22,700	9,505	406	$970	4	23.4
11	Eureka Hall	$59,488	20,929	941	$2,168	9	27.4
12	Facilities Management	$38,872	10,719	409	$1,059	4	36.7
13	Kadema Hall	$46,184	32,542	1,068	$3,094	11	14.9
14	Lassen Hall	$80,445	37,576	1,510	$3,767	14	21.4
15	Mariposa Hall	$78,079	71,249	688	$5,614	16	13.9
16	Mendocino Hall	$77,000	48,485	513	$3,852	11	20.0
17	Placer Hall	$67,101	52,909	1,624	$4,951	18	13.6
18	University Print & Mail	$5,000	2,360	48	$203	1	24.6
19	Riverside Hall	$83,316	28,291	615	$2,469	8	33.7
20	Sacramento Hall	$38,090	15,675	679	$1,606	6	23.7
21	Shasta Hall	$62,667	37,351	1,208	$3,539	13	17.7
22	Tahoe Hall	$64,764	14,526	900	$1,679	7	38.6
23	Yosemite Hall	$82,301	89,891	2,626	$8,319	29	9.9
24	Library I & II	$377,074	86,940	4,549	$9,458	39	39.9
25	Sequoia Hall	$201,527	141,896	4,342	$13,270	47	15.2
26	Public Safety Building	$6,417	4,355	5,571	$8,271	30	0.8
27	Solano Hall	$67,710	61,237	914	$6,155	15	11.0
28	Broad Field House	$0	-	-	$0	-	-
Total:		**$1,838,783**	**1,056,852**	**35,255**	**$106,029**	**369**	**17.3**

Table 4.14B – Summary of Measure M-5 by Building (Non-State Buildings)

#	Building	Project Cost ($)	Annual Elecrticity Savings (kWh)	Annual Natural Gas Savings (Therms)	Annual Energy Cost Savings ($)	GHG Reduction (Tons/Year)	Simple Pay Back (Years)
1	Alumni Center	$10,800	7,127	598	$933	4	11.6
2	American River Courtyard	$209,050	163,372	1,261	$12,651	35	16.5
3	Del Norte Hall	$54,000	24,191	474	$2,075	7	26.0
4	Desmond Hall	$50,134	95,843	1,476	$7,939	24	6.3
5	Dining Commons	$22,747	167,819	1,095	$12,854	35	1.8
6	Draper Hall	$38,212	70,220	185	$5,186	13	7.4
7	Hornet Bookstore	$93,170	27,659	396	$2,270	7	41.0
8	Jenkins Hall	$38,212	50,983	185	$3,801	10	10.1
9	Modoc Hall	$85,402	137,313	865	$10,496	28	8.1
10	Napa Hall	$33,392	19,358	608	$1,822	7	18.3
11	Parking Structure (ALL)						
12	Riverfront Center	$40,198	10,493	1,173	$1,580	8	25.4
13	Riverview Hall	$128,000	108,772	1,961	$9,211	29	13.9
14	Sierra Hall	$41,662	5,724	685	$894	5	46.6
15	Sutter Hall	$40,102	20,858	623	$1,940	7	20.7
16	The Well	$150,845	73,190	3,457	$7,701	31	19.6
17	University Union	$217,000	100,277	5,980	$11,425	49	19.0
18	Child Development Center						
19	Exterior Lights	$0	-	-	$0	-	-
Total:		**$1,252,926**	**1,083,198**	**21,023**	**$92,777**	**298**	**13.5**

HVAC Project M-6: Replace Existing Chillers with New High Efficiency Chillers

Replace the four existing chillers with new high-efficiency chillers of the same capacity. The best available centrifugal chillers on the market today are efficient as 0.38 kW/Ton (Integrated Part Load Value - IPLV). This technology utilizes variable frequency drives and frictionless compressors to achieve the high efficiencies.

Assumptions:

- It is estimated that the existing chillers operate with an efficiency of 0.5 kW/Ton (IPLV). This does not include the operating efficiency of auxiliary equipment (i.e., pumps, cooling towers, etc.) which adds another estimated 0.2 kW/Ton. Additionally, the 350 Ton Chiller at Modoc Hall uses banned refrigerant HCFC and should be phased out.
- An overall plant efficiency improvement of 10% resulting in a net operating efficiency of 0.63 kW/Ton (IPLV) is assumed for this EEM.
- Project costs estimated as $1,500 per ton. Total installed capacity of 910 tons.

Table 4.15 – Summary of Measure M-6 by Building (Non-State Buildings)

#	Building	Project Cost ($)	Annual Elecrticity Savings (kWh)	Annual Natural Gas Savings (Therms)	Annual Energy Cost Savings ($)	GHG Reduction (Tons/Year)	Simple Pay Back (Years)
1	Alumni Center						
2	American River Courtyard						
3	Del Norte Hall						
4	Desmond Hall	$240,000	34,339		$3,091	6	77.6
5	Dining Commons						
6	Draper Hall	$90,000	12,877		$1,159	2	77.6
7	Hornet Bookstore						
8	Jenkins Hall	$90,000	12,877		$1,159	2	77.6
9	Modoc Hall	$525,000	60,094		$5,409	10	97.1
10	Napa Hall						
11	Parking Structure (ALL)						
12	Riverfront Center						
13	Riverview Hall						
14	Sierra Hall						
15	Sutter Hall						
16	The Well						
17	University Union						
18	Child Development Center						
19	Exterior Lights						
Total:		**$945,000**	**120,187**	**-**	**$10,818**	**21**	**87.4**

HVAC Project M-7: Replace Existing Non-Condensing Boilers with New Condensing Boilers

Replace all non-condensing boilers with new high-efficiency condensing boilers of the same capacity. Heating hot water is currently provided by an array of in-building boilers located at various buildings on campus.

Assumptions:

- The best available condensing boilers on the market today have efficiencies of over 95%. This compared to non-condensing boiler efficiencies of approximately 80%.
- It is estimated that the existing boilers operate with an efficiency of 75%. Proposed cased assumes an operating efficiency of 85% (after accounting for miscellaneous losses).
- Project costs estimated as $173 per MBtuh. Total boiler capacity to be replaced is 1,720 MBtuh.

Table 4.16 – Summary of Measure M-7 by Building (Non-State Buildings)

#	Building	Project Cost ($)	Annual Elecrticity Savings (kWh)	Annual Natural Gas Savings (Therms)	Annual Energy Cost Savings ($)	GHG Reduction (Tons/Year)	Simple Pay Back (Years)
1	Alumni Center						
2	American River Courtyard						
3	Del Norte Hall						
4	Desmond Hall	$276,800		4,921	$3,459	26	80.0
5	Dining Commons						
6	Draper Hall	$10,380		615	$432	3	24.0
7	Hornet Bookstore						
8	Jenkins Hall	$10,380		615	$432	3	24.0
9	Modoc Hall						
10	Napa Hall						
11	Parking Structure (ALL)						
12	Riverfront Center						
13	Riverview Hall						
14	Sierra Hall						
15	Sutter Hall						
16	The Well						
17	University Union						
18	Child Development Center						
19	Exterior Lights						
Total:		**$297,560**	**-**	**6,151**	**$4,324**	**33**	**68.8**

4.2 BUILDING HEATING ELECTRIFICATION

4.2.1 Building Heating Electrification

Shifting from furnaces and boilers powered by fossil fuels to air source heat pumps (ASHPs) powered by low-carbon electricity is the primary strategy for decarbonizing space heating.

While ASHPs can take many forms, a typical ASHP consists of a closed loop refrigeration system with a compressor and two heat exchangers (one indoors and one outside). In heating mode, the refrigerant evaporates when it flows through the outside heat exchanger and releases heat to the indoor heat exchanger as it condenses back to liquid. A reversing valve can switch the operating mode from heating to cooling as it reverses the thermodynamic cycle. A critical issue for electrification of heating is the temperature required for the end use. The maximum temperature, 140 deg F, provided by heat pumps is limited and may not be sufficient for some applications, such as hot water coils designed for 189 deg F hot water. Higher temperature heat pumps are beginning to emerge on the market but are not yet widely available. Although the heat exchanger coil problem could be addressed by changing to larger heat exchangers coils, that is an expensive and disruptive alternative and does not address the capacity of the distribution network. There are however several other options available, the best of which is to reduce building loads through energy efficiency (i.e., at lower loads the heat exchangers and distribution network can operate with lower water temperature).

We have identified and analyzed three locations for the ASHP satellite plants, distributed across the campus. Refer to **Table 4.17** for analysis summary. See **Appendix C** for analysis and project single line layout.

Table 4.17 – Summary of Building Heating Electrification Measure

	Satellite Plant A	Satellite Plant B	Satellite Plant C	Satellite Plant D	Satellite Plant E	Additional Plant	Total
Buildings Connected	*Buildings Connected: Library (North & South), Amador Hall, Tahoe Hall, Capistrano*	*Buildings Connected: Eureka Hall, Mariposa Hall, Solano Hall, Yosemite Hall, Kadema, Lassen Hall, Sacramento Hall*	*Buildings Connected: Riverside Hall, Santa Clara Hall, Sequoia Hall, Humboldt Hall, Mendocino Hall, Del Norte Hall, Riverfront Center, Shasta Hall*	*Buildings Connected: University Union, Hornet Bookstore, Academic Information Resource Center*	*Buildings Connected: Housing Buildings (American River Courtyard, Desmond Hall, Draper Hall, Jenkins Hall, Riverview Hall, Sierra Hall, Sutter Hall, Dining Commons)*	*Remaning Buildings: The Well, Public Safety Building, Riverview Hall, Placer Hall, Modoc Hall, Broad Field House, Alpine Hall, Brighton Hall, Napa Hall, Alumni Center, Benicia Hall, Athletics Center, Calveras Hall, Facilities Management, Douglass Hall, University Print & Mail, & Hot Water Heaters*	
Project Implementation Goal / Deadline - Year	2030	2030	2030	2035	2035	2035	
	-	-	-	-	-	-	
Annual Natural Gas Consumption Shifted - Therms	76,986	156,185	154,257	158,514	141,945	301,516	**989,404**
	-	-	-	-	-	-	
Annul Emissions Eliminated (Metric Tons)	329	668	660	678	607	1,290	**4,234**
	-	-	-	-	-	-	
Number of 30 Ton Heat Pumps	42	38	69	30	41	50	**989,404**
	-	-	-	-	-	-	
Annual Energy Cost Savings ($)	$13,014	$26,401	$26,075	$26,795	$23,994	$50,968	**$167,247**
Project Cost ($) - Million	$17.4	$15.8	$28.6	$12.4	$17.0	$20.7	**$111.9**
Financial Investment/Emissions to be Eliminated ($/Metric Tons)	$52,853	$23,571	$43,335	$18,335	$27,983	$16,065	**$26,438**

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4.3 RENEWABLES

4.3.1 Photovoltaic (PV)

To achieve the net zero status the zero-carbon electricity is the primary strategy. The renewable energy resources are naturally replenishing but flow limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Renewable energy resources include biomass, hydro, geothermal, wind, ocean thermal, wave action and solar. The campus presently generates approximately 4.7 million kWh from photovoltaics. Should it aspire to become a Zero Net Energy Campus by 2040, the campus must generate approximately **30.2 million kWh** of electricity by installing **18.9 MW** of photovoltaic (PV) system.

Open parking lots are a good candidate for the PV installation. The suitability of PV on a building rooftop depends on several factors including roof orientation, structural properties of the building, roof condition, potential obstructions due to existing equipment, clearances required from the edges, clearances required between PV rows to avoid inter-array shading, etc. Based on experience at other campuses, we conservatively estimate that the PV module area to actual roof footprint is in the range of 10% – 20%. In parking structures, it is possible to place PV on the roof, in a single bay configuration of a double bay configuration. In some cases, shading effects due to buildings in proximity, trees, and other shading effects could limit the potential.

4.3.2 Renewable Energy Credits (RECs)

Presently the University is limited /capped on the amount of onsite photovoltaic systems that can be installed, under the contract with the utility provider. The alternate option to the on-site PV system is procuring renewable energy credits. RECs can be a flexible tool to help achieve clean energy goals, lower scope 2 emissions associated with purchased electricity, and support the renewable energy market. Though RECs are the essential accounting instrument required for all renewable energy usage claims, regardless of how renewable energy is purchased or consumed, RECs can also be purchased separately from electricity and independently matched with electricity consumption. This can be an attractive option for organizations in regions where renewable energy options, such as utility green pricing /marketing programs are not offered by local suppliers, where policy support for direct engagement in renewable energy projects is lacking, or where these other options are too expensive or not suited to the organizations size or needs.

By purchasing RECs and electricity separately, organizations do not need to alter existing power contracts to obtain green power. Additionally, RECs are not limited by geographic boundaries or transmission constraints. For organizations with facilities in multiple states or energy grids, a single, consolidated REC procurement can be part of an organization's strategy to efficiently meet overall clean energy goals.8 RECs can be purchased from marketers or sometimes directly from renewable energy generators. Several REC marketers/environmental attribute brokers are active in REC markets, offering another approach to procurement that is increasingly being used by large purchasers. Brokers do not own the certificates but rely on their knowledge of the market to connect buyers and sellers for a fee.

Brokers also aggregate and disaggregate supply into customized offerings that meet specific consumer needs. This includes breaking up output from very large projects into smaller bundles as well as aggregating smaller projects offtakes into larger consolidated bundles.

5 LONG TERM VISION

5.1 DEFINITION OF LONG-TERM GOALS

Looking ahead 20 to 30 years from now, Cal State Sacramento aims towards reducing campus energy use as much as economically feasible via emerging technologies and funding opportunities. The campus will also seek to reduce its dependence on purchased electricity by installation of renewable energy system wherever suitable. For purposes of this Strategic Energy Plan (SEP) and tracking progress, the following long-term goals are identified.

Table 5.1 – Cal State Sacramento Energy Targets

ID	Target / Goal	Target Date	Target Origin	Recommendations to Attain Target/Goal	Status
Target 1	Reduce GHG Emissions to 1990 Levels	2020	Assembly Bill (AB) #32	NA	Achieved/Exceeded
Target 2	50% Reduction of 1990 GHG Emissions	2030	2018 CSU Sacramento's Climate Action Plan ad Senate Bill (SB) #350	Energy Conservartion Measures , Heating System Electrification (39.2 % shift to electric systems: Satellite Plant A,B, & C)	Pending
Target 3	80% Reduction of 1990 GHG Emissions	2035	2018 CSU Sacramento's Climate Action Plan	Heating System Electrification (60.8% shift to electric sysetms: Satellite Plant D, E & Additional Plant/Complete	Pending
Target 4	100% Reduction of 1990 GHG Emissions	2040	2018 CSU Sacramento's Climate Action Plan	Photovoltaic - Renewable Electricity (11.4 Mega Watt) or Purchase 18.2 Million kWh REC	Pending

In addition to the GHG emissions reduction goals outlined above, the 2014 CSU Sustainability Policy mandates that campuses perform a GHG inventory starting in fiscal year 2014-15 and every two years thereafter using the Climate Registry protocol and voluntary reporting tool, which includes both on-site emissions and purchased utilities. Cal State Sacramento is committed to doing this task.

5.2 MEETING LONG TERM GOALS

Section 4 of this SEP outlines all measures necessary to achieve all the targets. Achieving targets/goals understandably complex will rely upon an energy industry that is continually innovating new ways and means for achieving high building energy efficiencies. Changes are to be expected in all areas ranging from building envelope, glazing, roofing materials, insulation, interior and exterior lighting systems and controls, DC power systems, high efficiency refrigeration compressors, building HVAC controls, etc. At the same time, innovation in manufacturing methods and competition continue to drive the cost of renewable energy resources to a cost-effective range.

Table 5.2 presents a high-level summary of conditions necessary at the campus to reach Target 2 through Target 4. As the table shows, for campus reach Target 2, the following key milestones are necessary:

1. Cal State Sacramento substantially completes the Energy Efficiency Measures (EEMs) identified in this report.
2. During the next 9-10 years, new technologies and opportunities arise to considerably reduce building energy use in heating, cooling, lighting, ventilation and plug loads.

3. Cal State Sacramento's energy use efficiency improves to an extent where building energy use index drops by ***19.0*** compared to FY '18/19 levels.
4. Cal State Sacramento continues to operate its existing PV sytem which generates approximately 5.4 million kWh of electricity per year. Includes 4.7 million kWh from year 2020 2.61 Mega-watt PV installation.
5. Cal State Sacramento shifts ***39.2%*** of heating load from fossil fuel (natural gas) to electricity.

For achieving Target 3, In addition to all the above, the following is necessary:

1. Cal State Sacramento shifts ***60.8%*** of heating load from fossil fuel (natural gas) to electricity.
2. Installs on-site (or off-site) renewable energy equivalent to nearly ***7.4 MW*** of PV capacity (or ***11.8*** million kWh/year of annual renewable energy generation). There could be other combinations of scenarios that could help accomplish the same goal. Other forms of renewable energy beyond PV could be considered (e.g., fuel cell). A later section of this report discusses pros and cons of other technology options.

Achieving Zero Net Energy (Target 4) faces even bigger challenges and will entail the following, in addition to the items listed for Target #2 and #3:

1. Installs on-site (or off-site) renewable energy equivalent to nearly ***11.4 MW*** of PV capacity (or ***18.2*** million kWh/year of annual renewable energy generation).

Table 5.2 – Energy Efficiency and Renewable Generation Required for Reaching Target 2, Target 3, and Target 4

				Individual Changes/Improvements				% Change				
Item	FY '90/91	FY '18/19	FY '20/21	Target 2 - 50% Reduction of 1990 GHG Emissions 2030	Target 3 - 80% Reduction of 1990 GHG Emissions 2035	Target 4 - 100% Reduction of 1990 GHG Emissions 2040	Net Final after Conservation and Renewables [7]	FY'18/19 vs. FY'90/91 (As is)	FY'20/21 vs. FY'90/91 (As is)	Net Final Post Measures vs. FY'90/91	Net Final Post Measures vs. FY'18/19	Net Final Post Measures vs. FY'20/21
Campus-wide Electricity Use (kWh), including PV [1]	30,699,296	43,024,229	43,024,229	(11,987,448)	3,960,088	-	34,996,869	40%	40%	14%	-19%	-19%
Solar PV Contribution Electricity (kWh)	0	-710,874	*-4,678,074*	-	(11,801,031)	(18,196,930)	*(34,676,035)*					
Utility Purchased Electricity (kWh)	30,699,296	42,313,355	*38,346,155*	(11,987,448)	(7,840,943)	(18,196,930)	*320,834*	38%	25%	-99%	-99%	-99%
Natural Gas use (Therms) - Annual [1]	1,016,905	1,225,014	1,225,014	(562,903)	(625,831)	-	36,280	20%	20%	-96%	-97%	-97%
Gasoline (Gallons) [1]	2,827	0	0	-	-		0	n/a	n/a	n/a	n/a	n/a
Diesel (Gallons) [1]	9,320	0	0	-	-		0	n/a	n/a	n/a	n/a	n/a
GHG Emission Rate for Electricity (Metric Tons/kWh) [2], [6]	0.00033	0.00017	0.00017	0.00017	0.00017	0.00017	0.00000	-49%	-49%	-100%	-100%	-100%
GHG Emission rate for Natural gas (Metric Tons/Therm) [2], [6]	0.00521	0.00530	0.00530	0.00530	0.00530	0.00530	0.00000	2%	0%	-100%	-100%	-100%
GHG Emission rate for Gasoline (Metric Tons/Gallon) [2], [6]	0.01026	0.01016	0.01016	0.01016	0.01016	0.01016	0.00000	-1%	-1%	-100%	-100%	-100%
GHG Emission rate for Diesel (Metric Tons/Gallon) [2], [6]	0.00891	0.00859	0.00859	0.00859	0.00859	0.00859	0.00000	-4%	-4%	-100%	-100%	-100%
GHG Emissions (Metric Tons/Year)	15,683	13,788	13,105	(5,051)	(4,670)	(3,137)	248	-12%	-16%	-98%	-98%	-98%
GHG Emissions (Lbs./Year)	34,574,166	30,398,135	28,890,599	(11,134,944)	(10,294,832)	(6,914,833)	0					
Building GSF On Line [1]	2,715,218	4,005,519	4,005,519				4,005,519	48%	48%	48%	0%	0%
Building Site Energy Use Index (kBTU/GSF) [3], [5]	76.6	67.2	67.2	-24.3	-12.3	0.0	30.7	-12%	-12%	-60%	-54%	-54%
Building Utility Use Index (kBTU/GSF)	76.6	66.6	63.2	-24.3	-22.3	-15.5	1.2	-13%	-17%	-98%	-98%	-98%
Project Cost ($)				$95,748,303	$73,457,664	$35,914,993	$205,120,960					
Cost per Metric Ton of GHG Reduction ($/Metric Ton GHG/Year)				$18,957	$15,731	$11,451						

Notes

[1] Based on campus records

[2] Emisssion rates are from SIMAP Portal. *See link below:*

https://unhsimap.org/cmap/utility-emission-factors/

[3] kBtu = 1000 Btu. Accounts for all building consumption including what is generated by renewables (i.e., PV)

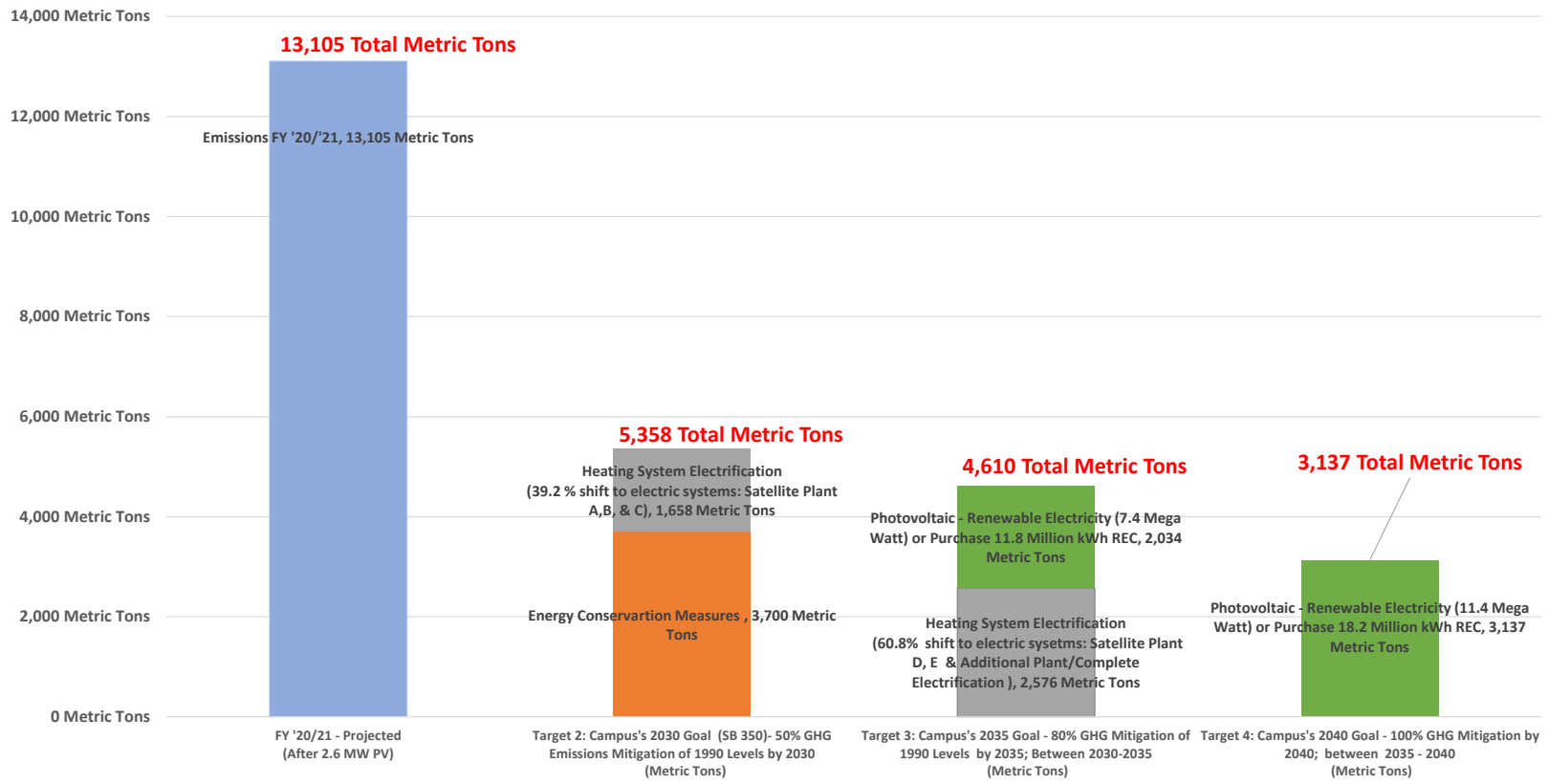
[4] Takes into account kWh production from newly installed 2.61 Mega-watt solar project.

[5] Parking structures included in total GSF but with a factor / approximation of 0.007 (e.g., Actual GSF x 0.07 = Equivalent GSF)

[6] Assuming constant emission factors.

The following **Figure 5.1** depicts the progressive potential GHG Emission reduction required from the measures discussed.

Figure 5.1 – Progressive Potential GHG Emission Reduction Required



Target 2: All EEM's identified in this report and 39.8% of the heating load shift from natural gas to electricity.

Target 3: Long term goal to reduce GHG emissions to 80% below 1990 levels. Includes 60.2% of the heating load shift from natural gas to electricity and a total PV system installation of 7.4 MW.

Target 4: Big Bold goal to achieve zero net energy. Includes a total PV system installation of 11.4 MW

5.3 ECONOMICS OF MEETING TARGETS

Table 5.3 below identifies the building side improvements and renewable generation projects necessary to achieve Target 2 (i.e., projects identified in **Section 4** of this SEP). Table includes energy savings, utility cost savings, project costs, and simple payback period.

Table 5.3 – Target 2: Project Costs and Savings

Target 2 - 50% Reduction of 1990 GHG Emissions 2030								
#	Projects Identified	Electricity Savings (kWh)	Natural Gas Savings (Therms)	Project Cost ($) [2]	GHG Emission Eliminated (Metric Tons)	$ Investment/Metric Ton Eliminated	Energy Cost Savings ($) [1]	Simple Payback (years)
1	Lighting EEMs	9,076,354	-	$16,790,854	1,564	10,733	$793,961	21.1
2	Mechanical EEMs	4,951,965	196,288	$16,227,026	1,894	8,566	$512,909	31.6
3	Building Envelope EEMs	161,968	39,323	$948,146	236	4,011	$42,417	22.4
4	Plug Load EEMS	27,291		$7,425	5	1,578	$9,591	0.8
5	Heating System Electrification (39.2 % shift to electric systems: Satellite Plant A,B, & C)	(2,298,319)	387,428	$61,774,853	1,658	37,259	$65,467	943.6
Total:		**11,919,259**	**623,039**	**$95,748,303**	**5,358**	**17,871**	**$1,424,345**	**67.2**

[1] Project savings are based on the average historical utility rates, i.e., $0.090/kWh (electricity) and $0.730/Therms (Natural Gas).

[2] The air electric heat pump system's (heating electrification) cost is based on $13,820 per Ton. The photovoltaic (PV) system cost estimate is based on the cost index of installed PV cost of $3/Watt.

Assuming Target 2 is met, **Table 5.4** below identifies heating electrification and photovoltaic installation project necessary to achieve Target 3. All noted values are incremental over Target 2.

Table 5.4 – Target 3: Incremental Project Costs and Savings (Over Target 2) *[3], [4]*

Target 3 - 80% Reduction of 1990 GHG Emissions 2035								
#	Projects Identified	Electricity Savings (kWh)	Natural Gas Savings (Therms)	Project Cost ($) [2]	GHG Emission Eliminated (Metric Tons)	$ Investment/Metric Ton Eliminated	Energy Cost Savings ($) [1]	Simple Payback (years)
1	Heating System Electrification (60.8% shift to electric sysetms: Satellite Plant D, E & Additional Plant/Complete Electrification)	(3,571,065)	601,975	$50,166,155	2,576	19,473	$101,721	493.2
2	Photovoltaic - Renewable Electricity (7.4 Mega Watt) or Purchase 11.8 Million kWh REC	11,801,031	-	$23,291,509	2,034	11,451	$1,062,219	21.9
Total:		**8,229,966**	**601,975**	**$73,457,664**	**4,610**	**15,934**	**$1,163,940**	63.1
Grand-Total [5]:		**20,149,225**	**1,225,014**	**$169,205,967**	**9,968**	**16,975**	**$2,588,286**	**65.4**

[1] Project savings are based on the average historical utility rates, i.e., $0.090/kWh (electricity) and $0.730/Therms (Natural Gas).

[2] The air electric heat pump system's (heating electrification) cost is based on $13,820 per Ton. The photovoltaic (PV) system cost estimate is based on the cost index of installed PV cost of $3/Watt.

[3] The numbers presented for Targets 2, 3, and 4 are the best estimates. At later stage, a more specific and detailed analysis of the available technologies and an economic feasibility will be required before the final determination/selection of the specific project can be made.

[4] Projects presented for Target 3 and Target 4 are in addition/incremental to savings accomplished with earlier round (Target 2) of projects (EEMs and Heating Electrification).

[5] Grand Total includes projects in Target 2; Grand Total refers to aggregate SEP related investment to date.

Assuming Target 2 is met, **Table 5.5** below identifies the renewable generation project necessary to achieve Target 4 All noted values are incremental over Target 2 &3.

Table 5.5 – Target 4 (Net Zero): Incremental Project Costs and Savings (Over Target 2 &3) *[3], [4]*

Target 4 - 100% Reduction of 1990 GHG Emissions 2040								
#	Projects Identified	Electricity Savings (kWh)	Natural Gas Savings (Therms)	Project Cost ($) [2]	GHG Emission Eliminated (Metric Tons)	$ Investment/Metric Ton Eliminated	Energy Cost Savings ($) [1]	Simple Payback (years)
1	Photovoltaic - Renewable Electricity (11.4 Mega Watt) or Purchase 18.2 Million kWh REC	18,196,930	-	$35,914,993	3,137	11,451	$1,637,918	21.9
Grand-Total [5] :		**38,346,155**	**1,225,014**	**$205,120,960**	**13,105**	**15,653**	**$4,226,204**	**48.5**

[1] Project savings are based on the average historical utility rates; i.e., $0.090/kWh (electricity) and $0.730/Therms (Natural Gas).

[2] The air electric heat pump system's (heating electrification) cost is based on $13,820 per Ton. The photovoltaic (PV) system cost estimate is based on the cost index of installed PV cost of $3/Watt.

[3] The numbers presented for Targets 2, 3, and 4 are the best estimates. At later stage, a more specific and detailed analysis of the available technologies and an economic feasibility will be required before the final determination/selection of the specific project can be made.

[4] Projects presented for Target 3 and Target 4 are in addition/incremental to savings accomplished with earlier round (Target 2) of projects (EEMs and Heating Electrification).

[5] Grand Total includes projects in Target 2 and Target 3; Grand Total refers to aggregate SEP related investment to date.

While cost of renewable energy alone appears to be in the range of $3 - $4/Watt in 2020 (or approximately $59.2 million of investment for incremental long term **18.8 MW** of PV), it is impossible to forecast with any degree of certainty what the costs would be in 20-30 years. In rough order of magnitude, it would not be unrealistic to forecast that achieving Net Zero (Target 4) could require at least ***$59.2*** million in renewable energy investment, ***$34.0*** million in building side improvements, and ***$102*** million in heating systems electrification.

5.4 UTILITY REBATE PROGRAMS

Sacramento Municipal Utility District (SMUD)

Through SMUD's Express Energy Solutions and Custom Energy Solutions Programs, business customers can receive incentives for implementing measures to improve energy efficiency. The Express Solutions program simplifies the process of applying for incentives by setting standard incentive amounts for specific types of measures. If a customer is interested in pursuing an energy efficiency improvement measure that is not included in the Express Solutions program, the customer can apply for an incentive through the Customized Solutions Program. These incentives are calculated on a case-by-case basis and are based on measured energy (kWh) and demand (kW) savings.

Express Energy Solutions Program (EESP)

In the Express Energy Solutions can pay rebates up to $20,000 per account, per year. The maximum Rebate that can be paid on a Project is the lesser of either: 1) $20,000 per meter per year, 2) 100% of the total project cost, or 3) aggregate of rebates amounts for each separate piece of qualifying equipment installed in a Project. *EESP has two project caps*: 1) $20,000 per meter per year for energy efficiency measures, and 2) $20,000 per meter per year for Go Electric (Gas to Electric) measures.

The program encourage energy efficient equipment upgrades within the end use categories of Lighting (Fluorescent, Fluorescent High Output, and HID to LED), HVAC & VFD, Food Service equipment, Refrigeration, and Gas to Electric conversion (Heating, Cooling, Water Heating, and Food Services). For detailed, by equipment, rebate information, please refer to: https://www.smud.org/-/media/Documents/Business-Solutions-and-Rebates/PDFs/Business-Rebates/EES-Manual_2020-2021-Program_Phase1.ashx

Custom Energy Solutions Program (CESP)

For large or complex projects not eligible for the Express Energy Solutions program, Custom Energy Solution Program (CESP) provides design assistance and calculated incentives to optimize non-residential projects for electrification and energy efficiency. Electrification refers to projects reducing gas use through implementation of efficient electric technologies. Individual systems are calculated using spreadsheets or other tools to determine annual site electrification savings (measured in equivalent kilowatt-hours, or kWh-e) or energy savings (measured in kilowatt-hours, or kWh). Site kWh-e is the baseline equipment's gas usage (converted to kWh) less the proposed equipment's site electrical kWh usage. In addition, the programs seek to drive participation in other demand side management activities, specifically retro-commissioning and demand response. See table below for incentive details.

Table 5.6 – SMUD CESP Incentive by Category

Category	Incentive
Electrification	1) $0.30 / kWh-e for first year energy savings: kWh-e = (baseline gas usage converted to kWh) – (proposed equipment electrical usage in kWh) 2) Incentives are limited to $0.30 / kWh-e, 50% of eligible project cost (refer to section 13.0), or $150,000, whichever is less.
Energy Efficiency Incentive	1) $0.15 / kWh for first year energy savings for non-lighting measures. 2) $0.10 / kWh for general lighting measures. 3) Incentives are limited to program $ / kWh incentive rates, 50% of eligible project cost (or $100,000, whichever is less.
Retro-commissioning	1) $0.08 / kWh for first year energy savings 2) Incentives are limited to $0.08 / kWh, 50% of eligible project cost, or $100,000, whichever is less.
Demand Response	1) $5.00/kW per month for 1-year commitment 2) The minimum load reduction needed to participate is 50kW and 5% of peak period demand. Typical load reduction measures include HVAC temperature set point adjustments, Lighting power or scheduling adjustments, Variable frequency drive (VFD) reductions on Pumps/motors/irrigation

For details, refer to the following links: https://www.smud.org/-/media/Documents/Business-Solutions-and-Rebates/PDFs/Business-Rebates/ACS-Procedures-Manual.ashx

5.5 SEP IMPLEMENTATION STRATEGY

Any long-term strategic energy plan faces the challenge of future unknowns. Consequently, successful implementation of an SEP needs to continually revisit the plan, evaluate progress towards goal, assess factors influencing proposed near-term actions, and make changes to the plan and proposed projects accordingly.

Figure 5.2 below presents an SEP implementation strategy in a flow chart. The chart highlights the varying factors that can affect direction of the SEP. It is recommended that the campus review this strategy on a year-by-year basis with the objective of amending the SEP and adjusting the proposed projects accordingly. Some of these factors may include the following:

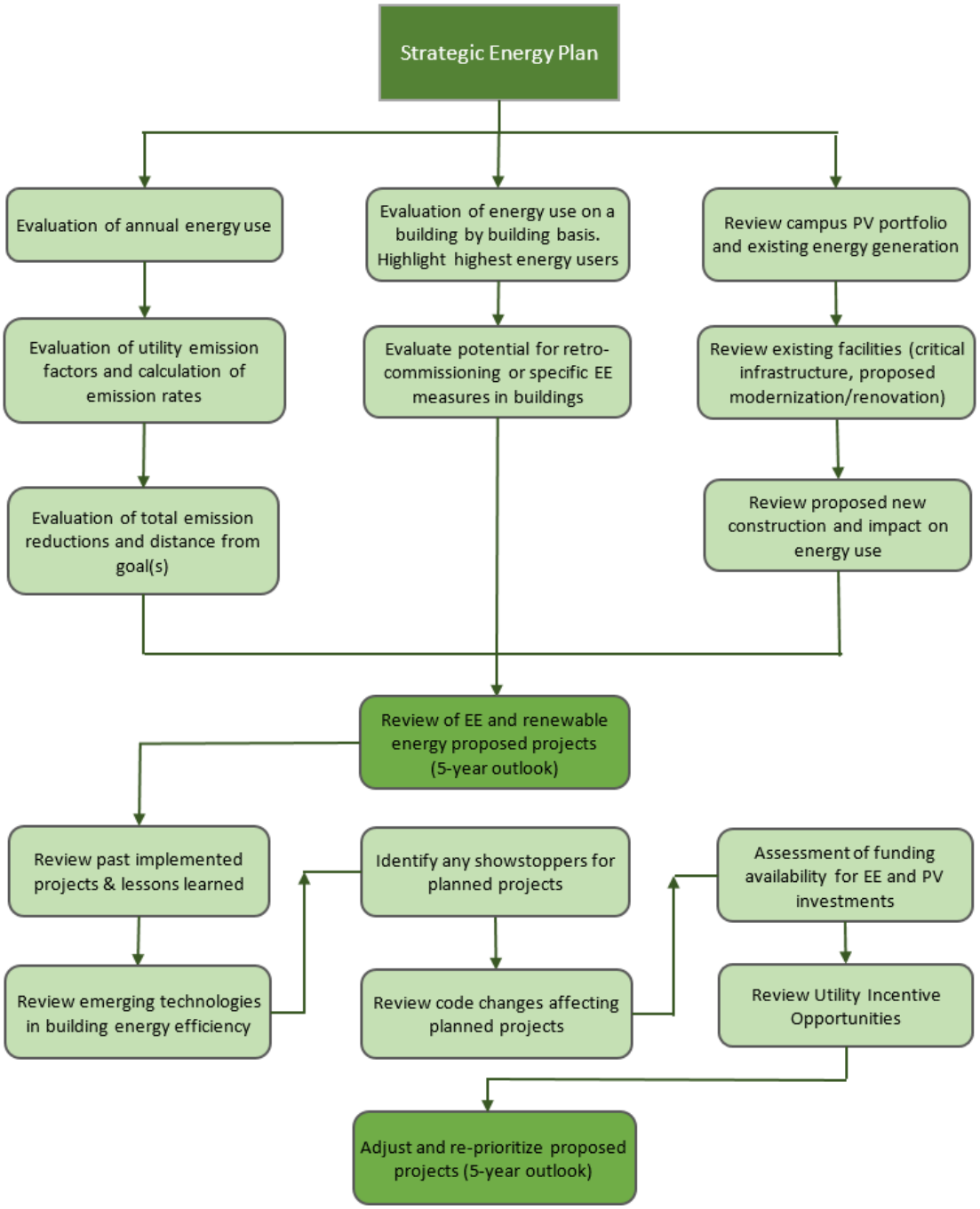
- Technology advancements in building energy systems and renewable energy. Campus must remain flexible to adapt to new technologies.
- Technology cost fluctuations. Typically, new technologies have a downward cost trend as the technology becomes more viably available and market competition drives costs down.
- Funding availability is perhaps the largest obstacle facing the road to Zero Net Energy (ZNE). Available funding at any given time may increase or decrease and thus changes to the plan may be necessary.
- With strategic planning, campus can leverage available utility rebates to implement energy projects. Utility programs are constantly changing and it's important to take advantage of available extra funding opportunities as they become available.
- Building and energy code revisions may drive future new construction and building modernization decisions.
- Impact of proposed new construction on greenhouse gas emissions.
- Changes to SMUD's Time-of-Use (TOU) tariff structures

It is also foreseeable that the campus may need to conduct additional studies to investigate possible showstoppers or regulatory limitations affecting the road to a ZNE campus. These may include:

- Assessment of electrical infrastructure for the allocation of large scale photovoltaics (or other renewable energy systems) on-campus. As these large-scale photovoltaic systems come on-line, utilities will become increasing concerned with the net effects of the existing grid and infrastructure.
- Assessment of roof infrastructure for the installation of roof-mounted photovoltaics.
- Focused study on off-site renewable energy options. Taking into consideration the limited area of existing campus building rooftops and campus non-developed space, off-site renewable energy options may need to be investigated. Investigation also to include whether it's possible to attain net zero through the purchase of renewable energy credits.
- Impact of a policy change that mandates Zero Net Energy (ZNE) buildings for all new construction.

- Potential impact of electric vehicle charging stations on the overall campus energy use and electrical infrastructure.

Figure 5.2 – Implementation Strategy for SEP



5.6 SEP IMPLEMENTATION SCHEDULE

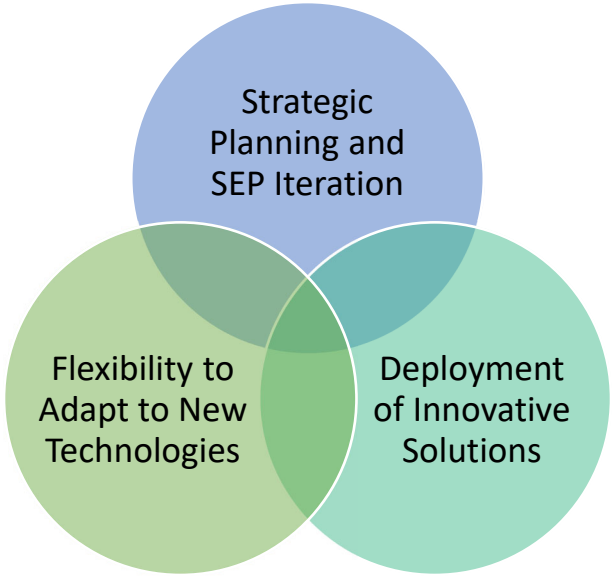
Figure 5.3 – Implementation Schedule for Energy Efficiency, Heating Electrification & Renewable Energy Measures

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Projects	**Notes**	**'21/'22**	**'22/'23**	**'23/'24**	**'24/'25**	**'25/'26**	**'26/'27**	**'27/'28**	**'28/'29**	**'29/'30**	**'30/'31**	**'31/'32**	**'32/'33**	**'33/'34**	**'34/'35**	**'35/'36**	**'36/'37**	**'37/'38**	**'38/'39**	**'39/'40**
Immediate Implementation																				
L-2, E-1 (Low Hanging Fruit Identified in Section 4.2.4)	Campus wide implementation Two year goal to implement																			
Lighting Projects																				
L-1 (Interior Lighting LED Conversions & Controls)	Complete lighting conversion and controls project campus wide. Nine year goal to implement																			
L-8 (Exterior & Parking Lighting LED Conversion & Controls)	Complete lighting conversion and controls project campus wide. Nine year goal to implement																			
Building Envelope Projects																				
B-1 (High Efficiency Windows)	Envelope measures to be considered during planned building modernization																			
Mechanical Projects																				
M-3 & M-4 (Minor HVAC Controls)	Five year goal to implement																			
M-1 & M-2 (Major HVAC Conversion & Controls)	Nine year goal to implement																			
M-5 (Retrocommissioning)	Implementation focussing on highest energy users																			
M-6 (Replace Chillers)																				
M-7 (Replace Boilers)	Done at end of service life (15/20+ years)																			
Heating Electrification/Decarbonization Project																				
H-1A (Air Source Heat Pumps)	Heating System Electrification (39.2 % shift to electric systems: Satellite Plant A,B, & C)																			
H-1B (Air Source Heat Pumps)	Heating System Electrification (60.8% shift to electric sysetms: Satellite Plant D, E & Additional Plant/Complete Electrification)																			
Renewable-Photovoltaic Project																				
PV-1A	Photovoltaic - Renewable Electricity (7.4 Mega Watt) or Purchase 11.8 Million kWh REC																			
PV-1B	Photovoltaic - Renewable Electricity (11.4 Mega Watt) or Purchase 18.2 Million kWh REC																			

5.7 CONCLUDING STATEMENT

Cal State Sacramento's Strategic Energy Plan (SEP) aims for the campus to be a Zero Net Energy (ZNE) by the year 2040. While the long-term goal may seem ambitious, it is certainly attainable with strategic planning, funding availability, deployment of innovative solutions, and flexibility to adapt to new technologies. As proven by the long list of accomplishments previously defined in this SEP, the campus has stayed ahead of the curve with respect to energy efficiency and sustainability. These accomplishments are the fruits of efforts by University administration, academic staff and students. It is the intent of this SEP to build-upon this same message put forth by campus leadership and to continue building a sustainable road map for the future. It is also emphasized that this SEP is not static. The SEP is a living document that is to be revisited and updated according to unforeseen changes. This iterative process will be a key component to its success.

Figure 5.4 – Key Elements for a Successful SEP



Appendix A – Campus Energy Usage

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Ranking by Electricity Consumption (By Highest User)

Rank	Building Name	Area (GSF)	Building Level Electricity Consumption (kWh)	Central Plant Cooling Electricity Consumption (kWh) - where applicable	Total Electricity Consumption (kWh)	Electricity Consumption Index (kWh/Sq.ft.)
1	Library I & II	377,074	2,831,358	139,277	2,970,634	7.9
2	American River Courtyard	209,050	2,890,126	-	2,890,126	13.8
3	Sequoia Hall	201,527	1,538,868	709,442	2,248,310	11.2
4	Exterior Lights	9,300,060	2,225,000	-	2,225,000	0.2
5	University Union	217,000	2,142,513	-	2,142,513	9.9
6	Academic Information Resource Center	97,923	698,252	1,238,852	1,937,105	19.8
7	Dining Commons	22,747	1,764,594	-	1,764,594	77.6
8	Modoc Hall	85,402	1,693,725	-	1,693,725	19.8
9	Parking Structure (All)	165,504	1,609,187	-	1,609,187	9.7
10	The Well	150,845	1,485,071	-	1,485,071	9.8
11	Riverview Hall	128,000	559,990	884,006	1,443,996	11.3
12	Yosemite Hall	82,301	793,839	499,872	1,293,711	15.7
13	Desmond Hall	50,134	1,220,592	-	1,220,592	24.3
14	Mariposa Hall	78,079	697,139	356,324	1,053,463	13.5
15	Lassen Hall	80,445	780,776	147,424	928,200	11.5
16	Santa Clara Hall	66,391	592,089	305,127	897,216	13.5
17	Mendocino Hall	77,000	746,722	143,217	889,939	11.6
18	Draper Hall	38,212	888,419	-	888,419	23.2
19	Solano Hall	67,710	859,917	-	859,917	12.7
20	Placer Hall	67,101	487,865	288,552	776,417	11.6
21	Jenkins Hall	38,212	704,470	-	704,470	18.4
22	Capistrano Hall	84,722	534,280	156,043	690,323	8.1
23	Riverside Hall	83,316	522,226	139,670	661,895	7.9
24	Shasta Hall	62,667	503,019	151,033	654,052	10.4
25	Hornet Bookstore	93,170	537,918	59,433	597,350	6.4
26	Amador Hall	67,138	520,905	48,203	569,108	8.5
27	Kadema Hall	46,184	374,933	168,749	543,681	11.8
28	Public Safety Building	11,892	528,448	-	528,448	44.4
29	Eureka Hall	59,488	401,986	91,886	493,871	8.3
30	Tahoe Hall	64,764	310,080	104,791	414,871	6.4
31	Sutter Hall	40,102	251,436	155,546	406,982	10.1
32	Napa Hall	33,392	392,058	-	392,058	11.7
33	Athletics Center	27,313	278,624	101,299	379,923	13.9
34	Broad Field House	26,013	369,385	-	369,385	14.2
35	Del Norte Hall	54,000	298,761	68,268	367,029	6.8
36	Sacramento Hall	38,090	252,913	80,271	333,184	8.7
37	Riverfront Center	40,198	325,983	-	325,983	8.1
38	Brighton Hall	30,000	175,674	102,965	278,639	9.3
39	Sierra Hall	41,662	266,936	-	266,936	6.4
40	Alpine Hall	30,550	148,082	109,184	257,267	8.4
41	Facilities Management	38,872	254,838	-	254,838	6.6
42	Child Development Center	13,704	230,227	-	230,227	16.8
43	Calaveras Hall	21,630	147,976	71,318	219,294	10.1
44	Handball Courts	2,500	178,647	-	178,647	71.5
45	Douglass Hall	22,700	107,158	67,947	175,105	7.7
46	Alumni Center	10,800	104,979	-	104,979	9.7
47	University Print & Mail	3,500	73,712	-	73,712	21.1
48	Benicia Hall	7,203	60,449	-	60,449	8.4
49	Central Plant	13,569	46,353	8,796	55,149	4.1
Sub-Total Electricity Use:		3,369,796	35,408,495	6,397,494	41,805,988	12.4
				Remaining kWh:	1,218,241	
				Total:	43,024,229	

[1] Central Plant cooling load makes up approximately of the total 15%

[2] Parking structure GSF is approximated at 0.07 of the total GSF

Note: Where actual building level metering data was not available, that the energy use data presented in the table above are estimates only based on building walkthroughs, inventory of HVAC systems, sample lighting checks, etc.

Ranking by Natural Gas Consumption (By Highest User)

Rank	Building Name	Area (GSF)	Building Level Natural Gas Consumption (Therms)	Central Plant Heating Natural Gas Consumption (Therms) - where applicable	Total Natural Gas Consumption (Therms)	Natural Gas Consumption Index (Therms/Sq.ft.)
1	University Union	217,000	-	119,603	119,603	0.55
2	Library I & II	377,074	-	90,974	90,974	0.24
3	Sequoia Hall	201,527	-	86,833	86,833	0.43
4	Public Safety Building	11,892	74,285	-	74,285	6.25
5	The Well	150,845	69,147	-	69,147	0.46
6	Yosemite Hall	82,301	-	52,528	52,528	0.64
7	Academic Information Resource Center	97,923	-	42,801	42,801	0.44
8	Riverview Hall	128,000	-	39,222	39,222	0.31
9	Santa Clara Hall	66,391	-	37,959	37,959	0.57
10	Placer Hall	67,101	-	32,470	32,470	0.48
11	Lassen Hall	80,445	-	30,194	30,194	0.38
12	Desmond Hall	50,134	29,527	-	29,527	0.59
13	Capistrano Hall	84,722	-	25,317	25,317	0.30
14	American River Courtyard	209,050	25,229	-	25,229	0.12
15	Solano Hall	67,710	-	24,376	24,376	0.36
16	Shasta Hall	62,667	-	24,165	24,165	0.39
17	Riverfront Center	40,198	-	23,463	23,463	0.58
18	Dining Commons	22,747	21,897	-	21,897	0.96
19	Kadema Hall	46,184	-	21,352	21,352	0.46
20	Eureka Hall	59,488	-	18,819	18,819	0.32
21	Tahoe Hall	64,764	-	18,009	18,009	0.28
22	Modoc Hall	85,402	17,300	-	17,300	0.20
23	Amador Hall	67,138	-	16,639	16,639	0.25
24	Broad Field House	26,013	-	14,567	14,567	0.56
25	Mariposa Hall	78,079	-	13,755	13,755	0.18
26	Sierra Hall	41,662	13,702	-	13,702	0.33
27	Sacramento Hall	38,090	-	13,589	13,589	0.36
28	Alpine Hall	30,550	-	13,484	13,484	0.44
29	Brighton Hall	30,000	-	12,716	12,716	0.42
30	Sutter Hall	40,102	12,457	-	12,457	0.31
31	Riverside Hall	83,316	-	12,290	12,290	0.15
32	Napa Hall	33,392	12,167	-	12,167	0.36
33	Alumni Center	10,800	11,952	-	11,952	1.11
34	Athletics Center	27,313	-	11,141	11,141	0.41
35	Mendocino Hall	77,000	-	10,256	10,256	0.13
36	Del Norte Hall	54,000	-	9,481	9,481	0.18
37	Calaveras Hall	21,630	-	8,807	8,807	0.41
38	Facilities Management	38,872	8,171	-	8,171	0.21
39	Douglass Hall	22,700	-	8,120	8,120	0.36
40	Hornet Bookstore	93,170	7,926	-	7,926	0.09
41	Jenkins Hall	38,212	3,691	-	3,691	0.10
42	Draper Hall	38,212	3,691	-	3,691	0.10
43	Central Plant	13,569	-	1,126	1,126	0.08
44	University Print & Mail	3,500	951	-	951	0.27
45	Benicia Hall	7,203	891	-	891	0.12
46	Parking Structure (All)	2,364,343	-	-	-	-
47	Handball Courts	2,500	-	-	-	-
48	Child Development Center	13,704	-	-	-	-
49	Exterior Lights	9,300,060	-	-	-	-
Sub-Total Electricity Use:			312,093	834,056	1,146,149	

Remaining Natural Gas	78,865
Total:	1,225,014
[1] Central Plant steam plant makes up approximately of the total	73%

Note: Where actual building level metering data was not available, that the energy use data presented in the table above are estimates only based on building walkthroughs, inventory of HVAC systems, sample lighting checks, etc.

Appendix B – Existing Energy Systems

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Summary of Existing Envelope Characteristics at Campus Buildings

			Stories				Glazing % of Wall Area			
Building ID	**Building Name**	**GSF**	**Above Ground**	**Below Ground**	**Glazing Type**	**Clear/Tint**	**South**	**West**	**North**	**East**
1	Academic Information Resource Center	97,923	3	1	Double	Clear	35%	10%	70%	60%
2	Alpine Hall	30,550	2	0	Single	Clear	90%	10%	90%	10%
3	Alumni Center	10,800	1	0	Double	Clear	60%	80%	80%	80%
4	Amador Hall	67,138	5	0	Double	Clear	10%	10%	20%	10%
5	American River Courtyard	209,050	4	0	Double	Clear	20%	20%	20%	20%
6	Athletics Center	27,313	2	0	Double	Clear	5%	5%	10%	5%
7	Benicia Hall	7,203	1	0	Double	Clear	25%	25%	25%	25%
8	Brighton Hall	30,000	2	0	Single	Clear	90%	10%	90%	10%
9	Broad Field House	26,013	2	0	Double	Clear	50%	50%	50%	50%
10	Calaveras Hall	21,630	1	0	Single	Clear	60%	20%	60%	20%
11	Capistrano Hall	84,722	4	0	Single	Clear	10%	50%	10%	50%
12	Central Plant	13,569	1	0	Double	Clear	5%	5%	5%	70%
13	Child Development Center	13,704	1	0	Single	Clear	20%	20%	40%	20%
14	Del Norte Hall	54,000	3	0	Double	Clear	5%	10%	5%	10%
15	Desmond Hall	50,134	3	0	Double	Clear	20%	20%	20%	20%
16	Dining Commons	22,747	1	0	Double	Clear	5%	5%	5%	70%
17	Douglass Hall	22,700	2	0	Single	Clear	80%	20%	80%	20%
18	Draper Hall	38,212	3	0	Single	Clear	20%	20%	20%	20%
19	Eureka Hall	59,488	4	0	Double	Tint	80%	80%	80%	80%
20	Exterior Lights	N/A	1	0	NA	NA	NA	NA	NA	NA
21	Facilities Management	38,872	1	0	Double	Clear	20%	40%	40%	20%
22	Handball Courts	2,500	0	0	0	0	0%	0%	0%	0%
23	Hornet Bookstore	93,170	2	0	Double	Clear	20%	35%	45%	5%
24	Jenkins Hall	38,212	3	0	Single	Clear	20%	20%	20%	20%
25	Kadema Hall	46,184	2	0	Single	Clear	70%	5%	70%	5%
26	Lassen Hall	80,445	3	0	Single	Clear	75%	5%	15%	25%
27	Library I & II	377,074	4	0	Double	Clear	10%	5%	10%	10%
28	Mariposa Hall	78,079	5	0	Double	Tint	80%	80%	10%	10%
29	Mendocino Hall	77,000	5	0	Double	Clear	50%	30%	50%	25%
30	Modoc Hall	85,402	4	0	Double	Tint	40%	40%	40%	40%
31	Napa Hall	33,392	3	0	Double	Clear	80%	20%	80%	20%
32	Parking Structure (All)	77,000	4	0	NA	NA	NA	NA	NA	NA
33	Placer Hall	67,101	5	0	Double	Tint	90%	90%	90%	90%
34	Public Safety Building	11,892	2	0	Single	Clear	30%	10%	30%	10%
35	Riverfront Center	40,198	0	0	0	0	0%	0%	0%	0%
36	Riverside Hall	83,316	5	0	Double	Tint	20%	5%	20%	50%
37	Riverview Hall	128,000	4	0	Double	Clear	20%	20%	20%	20%
38	Sacramento Hall	38,090	2	0	Single	Clear	30%	30%	30%	30%
39	Santa Clara Hall	66,391	1	0	Single	Clear	40%	10%	40%	15%
40	Sequoia Hall	201,527	5	0	Double	Tint	80%	5%	80%	5%
41	Shasta Hall	62,667	2	0	Double	Clear	5%	5%	80%	25%
42	Sierra Hall	41,662	3	0	Single	Clear	20%	20%	20%	20%
43	Solano Hall	67,710	5	0	Double	Clear	30%	10%	10%	10%
44	Sutter Hall	40,102	3	0	Single	Clear	20%	20%	20%	20%
45	Tahoe Hall	64,764	3	0	Double	Clear	40%	20%	40%	5%
46	The Well	150,845	2	0	Double	Clear	50%	25%	70%	30%
47	University Print & Mail	3,500	1	0	Double	Clear	5%	0%	0%	0%
48	University Union	217,000	3	0	Double	Clear	10%	25%	80%	30%
49	Yosemite Hall	82,301	2	0	Double	Clear	10%	80%	0%	25%

Summary of Existing Lighting and Plug Load Characteristics at Campus Buildings

Building ID	Building Name	Building Area (GSF)	Lighting Type 1	Estimated Lighting Type 1 Proportion (%)	Lighting Type 2	Estimated Lighting Type 2 Proportion (%)	Occupancy Sensor (Yes/No)	Daylight Harvesting (Yes/No)	Lighting Avg. Watts/SFT	Plug Load Avg. Watts/SFT
1	Academic Information Resource Center	97,923	T8	(80% of bldg.)	CF	(20% of bldg.)	YES	NO	0.93	0.89
2	Alpine Hall	30,550	T8	(90% of bldg.)	CFL	(10% of bldg.)	YES	NO	1.00	0.28
3	Alumni Center	10,800	FL	(50% of bldg.)	HI	(50% of bldg.)	NO	NO	0.58	0.25
4	Amador Hall	67,138	T8	(100% of bldg.)	CF	0	NO	NO	1.24	0.00
5	American River Courtyard	209,050	Linear Fluorescent T8	(90% of bldg.)	T12	(10% of bldg.)	Partial	NO	1.32	0.16
6	Athletics Center	27,313	T8	(100% of bldg.)	0	0	NO	NO	1.69	1.91
7	Benicia Hall	7,203	T8	(90% of bldg.)	CF	(10% of bldg.)	NO	NO	1.38	0.77
8	Brighton Hall	30,000	T8	(90% of bldg.)	CF	(10% of bldg.)	YES	NO	0.93	0.32
9	Broad Field House	26,013	LED	(50% of bldg.)	T8	(50% of bldg.)	YES	YES	1.01	0.88
10	Calaveras Hall	21,630	T8	(100% of bldg.)	CFL	0	0.5	NO	1.31	0.00
11	Capistrano Hall	84,722	T8	(100% of bldg.)	None	(0% of bldg.)	Partial	NO	1.25	0.00
12	Central Plant	13,569	LED	(70% of bldg.)	T8	(30% of bldg.)	NO	NO	1.29	0.44
13	Child Development Center	13,704	T8	(70% of bldg.)	CF	(30% of bldg.)	NO	NO	1.26	0.88
14	Del Norte Hall	54,000	T8	(50% of bldg.)	LED	(50% of bldg.)	Partial	NO	1.09	2.28
15	Desmond Hall	50,134	Linear Fluorescent T8	(100% of bldg.)	Compact Fluorescent	0	YES	NO	1.37	0.16
16	Dining Commons	22,747	LED	(50% of bldg.)	Compact Fluorescent	(50% of bldg.)	NO	NO	0.72	0.17
17	Douglass Hall	22,700	T8	(60% of bldg.)	LED	(40% of bldg.)	Partial	NO	0.98	0.28
18	Draper Hall	38,212	Linear Fluorescent T8	(70% of bldg.)	LED	(30% of bldg.)	Partial	NO	1.31	0.16
19	Eureka Hall	59,488	T8	(85% of bldg.)	LED	(15% of bldg.)	YES	NO	1.75	0.00
20	Exterior Lights	NA	HID	80 %	CF	20%	0	0	0.00	0.00
21	Facilities Management	38,872	LED	(50% of bldg.)	T8	(50% of bldg.)	NO	NO	0.76	0.76
22	Handball Courts	2,500	0	0	0	0	0	0	0.00	0.00
23	Hornet Bookstore	93,170	Linear Fluorescent T5	(50% of bldg.)	Metal Halide 100W	(50% of bldg.)	NO	NO	1.16	0.77
24	Jenkins Hall	38,212	Linear Fluorescent T8	(70% of bldg.)	LED	(30% of bldg.)	Partial	NO	1.33	0.16
25	Kadema Hall	46,184	T8	(100% of bldg.)	0	0	NO	NO	1.19	0.00
26	Lassen Hall	80,445	T8	(80% of bldg.)	CF	(20% of bldg.)	YES	NO	1.71	1.31
27	Library I & II	377,074	T8	(100% of bldg.)	CF	0	NO	NO	1.49	0.74
28	Mariposa Hall	78,079	T8	(85% of bldg.)	LED	(15% of bldg.)	Partial	NO	1.21	0.00
29	Mendocino Hall	77,000	T8	(90% of bldg.)	CFL	(10% of bldg.)	NO	NO	1.22	0.00
30	Modoc Hall	85,402	FL	(80% of bldg.)	LED	(20% of bldg.)	Partial	NO	1.00	0.18
31	Napa Hall	33,392	FL	(80% of bldg.)	CFL	(20% of bldg.)	Partial	NO	1.28	0.00
32	Parking Structure (All)	77,000	0	0	0	0	0	0	0.00	0.00
33	Placer Hall	67,101	T8	(90% of bldg.)	FL	(10% of bldg.)	YES	NO	1.17	0.00
34	Public Safety Building	11,892	T8	(70% of bldg.)	CF	(30% of bldg.)	NO	NO	1.36	0.88
35	Riverfront Center	40,198	0	0	0	0	0	0	0.00	0.00
36	Riverside Hall	83,316	T8	(90% of bldg.)	CFL	(10% of bldg.)	NO	NO	0.92	0.30
37	Riverview Hall	128,000	LED	(100% of bldg.)	0	0	Partial	NO	0.76	0.15
38	Sacramento Hall	38,090	T8	(100% of bldg.)	0	0	NO	NO	0.93	1.43
39	Santa Clara Hall	66,391	Linear Fluorescent T8	(100% of bldg.)	0	(0% of bldg.)	NO	NO	1.17	0.73
40	Sequoia Hall	201,527	T8	(90% of bldg.)	CFL	(10% of bldg.)	NO	NO	0.97	0.00
41	Shasta Hall	62,667	T8	(90% of bldg.)	CF	(10% of bldg.)	YES	NO	1.53	0.96
42	Sierra Hall	41,662	Linear Fluorescent T8	(90% of bldg.)	LED	(10% of bldg.)	Partial	NO	1.36	0.16
43	Solano Hall	67,710	T8	(70% of bldg.)	CF	(30% of bldg.)	NO	NO	1.26	0.88
44	Sutter Hall	40,102	Linear Fluorescent T8	(90% of bldg.)	LED	(10% of bldg.)	Partial	NO	1.34	0.17
45	Tahoe Hall	64,764	T8	(80% of bldg.)	CF	(20% of bldg.)	NO	NO	1.03	1.28
46	The Well	150,845	Linear Fluorescent T5	(50% of bldg.)	LED	(50% of bldg.)	YES	NO	1.01	0.23
47	University Print & Mail	3,500	T8	(100% of bldg.)	0	(0% of bldg.)	NO	NO	2.52	0.00
48	University Union	217,000	LED	(50% of bldg.)	Compact Fluorescent	(50% of bldg.)	Partial	NO	0.88	0.29
49	Yosemite Hall	82,301	T8	(70% of bldg.)	LED	(30% of bldg.)	NO	NO	0.98	0.90

Summary of Existing HVAC System Characteristics at Campus Buildings

Building ID	Building Name	Building Area (GSF)	System Type	Zone Level System	Cooling Type	SFT Per Cooling Ton	Connected to CHW Plant (YES/NO)	Heating Type	SFT per Heating MBH	Connected to Central Steam Plant (YES/NO)	AHU Quantity	Total Supply Fan HP	Total Return Fan HP	Fan on VFD	Economizer	Controls Type	CO2 DCV Controls	Occupancy Based HVAC Controls	Pumps Quantity	Pumps HP	Pumps on VFD	Optimal Start
1	Academic Information Resource Center	97,923	Central AHUs	Triple Deck VAV	Central Plant CHW	231	YES	Central Plant Steam	22.2	YES	26	69	0	YES	YES	DDC	YES	NO	3	22.5	YES	NO
2	Alpine Hall	30,550	Central AHUs	Dual-Duct VAV	Central Plant CHW	600	YES	Central Plant Steam	25.0	YES	2	15	5	YES	YES	Partial	NO	NO	2	2	NO	NO
3	Alumni Center	10,800	Rooftop Gas-Electric Package	Constant Volume Single Zone	CHW	190	NO	Gas Fired Furnace	42.5	NO	8	4	0	NO	YES	DDC	NO	NO	Not Applicable	Not Applicable	Not Applicable	NO
4	Amador Hall	67,138	Central AHUs	Std. VAV w/ HW Reheat	Central Plant CHW	600	YES	Central Plant Stram	25.0	YES	3	140	35	YES	YES	Partial	YES	NO	5	19	NO	YES
5	American River Courtyard	209,050	Central AHUs	Fan Coil - Four Pipe	Standalone Chiller	503	NO	Standalone Boiler	50.3	NO	2	50	0	NO	NO	NO	NO	NO	0	0	0	NO
6	Athletics Center	27,313	Central AHUs	Dual-Duct Constant Vol.	Central Plant CHW	600	YES	Central Plant Steam	25.0	YES	2	20	5	NO	NO	Partial	NO	NO	3	4	NO	NO
7	Benicia Hall	7,203	Central AHUs	Const. Vol. Multi-Zone	DX	224	NO	Gas Furnace	16.6	NO	5	7	0	NO	YES	DDC	NO	NO	0	0	No	NO
8	Brighton Hall	30,000	Central AHUs	Dual-Duct VAV	Central Plant CHW	600	YES	Central Plant Steam	25.0	YES	1	40	0	YES	YES	Partial	NO	NO	1	3	No	NO
9	Broad Field House	26,013	Central AHUs	Std. VAV w/ HW Reheat	Central Plant CHW	600	NO	Standalone Boiler	25.0	NO	3	30	10	0	0	DDC	NO	NO	4	22	0	YES
10	Calaveras Hall	21,630	Central AHUs	Dual-Duct VAV	Central Plant CHW	600	YES	Central Plant Steam	25.0	YES	1	40	0	YES	YES	Partial	NO	NO	1	2	NO	NO
11	Capistrano Hall	84,722	Central AHUs	Dual-Duct VAV	Central Plant CHW	600	YES	Central Plant Steam	25.0	YES	2	80	30	YES	YES	YES	NO	YES	2	6	No	NO
12	Central Plant	13,569	Central AHUs	Std. VAV w/ HW Reheat	CHW	600	YES	HHW	25.0	YES	2	1	0	YES	YES	NO	NO	NO	0	0	0	0
13	Child Development Center	13,704	Central AHUS	Heat Pumps	Heat Pumps	600	NO	Heat Pumps	25.0	NO	3	5	2	0	0	Programmable Thermostat	NO	NO	0	0	0	YES
14	Del Norte Hall	54,000	Central AHUs	Dual-Duct VAV	Central Plant CHW	600	YES	Central Plant HW	25.0	YES	5	56	8	YES	YES	DDC	YES	NO	3	11	YES	NO
15	Desmond Hall	50,134	Fan Coil - Four Pipe	Fan Coil - Four Pipe	Standalone Chiller	177	NO	Standalone Boiler	17.7	NO	131	131	0	YES	NO	YES	NO	NO	6	50	YES	NO
16	Dining Commons	22,747	Central AHUs	Std. VAV w/ HW Reheat	Standalone Chiller	38	NO	Standalone Boiler	9.4	NO	3	27	0	YES	YES	YES	NO	NO	6	90	YES	0
17	Douglass Hall	22,700	Central AHUs	Fan Coil Units	Central Plant CHW	600	YES	Central Plant Steam	25.0	YES	2	9	3	NO	NO	Partial	NO	NO	1	3	No	NO
18	Draper Hall	38,212	Central AHUs	Four Pipe - Fan Coil	Standalone Chiller	185	NO	Standalone Boiler	114.8	NO	121	21	0	NO	NO	YES	NO	NO	3	13	YES	NO
19	Eureka Hall	59,488	Central AHUs	Dual-Duct VAV	Central Plant CHW	600	YES	Central Plant Steam	25.0	YES	1	60	30	YES	YES	DDC	YES	NO	1	3	No	NO
20	Exterior Lights	NA	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	Facilities Management	38,872	Central AHUs	Constant Volume SZ & MZ	DX	478	NO	Gas Furnace	28.3	NO	15	16	0	NO	YES	YES	NO	NO	0	0	Not Applicable	NO
22	Handball Courts	2,500	Central AHUs	Const. Vol. Multi-Zone	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	Hornet Bookstore	93,170	Central AHUs	Std. VAV w/ HW Reheat	CHW Campus Loop	209	YES	HHW - Gas Fired Boilers (2)	18.0	NO	2	130	45	YES	YES	DDC	YES	NO	4	22.5	YES	YES

Summary of Existing HVAC System Characteristics at Campus Buildings

Building ID	Building Name	Building Area (GSF)	System Type	Zone Level System	Cooling Type	SFT Per Cooling Ton	Connected to CHW Plant (YES/NO)	Heating Type	SFT per Heating MBH	Connected to Central Steam Plant (YES/NO)	AHU Quantity	Total Supply Fan HP	Total Return Fan HP	Fan on VFD	Economizer	Controls Type	CO2 DCV Controls	Occupancy Based HVAC Controls	Pumps Quantity	Pumps HP	Pumps on VFD	Optimal Start
24	Jenkins Hall	38,212	Central AHUs	Fan Coil - Four Pipe	Standalone Chiller	359	NO	Standalone Boiler	114.8	NO	121	21	0	NO	NO	YES	NO	NO	3	13	YES	NO
25	Kadema Hall	46,184	Central AHUs	Dual-Duct Constant Vol.	Central Plant CHW	600	YES	Central Plant Steam	25.0	YES	3	50	30	YES	YES	Partial	YES	NO	3	3	No	NO
26	Lassen Hall	80,445	Central AHUs	Dual-Duct VAV	Central Plant CHW	600	YES	Central Plant Steam	25.0	YES	4	80	20	YES	Yes	Partial	Yes	NO	3	5	No	YES
27	Library I & II	377,074	Central AHUs	Dual-Duct VAV Std. VAV w/ HW Reheat	Central Plant CHW	600	YES	Central Plant Steam	25.0	YES	12	195	101	YES	YES	Partial	YES	NO	7	52	YES	YES
28	Mariposa Hall	78,079	Central AHUs	Std. VAV w/ HW Reheat	Central Plant CHW	162	YES	Central Plant Steam	44.0	YES	6	188	50	YES	YES	YES	YES	NO	4	36	YES	YES
29	Mendocino Hall	77,000	Central AHUs	Std. VAV w/ HW Reheat	Central Plant CHW	600	YES	Central Plant Steam	60.0	YES	2	100	30	YES	YES	YES	YES	NO	4	75	YES	NO
30	Modoc Hall	85,402	Central AHUs	Std. VAV w/ HW Reheat	Standalone Chiller	102	NO	Standalone Boiler	55.0	NO	3	151	30	YES	YES	YES	NO	NO	7	72	Partial	NO
31	Napa Hall	33,392	Central AHUs	VAV	DX Package Unit	216	NO	Gas Furnace	21.0	NO	2	88	20	YES	YES	YES	NO	NO	Not Applicable	Not Applicable	Not Applicable	NO
32	Parking Structure (All)	77,000	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	Placer Hall	67,101	Central AHUs	Dual-Duct VAV	Central Plant CHW	600	YES	Central Plant Steam	25.0	YES	1	120	50	YES	YES	YES	YES	NO	4	30	YES	NO
34	Public Safety Building	11,892	Fan Coil - Four Pipe	Fan Coil Units	Air Cooled Chiller	600	NO	Standalone Boiler	25.0	NO	13	13	5	0	0	Pneumatic Hybrid	NO	NO	4	10	0	YES
35	Riverfront Center	40,198	Central AHUs	FALSE	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	Riverside Hall	83,316	Central AHUs	Std. VAV w/ HW Reheat	Cental Plant Chilled Water	291	YES	Central Plant Steam	47.6	YES	3	73	10	YES	YES	Partial	YES	NO	2	8	NO	YES
37	Riverview Hall	128,000	Central AHUs	Std. VAV w/ HW Reheat	Central Plant CHW Loop	138	YES	Steam (Central Plant Steam Loop)	24.5	YES	7	175	50	YES	YES	YES	NO	NO	0	0	0	NO
38	Sacramento Hall	38,090	Central AHUs	Dual-Duct VAV	Central Plant CHW	600	YES	Central Plant Steam	25.0	YES	2	30	13	YES	YES	Partial	YES	NO	1	2	No	NO
39	Santa Clara Hall	66,391	Central AHUs	Constant Voulme Single Zone	CHW (Central Plant Loop)	600	YES	Steam (Central Plant Loop)	25.0	YES	10	37	12	NO	YES	Pneumatic Hybrid	NO	NO	3	3	NO	NO
40	Sequoia Hall	201,527	Central AHUs	Dual-Duct VAV	Central Plant CHW	600	YES	Central Plant Steam	25.0	YES	5	250	56	YES	YES	Pneumatic Hybrid	NO	NO	29	68	YES	NO
41	Shasta Hall	62,667	Central AHUs	Dual-Duct VAV	Central Plant CHW	600	YES	Central Plant Steam	25.0	YES	13	71	2	YES	YES	Partial	NO	NO	3	24	YES	NO
42	Sierra Hall	41,662	Central AHUs	Std. VAV w/ HW Reheat	CHW - From Dining Commons	571	NO	HHW	23.7	NO	5	28	0	YES	YES	YES	NO	NO	4	11	YES	NO
43	Solano Hall	67,710	Central AHUs	Std. VAV w/ HW Reheat	Central Plant CHW	600	YES	Central Plant Steam	25.0	YES	7	30	10	0	0	DDC	NO	NO	4	17	0	YES
44	Sutter Hall	40,102	Central AHUs	Std. VAV w/ HW Reheat	Campus Chilled Water Loop	509	YES	Standalone Boiler	26.0	NO	0	0	0	YES	YES	YES	NO	NO	4	11	YES	NO
45	Tahoe Hall	64,764	Central AHUs	Std. VAV w/ HW Reheat	Central Plant CHW	600	YES	Central Plant Steam	25.0	YES	3	29	31	YES	YES	DDC	YES	NO	2	2	No	NO
46	The Well	150,845	Central AHUs	Std. VAV w/ HW Reheat	CHW - Chillers Standalone	435	NO	Steam	21.6	NO	4	140	53	YES	YES	YES	NO	NO	0	0	0	0

Summary of Existing HVAC System Characteristics at Campus Buildings

Building ID	Building Name	Building Area (GSF)	System Type	Zone Level System	Cooling Type	SFT Per Cooling Ton	Connected to CHW Plant (YES/NO)	Heating Type	SFT per Heating MBH	Connected to Central Steam Plant (YES/NO)	AHU Quantity	Total Supply Fan HP	Total Return Fan HP	Fan on VFD	Economizer	Controls Type	CO2 DCV Controls	Occupancy Based HVAC Controls	Pumps Quantity	Pumps HP	Pumps on VFD	Optimal Start
47	University Print & Mail	3,500	Gas Electric Package Unit	CVMZ	DX	253	NO	Gas Furnace	95.0	NO	1	4	0	NO	NO	NO	NO	NO	0	0	0	0
48	University Union	217,000	Central AHUs	Std. VAV w/ HW Reheat	Standalone Chillers	338	NO	Campus Steam	22.3	YES	5	265	123	YES	Partial	YES	NO	NO	0	0	0	0
49	Yosemite Hall	82,301	Central AHUs	CVSZ, Dual Duct VAV, CVMZ	Central Plant CHW	600	YES	Central Plant Steam	25.0	YES	6	120	16	NO	YES	YES	YES	NO	6	6	NO	NO

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Appendix C - Heating Electrification

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High Level - Preliminary Impact of Heat Pump and Energy Conservation

	Satellite Plant A		Satellite Plant B		Satellite Plant C		Satellite Plant D		Satellite Plant E		Standalone ASHP Systems		Total	
	Buildings Connected: Library (North & South), Amador Hall, Tahoe Hall, Capistrano		Buildings Connected: Eureka Hall, Mariposa Hall, Solano Hall, Yosemite Hall, Kadema, Lassen Hall, Sacramento Hall		Buildings Connected: Riverside Hall, Santa Clara Hall, Sequoia Hall, Humboldt Hall, Mendocino Hall, Del Norte Hall, Riverfront Center, Shasta Hall		Buildings Connected: University Union, Hornet Bookstore, Academic Information Resource Center		Buildings Connected: Housing Buildings (American River Courtyard, Desmond Hall, Draper Hall, Jenkins Hall, Riverview Hall, Sierra Hall, Sutter Hall, Dining Commons)		Remaning Buildings: The Well, Public Safety Building, Riverview Hall, Placer Hall, Modoc Hall, Broad Field House, Alpine Hall, Brighton Hall, Napa Hall, Alumni Center, Benicia Hall, Athletics Center, Calveras Hall, Facilities Management, Douglass Hall, University Print & Mail, & Hot Water Heaters		Complete Electrification/ Decarbonization	
	Proposed Case - with Heat Pump	Base Case - with No Heat Pump	Proposed Case - with Heat Pump	Base Case - with No Heat Pump	Proposed Case - with Heat Pump	Base Case - with No Heat Pump	Proposed Case - with Heat Pump	Base Case - with No Heat Pump	Proposed Case - with Heat Pump	Base Case - with No Heat Pump	Proposed Case - with Heat Pump	Base Case - with No Heat Pump	Proposed Case - with Heat Pump	Base Case - with No Heat Pump
Building GSF	593,698.0	593,698.0	450,907.0	450,907.0	771,598.0	771,598.0	408,093.0	408,093.0	568,119.0	568,119.0	695,673.0	695,673.0	3,488,088.0	3,488,088.0
Heating Peak Btu/GSF	20	20	20	20	20	20	20	20	20	20	20	20	20	20
MMBtu Peak	11.87	11.87	9.02	9.02	15.43	15.43	8.16	8.16	11.36	11.36	13.91	13.91	69.76	69.76
Annual Therms		112,493.1		191,344.8		210,276.0		170,330.6		149,416.1		391,153.3		1,225,014.0
Annual MMBtu		11,249.3		19,134.5		21,027.6		17,033.1		14,941.6		39,115.3		122,501.4
Annual Therms Conservation		35,507.0		35,159.9		56,018.9		11,817.1		7,470.8		89,636.8		235,610.4
Annual Therms Usage Post Conservation		76,986.1		156,184.9		154,257.1		158,513.6		141,945.3		301,516.5		989,403.6
% from Boilers	0%	100%	0%	100%	0%	100%	0%	100%	0%	100%	0%	100%	0%	100%
% from Heat Pump	100%	0%	100%	0%	100%	0%	100%	0%	100%	0%	100%	0%	100%	0%
Annual Gas Usage (Therms)	-	76,986.13	-	156,184.92	-	154,257.14	-	158,513.56	-	141,945.33	-	301,516.48	-	989,403.55
Boiler Efficiency	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
Heating from Boilers (MMBtu)	-	5,774	-	11,714	-	11,569	-	11,889	-	10,646	-	22,614	-	74,205
Heating from Heat Pumps (MMBtu)	5,774		11,714		11,569		11,889		10,646		22,614		74,205	
Heat Pump MMBtu/Ton	0.0164356	0.0164356	0.0164356	0.0164356	0.0164356	0.0164356	0.0164356	0.0164356	0.0164356	0.0164356	0.0164356	0.0164356	0.0164356	0.0164356
Heat Pump kW/Ton	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Heat Pump Ton Hours	351,308.13		712,713.18		703,916.22		723,339.40		647,734.16		1,375,899.62		4,514,910.72	
Heat Pump kWh	456,701		926,527		915,091		940,341		842,054		1,788,670		5,869,384	
TOTAL Annual Electricity Usage	456,701	-	926,527	-	915,091	-	940,341	-	842,054	-	1,788,670	-	5,869,384	-
TOTAL Annual Natural Gas Usage		76,986		156,185		154,257		158,514		141,945		301,516		989,404
GHG Factors														
Gas (Metric Tons/Therm)	0.0053020	0.0053020	0.0053020	0.0053020	0.0053020	0.0053020	0.0053020	0.0053020	0.0053020	0.0053020	0.0053020	0.0053020	0.0053020	0.0053020
Elec (Metric Tons/kwh)	0.0001724	0.000172	0.0001724	0.000172	0.0001724	0.000172	0.0001724	0.000172	0.0001724	0.000172	0.0001724	0.000172	0.0001724	0.000172
TOTAL GHG (Metric Tons)	79	408	160	828	158	818	162	840	145	753	308	1,599	1,012	5,246
Emission Reduction (Metric Tons)	329		668		660		678		607		1,290		4,234	
% Annual GHG REDUCTION	80.7%		80.7%		80.7%		80.7%		80.7%		80.7%		80.7%	
TOTAL GHG (Metric Tons)	79	408	160	828	158	818	162	840	145	753	308	1,599	1,012	5,246
Emission Reduction (Metric Tons)	329		668		660		678		607		1,290		4,234	
% Annual GHG REDUCTION	80.7%		80.7%		80.7%		80.7%		80.7%		80.7%		80.7%	
Annual Utility Cost														
Elec Rate ($/kWh)	$0.09	$0.09	$0.09	$0.09	$0.09	$0.09	$0.09	$0.09	$0.09	$0.09	$0.09	$0.09	$0.09	$0.09
Gas Rate ($/MMBtu)	$7.03	$7.03	$7.03	$7.03	$7.03	$7.03	$7.03	$7.03	$7.03	$7.03	$7.03	$7.03	$7.03	$7.03
Electricity Cost ($)	$41,103	$0	$83,387	$0	$82,358	$0	$84,631	$0	$75,785	$0	$160,980	$0	$528,245	$0
Gas Cost ($)	$0	$54,117	$0	$109,789	$0	$108,434	$0	$111,426	$0	$99,779	$0	$211,948	$0	$695,491
TOTAL COST	$41,103	$54,117	$83,387	$109,789	$82,358	$108,434	$84,631	$111,426	$75,785	$99,779	$160,980	$211,948	$528,245	$695,491
Total Annual Energy Cost Savings ($)	$13,014		$26,401		$26,075		$26,795		$23,994		$50,968		$167,247	
Number of 30 Ton Heat Pumps	42.00		38.00		69.00		30.00		41.00		50.00		250.00	
kVA Capacity for Heat Pumps	2,618.78		2,369.38		4,302.29		1,870.56		2,556.43		3,117.60		15,588.00	
ROM - Costs for Planning														
Cost/Ton of Heat Pumps Installed	$13,820		$13,820		$13,820		$13,820		$13,820		$13,820		$13,820	
Total Installed Cost ($)	$17,413,046		$15,754,660		$28,607,146		$12,437,890		$16,998,449		$20,729,816		$111,941,008	
Simple Payback Period (Years)	1338.1		596.7		1097.1		464.2		708.4		406.7		669.3	
Cost per Metric Ton Eliminated ($)	$52,853.1		$23,571.0		$43,334.9		$18,335.3		$27,983.1		$16,065.4		$26,437.7	

High Level - Preliminary Impact of Heat Pump and Energy Conservation

	Satellite Plant A Buildings Connected: Library (North & South), Amador Hall, Tahoe Hall, Capistrano		Satellite Plant B Buildings Connected: Eureka Hall, Mariposa Hall, Solano Hall, Yosemite Hall, Kadema, Lassen Hall, Sacramento Hall		Satellite Plant C Buildings Connected: Riverside Hall, Santa Clara Hall, Sequoia Hall, Humboldt Hall, Mendocino Hall, Del Norte Hall, Riverfront Center, Shasta Hall		Satellite Plant D Buildings Connected: University Union, Hornet Bookstore, Academic Information Resource Center		Satellite Plant E Buildings Connected: Housing Buildings (American River Courtyard, Desmond Hall, Draper Hall, Jenkins Hall, Riverview Hall, Sierra Hall, Sutter Hall, Dining Commons)		Standalone ASHP Systems Remaning Buildings: The Well, Public Safety Building, Riverview Hall, Placer Hall, Modoc Hall, Broad Field House, Alpine Hall, Brighton Hall, Napa Hall, Alumni Center, Benicia Hall, Athletics Center, Calveras Hall, Facilities Management, Douglass Hall, University Print & Mail, & Hot Water Heaters		Total Complete Electrification/ Decarbonization	
	Proposed Case - with Heat Pump	Base Case - with No Heat Pump	Proposed Case - with Heat Pump	Base Case - with No Heat Pump	Proposed Case - with Heat Pump	Base Case - with No Heat Pump	Proposed Case - with Heat Pump	Base Case - with No Heat Pump	Proposed Case - with Heat Pump	Base Case - with No Heat Pump	Proposed Case - with Heat Pump	Base Case - with No Heat Pump	Proposed Case - with Heat Pump	Base Case - with No Heat Pump
Overall Natural Gas for building heating (Therms)	1225014		1225014		1225014		1225014		1225014		1225014		1225014	
Overall Savings (Therms)	235,610		235,610		235,610		235,610		235,610		235,610		235,610	
Total Campus Wide Natural Gas Usgae - Post ECMs (Therms)	989,404		989,404		989,404		989,404		989,404		989,404		989,404	
Total % Natural Gas Dependence Eliminated	7.8%		15.8%		15.6%		16.0%		14.3%		30.5%		100.0%	

Project Cost Estimate - 07.16.21

Campus: California State University Sacramento

Project: Air Source Heat Pump Estimate for CSUS - Location A (Plant & Electrical Infrastructure Cost)

Cost Factors

Tax Rate	7.75%
Sub Contractor Overhead & Profit Multiplier	1.26
City Location Price Multiplier	1.072 (Sacramento, CA)

Item #	Description	Qty	Units	Unit Material Cost ($)	Unit Labor Cost ($)	Unit Equipment Cost ($)	Total Unit Cost ($)	Material Cost ($)	Labor Cost ($)	Equipment Cost ($)	Taxes ($)	TOTAL DIRECT COST ($)	CONTRACTOR COST WITH O&P
	Heat Pump water Source - 30 Ton	42	Ea.	$ 23,700.00	$ 8,125.00		$ 31,825.00	$ 1,067,069	$ 365,820	$ -	$ 82,698	$ 1,515,587	$ 1,909,639
	Existing Condition	6000	SF		$ 5.00	$ 14.28	$ 5.00	$ -	$ 32,160	$ 91,849	$ -	$ 124,009	$ 156,251
	Pre-insulated sch. 40 pipe 2", chw/hhw supply and return	441	LF	$ 154.00	$ 23.00	$ 3.88	$ 177.00	$ 72,804	$ 10,873	$ 1,834	$ 5,642	$ 91,154	$ 114,854
	Pre-insulated sch. 40 pipe 3", chw/hhw supply and return	220.5	LF	$ 205.00	$ 42.00	$ 5.52	$ 247.00	$ 48,457	$ 9,928	$ 1,305	$ 3,755	$ 63,445	$ 79,941
	Pre-insulated sch. 40 pipe 6", chw/hhw supply and return	424.2	LF	$ 320.00	$ 77.00	$ 6.60	$ 397.00	$ 145,518	$ 35,015	$ 3,001	$ 11,278	$ 194,812	$ 245,463
	Pre-insulated sch. 40 pipe 10", chw/hhw supply and return	84	LF	$ 365.00	$ 116.00	$ 9.88	$ 481.00	$ 32,868	$ 10,446	$ 890	$ 2,547	$ 46,750	$ 58,905
	Pre-insulated sch. 40 pipe 12", chw/hhw supply and return	210	LF	$ 390.00	$ 147.00	$ 12.48	$ 537.00	$ 87,797	$ 33,093	$ 2,809	$ 6,804	$ 130,503	$ 164,434
	Elbows, Tees, Fittings for all piping (20% Adder on Piping)												$ 132,719
	Pipe Support - Branch Pipes	661.5	LF	$ 61.00	$ 58.00		$ 119.00	$ 43,257	$ 41,129	$ -	$ 3,352	$ 87,739	$ 110,551
	Pipe Support -Main Pipes	718.2	LF	$ 198.00	$ 78.00		$ 276.00	$ 152,442	$ 60,053	$ -	$ 11,814	$ 224,310	$ 282,630
	Vertical In-Line Pump - 10", 1500 gpm	2	Ea.	$ 30,000.00	$ 1,990.00		$ 31,990.00	$ 64,320	$ 4,267	$ -	$ 4,985	$ 73,571	$ 92,700
	Pump Support	2	Ea.	$ 10,000.00	$ 1,500.00		$ 11,500.00	$ 21,440	$ 3,216	$ -	$ 1,662	$ 26,318	$ 33,160
	Suction Diffuser - 10"	2	Ea.	$ 6,600.00	$ 1,230.00		$ 7,830.00	$ 14,150	$ 2,637	$ -	$ 1,097	$ 17,884	$ 22,534
	Dirt Separator - 12"	1	Ea.	$ 25,000.00	$ 1,660.00		$ 26,660.00	$ 26,800	$ 1,780	$ -	$ 2,077	$ 30,657	$ 38,627
	Flexible Coupling - 10"	2	Ea.	$ 332.00	$ 171.00		$ 503.00	$ 712	$ 367	$ -	$ 55	$ 1,134	$ 1,428
	Variable Frequency Drive - 40 HP Nema 3R	2	Ea.	$ 12,000.00	$ 3,600.00		$ 15,600.00	$ 25,728	$ 7,718	$ -	$ 1,994	$ 35,440	$ 44,655
	Butterfly Valve - 2"	21	Ea.	$ 1,500.00	$ 199.00		$ 1,699.00	$ 33,768	$ 4,480	$ -	$ 2,617	$ 40,865	$ 51,490
	Butterfly Valve - 6"	2	Ea.	$ 4,150.00	$ 930.00		$ 5,080.00	$ 8,898	$ 1,994	$ -	$ 690	$ 11,581	$ 14,592
	Butterfly Valve - 12"	6	Ea.	$ 8,500.00	$ 1,640.00		$ 10,140.00	$ 54,672	$ 10,548	$ -	$ 4,237	$ 69,458	$ 87,517
	Check Valve - 10"	2	Ea.	$ 5,325.00	$ 350.00	$ 208.00	$ 5,883.00	$ 11,417	$ 750	$ 446	$ 885	$ 13,498	$ 17,007
	Strainer - 10"	2	Ea.	$ 3,650.00	$ 1,410.00		$ 5,060.00	$ 7,826	$ 3,023	$ -	$ 606	$ 11,455	$ 14,433
	Equipment Pad 10"	32.9	Ea.	$ 1,292.00	$ 950.00	$ 20.40	$ 2,262.40	$ 45,567	$ 33,505	$ 719	$ 3,531	$ 83,324	$ 104,988
	DDC Controls (Controller, Control Points, Programming, Testing) & Instrumentation (Pressure, Temp etc)	1	Ea.				$ 75,000						$ 75,000
	Start-Up, Testing, and Balancing	1	Ea.	$ -	$ 10,000	$ -	$ 10,000	$ -	$ 10,720	$ -	$ -	$ 10,720	$ 13,507
	Electrical Infrastructure - Kva	2,618.78	Ea.				$ 1,000						$ 2,618,784
	INSTALLING CONTRACTOR COST												**$ 6,485,809**
	General Contractor O&P	15%											$ 972,871
	Construction Contingency	20%											$ 1,491,736
	Construction Cost with Contingency												$ 8,950,417
	Soft Costs Markup	30%											$ 2,685,125
	TOTAL PROJECT BUDGET ($)												**$ 11,635,542**

Project Cost Estimate - 07.16.2021

Campus: California State University Sacramento

Project: Air Source Heat Pump Estimate for CSUS - Location B (Plant & Electrical Infrastructure Cost)

Cost Factors

Tax Rate	7.8%
Sub Contractor Overhead & Profit Multiplier	1.26
City Location Price Multiplier	1.072 (Sacramento, CA)

Item #	Description	Qty	Units	Unit Material Cost ($)	Unit Labor Cost ($)	Unit Equipment Cost ($)	Total Unit Cost ($)	Material Cost ($)	Labor Cost ($)	Equipment Cost ($)	Taxes ($)	TOTAL DIRECT COST ($)	CONTRACTOR COST WITH O&P
	Heat Pump water Source - 30 Ton	38	Ea.	$ 23,700.00	$ 8,125.00		$ 31,825.00	$ 965,443	$ 330,980	$ -	$ 74,822	$ 1,371,245	$ 1,727,769
	Existing Condition	4500	SF		$ 5.00	$ 14.28	$ 5.00	$ -	$ 24,120	$ 68,887	$ -	$ 93,007	$ 117,188
	Pre-insulated sch. 40 pipe 2", chw/hhw supply and return	399	LF	$ 154.00	$ 23.00	$ 3.88	$ 177.00	$ 65,870	$ 9,838	$ 1,660	$ 5,105	$ 82,472	$ 103,915
	Pre-insulated sch. 40 pipe 3", chw/hhw supply and return	199.5	LF	$ 205.00	$ 42.00	$ 5.52	$ 247.00	$ 43,842	$ 8,982	$ 1,181	$ 3,398	$ 57,403	$ 72,327
	Pre-insulated sch. 40 pipe 6", chw/hhw supply and return	840	LF	$ 320.00	$ 77.00	$ 6.60	$ 397.00	$ 288,154	$ 69,337	$ 5,943	$ 22,332	$ 385,766	$ 486,065
	Pre-insulated sch. 40 pipe 10", chw/hhw supply and return	84	LF	$ 365.00	$ 116.00	$ 9.88	$ 481.00	$ 32,868	$ 10,446	$ 890	$ 2,547	$ 46,750	$ 58,905
	Pre-insulated sch. 40 pipe 12", chw/hhw supply and return	105	LF	$ 390.00	$ 147.00	$ 12.48	$ 537.00	$ 43,898	$ 16,546	$ 1,405	$ 3,402	$ 65,252	$ 82,217
	Elbows, Tees, Fittings for all piping (20% Adder on Piping)												$ 160,686
	Pipe Support - Branch Pipes	598.5	LF	$ 61.00	$ 58.00		$ 119.00	$ 39,137	$ 37,212	$ -	$ 3,033	$ 79,383	$ 100,022
	Pipe Support -Main Pipes	1029	LF	$ 198.00	$ 78.00		$ 276.00	$ 218,411	$ 86,041	$ -	$ 16,927	$ 321,379	$ 404,938
	Vertical In-Line Pump - 10", 1500 gpm	2	Ea.	$ 30,000.00	$ 1,990.00		$ 31,990.00	$ 64,320	$ 4,267	$ -	$ 4,985	$ 73,571	$ 92,700
	Pump Support	2	Ea.	$ 10,000.00	$ 1,500.00		$ 11,500.00	$ 21,440	$ 3,216	$ -	$ 1,662	$ 26,318	$ 33,160
	Suction Diffuser - 10"	2	Ea.	$ 6,600.00	$ 1,230.00		$ 7,830.00	$ 14,150	$ 2,637	$ -	$ 1,097	$ 17,884	$ 22,534
	Dirt Separator - 12"	1	Ea.	$ 25,000.00	$ 1,660.00		$ 26,660.00	$ 26,800	$ 1,780	$ -	$ 2,077	$ 30,657	$ 38,627
	Flexible Coupling - 10"	2	Ea.	$ 332.00	$ 171.00		$ 503.00	$ 712	$ 367	$ -	$ 55	$ 1,134	$ 1,428
	Variable Frequency Drive - 40 HP Nema 3R	2	Ea.	$ 12,000.00	$ 3,600.00		$ 15,600.00	$ 25,728	$ 7,718	$ -	$ 1,994	$ 35,440	$ 44,655
	Butterfly Valve - 2"	19	Ea.	$ 1,500.00	$ 199.00		$ 1,699.00	$ 30,552	$ 4,053	$ -	$ 2,368	$ 36,973	$ 46,586
	Butterfly Valve - 6"	2	Ea.	$ 4,150.00	$ 930.00		$ 5,080.00	$ 8,898	$ 1,994	$ -	$ 690	$ 11,581	$ 14,592
	Butterfly Valve - 12"	6	Ea.	$ 8,500.00	$ 1,640.00		$ 10,140.00	$ 54,672	$ 10,548	$ -	$ 4,237	$ 69,458	$ 87,517
	Check Valve - 10"	2	Ea.	$ 5,325.00	$ 350.00	$ 208.00	$ 5,883.00	$ 11,417	$ 750	$ 446	$ 885	$ 13,498	$ 17,007
	Strainer - 10"	2	Ea.	$ 3,650.00	$ 1,410.00		$ 5,060.00	$ 7,826	$ 3,023	$ -	$ 606	$ 11,455	$ 14,433
	Equipment Pad 10"	34.12	Ea.	$ 1,292.00	$ 950.00	$ 20.40	$ 2,262.40	$ 47,257	$ 34,748	$ 746	$ 3,662	$ 86,413	$ 108,881
	DDC Controls (Controller, Control Points, Programming, Testing) & Instrumentation (Pressure, Temp etc)	1	Ea.				$ 75,000						$ 75,000
	Start-Up, Testing, and Balancing	1	Ea.	$ -	$ 10,000	$ -	$ 10,000	$ -	$ 10,720	$ -	$ -	$ 10,720	$ 13,507
	Electrical Infrastructure - KVA	2,369.38	Ea.				1000					1000	2,369,376
	INSTALLING CONTRACTOR COST												**$ 6,294,036**
	General Contractor O&P	15%											$ 944,105
	Construction Contingency	20%											$ 1,447,628
	Construction Cost with Contingency												$ 8,685,770
	Soft Costs Markup	30%											$ 2,605,731
	TOTAL PROJECT BUDGET ($)												**$ 11,291,501**

Project Cost Estimate - 07.16.2021

Campus: California State University Sacramento

Project: Air Source Heat Pump Estimate for CSUS - Location C (Plant & Electrical Infrastructure Cost)

Cost Factors

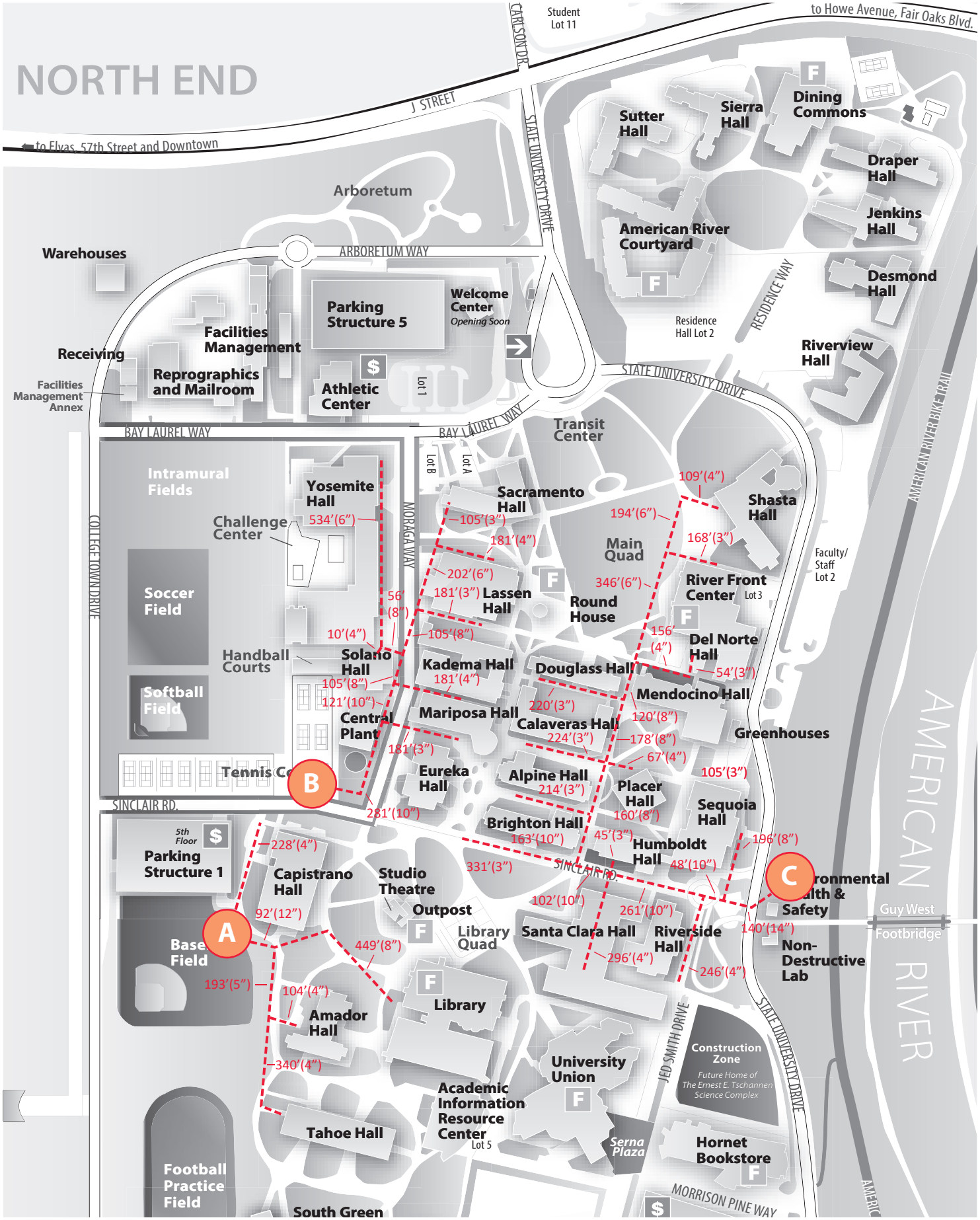
Tax Rate	7.75%
Sub Contractor Overhead & Profit Multiplier	1.26
City Location Price Multiplier	1.072 (Los Angeles, CA)

Item #	Description	Qty	Units	Unit Material Cost ($)	Unit Labor Cost ($)	Unit Equipment Cost ($)	Total Unit Cost ($)	Material Cost ($)	Labor Cost ($)	Equipment Cost ($)	Taxes ($)	TOTAL DIRECT COST ($)	CONTRACTOR COST WITH O&P
	Heat Pump water Source - 30 Ton	69	Ea.	$ 23,700.00	$ 8,125.00		$ 31,825.00	$ 1,753,042	$ 600,990	$ -	$ 135,861	$ 2,489,892	$ 3,137,264
	Existing Condition	6000	SF		$ 5.00	$ 14.28	$ 5.00	$ -	$ 32,160	$ 91,849	$ -	$ 124,009	$ 156,251
	Pre-insulated sch. 40 pipe 2", chw/hhw supply and return	724.5	LF	$ 154.00	$ 23.00	$ 3.88	$ 177.00	$ 119,606	$ 17,863	$ 3,013	$ 9,269	$ 149,752	$ 188,688
	Pre-insulated sch. 40 pipe 3", chw/hhw supply and return	362.25	LF	$ 205.00	$ 42.00	$ 5.52	$ 247.00	$ 79,608	$ 16,310	$ 2,144	$ 6,170	$ 104,231	$ 131,331
	Pre-insulated sch. 40 pipe 6", chw/hhw supply and return	646.8	LF	$ 320.00	$ 77.00	$ 6.60	$ 397.00	$ 221,878	$ 53,389	$ 4,576	$ 17,196	$ 297,040	$ 374,270
	Pre-insulated sch. 40 pipe 10", chw/hhw supply and return	84	LF	$ 365.00	$ 116.00	$ 9.88	$ 481.00	$ 32,868	$ 10,446	$ 890	$ 2,547	$ 46,750	$ 58,905
	Pre-insulated sch. 40 pipe 12", chw/hhw supply and return	126	LF	$ 390.00	$ 147.00	$ 12.48	$ 537.00	$ 52,678	$ 19,856	$ 1,686	$ 4,083	$ 78,302	$ 98,660
	Elbows, Tees, Fittings for all piping (20% Adder on Piping)												$ 170,371
	Pipe Support - Branch Pipes	1086.75	LF	$ 61.00	$ 58.00		$ 119.00	$ 71,065	$ 67,570	$ -	$ 5,508	$ 144,142	$ 181,619
	Pipe Support -Main Pipes	856.8	LF	$ 198.00	$ 78.00		$ 276.00	$ 181,861	$ 71,642	$ -	$ 14,094	$ 267,597	$ 337,173
	Vertical In-Line Pump - 10", 1500 gpm	2	Ea.	$ 30,000.00	$ 1,990.00		$ 31,990.00	$ 64,320	$ 4,267	$ -	$ 4,985	$ 73,571	$ 92,700
	Pump Support	2	Ea.	$ 10,000.00	$ 1,500.00		$ 11,500.00	$ 21,440	$ 3,216	$ -	$ 1,662	$ 26,318	$ 33,160
	Suction Diffuser - 10"	2	Ea.	$ 6,600.00	$ 1,230.00		$ 7,830.00	$ 14,150	$ 2,637	$ -	$ 1,097	$ 17,884	$ 22,534
	Dirt Separator - 12"	1	Ea.	$ 25,000.00	$ 1,660.00		$ 26,660.00	$ 26,800	$ 1,780	$ -	$ 2,077	$ 30,657	$ 38,627
	Flexible Coupling - 10"	2	Ea.	$ 332.00	$ 171.00		$ 503.00	$ 712	$ 367	$ -	$ 55	$ 1,134	$ 1,428
	Variable Frequency Drive - 40 HP Nema 3R	2	Ea.	$ 12,000.00	$ 3,600.00		$ 15,600.00	$ 25,728	$ 7,718	$ -	$ 1,994	$ 35,440	$ 44,655
	Butterfly Valve - 2"	35	Ea.	$ 1,500.00	$ 199.00		$ 1,699.00	$ 56,280	$ 7,466	$ -	$ 4,362	$ 68,108	$ 85,816
	Butterfly Valve - 6"	2	Ea.	$ 4,150.00	$ 930.00		$ 5,080.00	$ 8,898	$ 1,994	$ -	$ 690	$ 11,581	$ 14,592
	Butterfly Valve - 12"	6	Ea.	$ 8,500.00	$ 1,640.00		$ 10,140.00	$ 54,672	$ 10,548	$ -	$ 4,237	$ 69,458	$ 87,517
	Check Valve - 10"	2	Ea.	$ 5,325.00	$ 350.00	$ 208.00	$ 5,883.00	$ 11,417	$ 750	$ 446	$ 885	$ 13,498	$ 17,007
	Strainer - 10"	2	Ea.	$ 3,650.00	$ 1,410.00		$ 5,060.00	$ 7,826	$ 3,023	$ -	$ 606	$ 11,455	$ 14,433
	Equipment Pad 10"	47.58	Ea.	$ 1,292.00	$ 950.00	$ 20.40	$ 2,262.40	$ 65,899	$ 48,455	$ 1,041	$ 5,107	$ 120,503	$ 151,833
	DDC Controls (Controller, Control Points, Programming, Testing) & Instrumentation (Pressure, Temp etc)	1	Ea.				$ 75,000						$ 75,000
	Start-Up, Testing, and Balancing	1	Ea.	$ -	$ 10,000	$ -	$ 10,000	$ -	$ 10,720	$ -	$ -	$ 10,720	$ 13,507
	Electrical Infrastructure - Kva	4,302.29	Ea.				$ 1,000					$ 1,000	$ 4,302,288
	INSTALLING CONTRACTOR COST												**$ 9,829,632**
	General Contractor O&P	15%											$ 1,474,445
	Construction Contingency	20%											$ 2,260,815
	Construction Cost with Contingency												$ 13,564,892
	Soft Costs Markup	30%											$ 4,069,468
	TOTAL PROJECT BUDGET ($)												**$ 17,634,359**

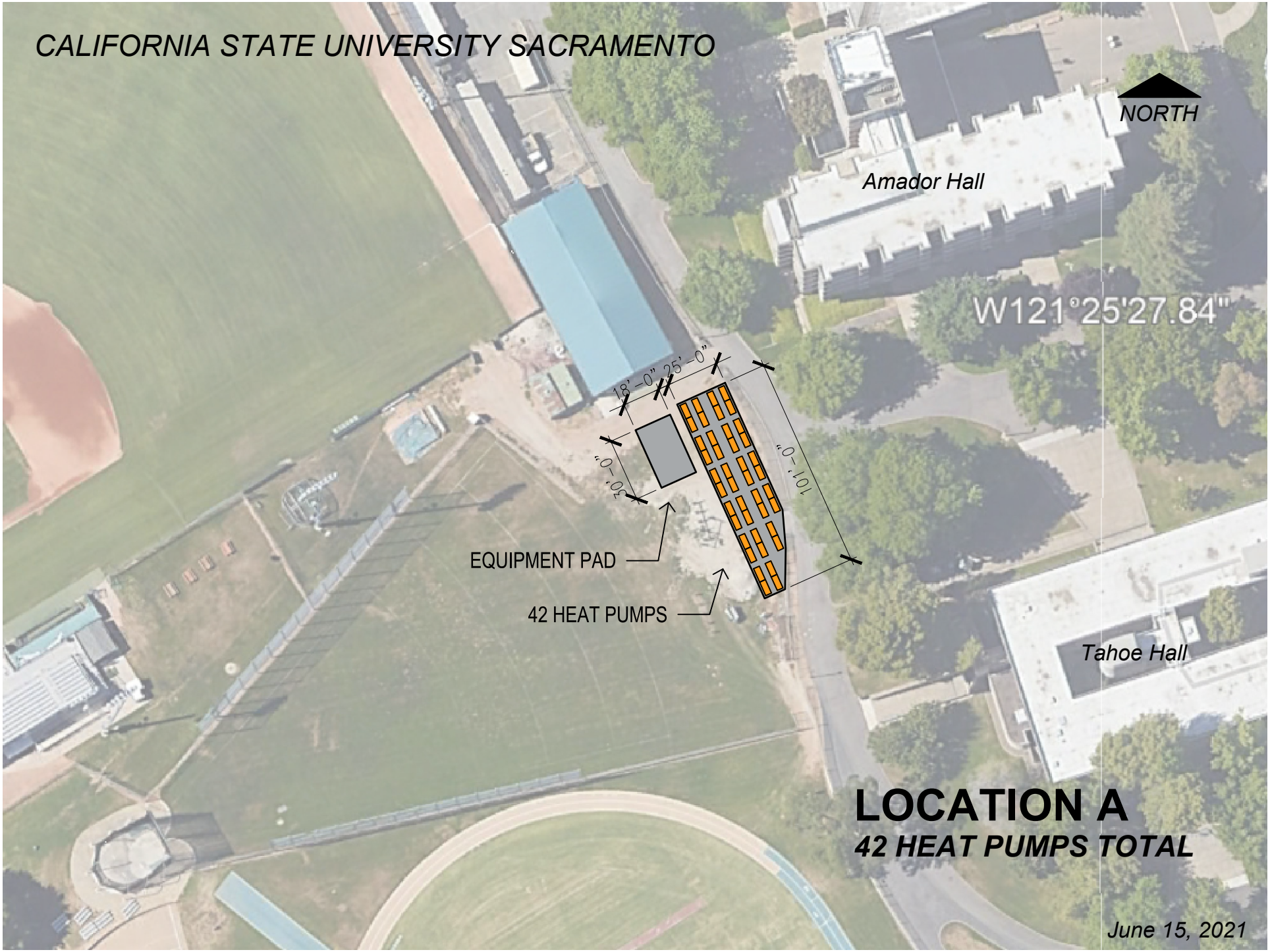
Construction Cost Summary

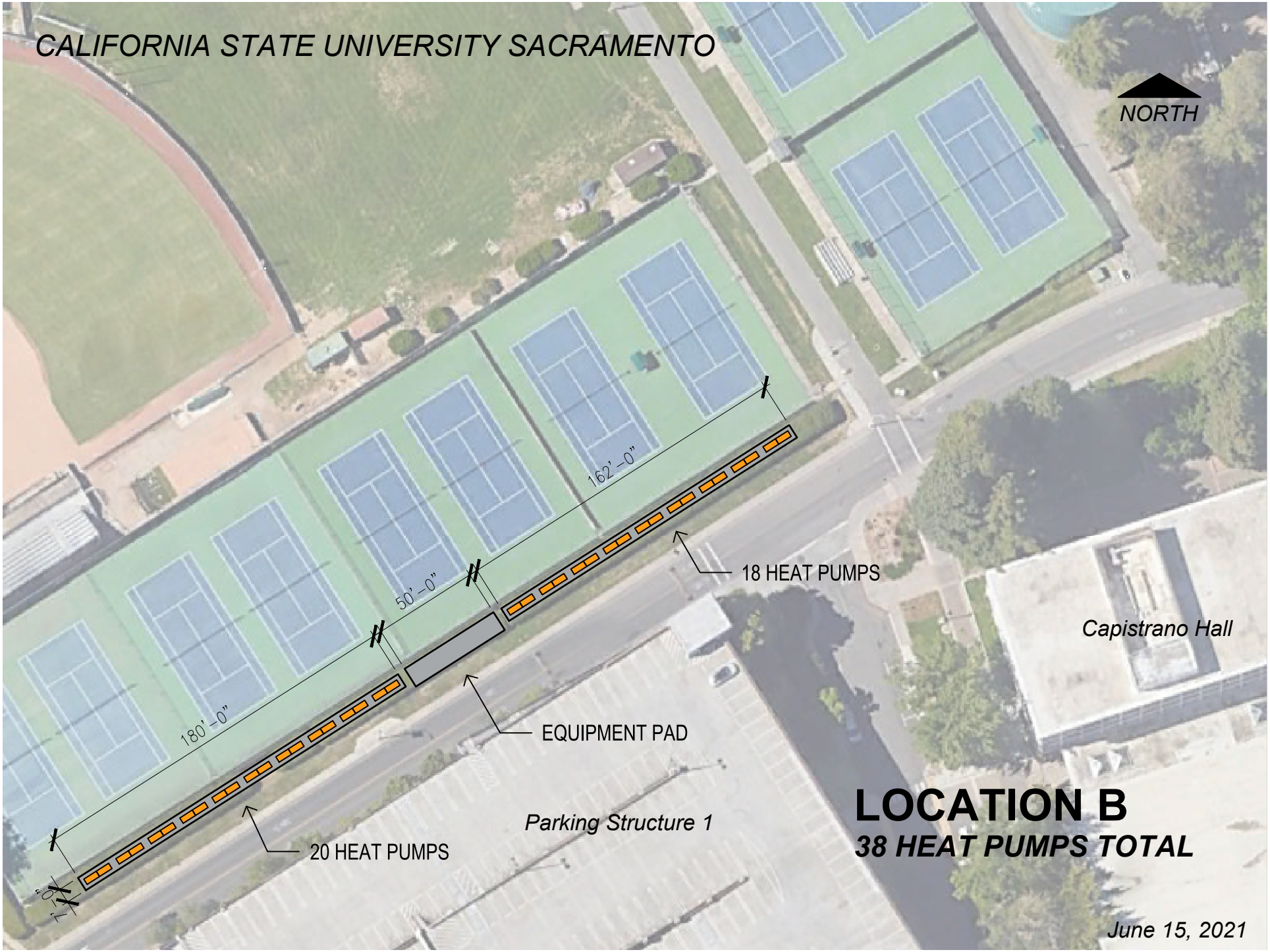
	Element		Total
1	General Requirements		$850,848
2	Existing Conditions		$253,581
31	Earthwork		$86,679
32	Exterior Improvements		$748,960
33	Utilities		$13,133,800
	Subtotal		$15,073,868
	Design Contingency	15.00%	$2,261,080
	Subtotal		$17,334,948
	General Conditions and Requirements	12.00%	$2,080,194
	Subtotal		$19,415,142
	General Contractor Fee	4.00%	$776,606
	Subtotal		$20,191,748
	Bonds and Insurance	2.00%	$403,835
	Subtotal		$20,595,583
	Escalation to MOC	3.00%	$617,867
	Total Estimated Construction Cost		**$21,213,450**

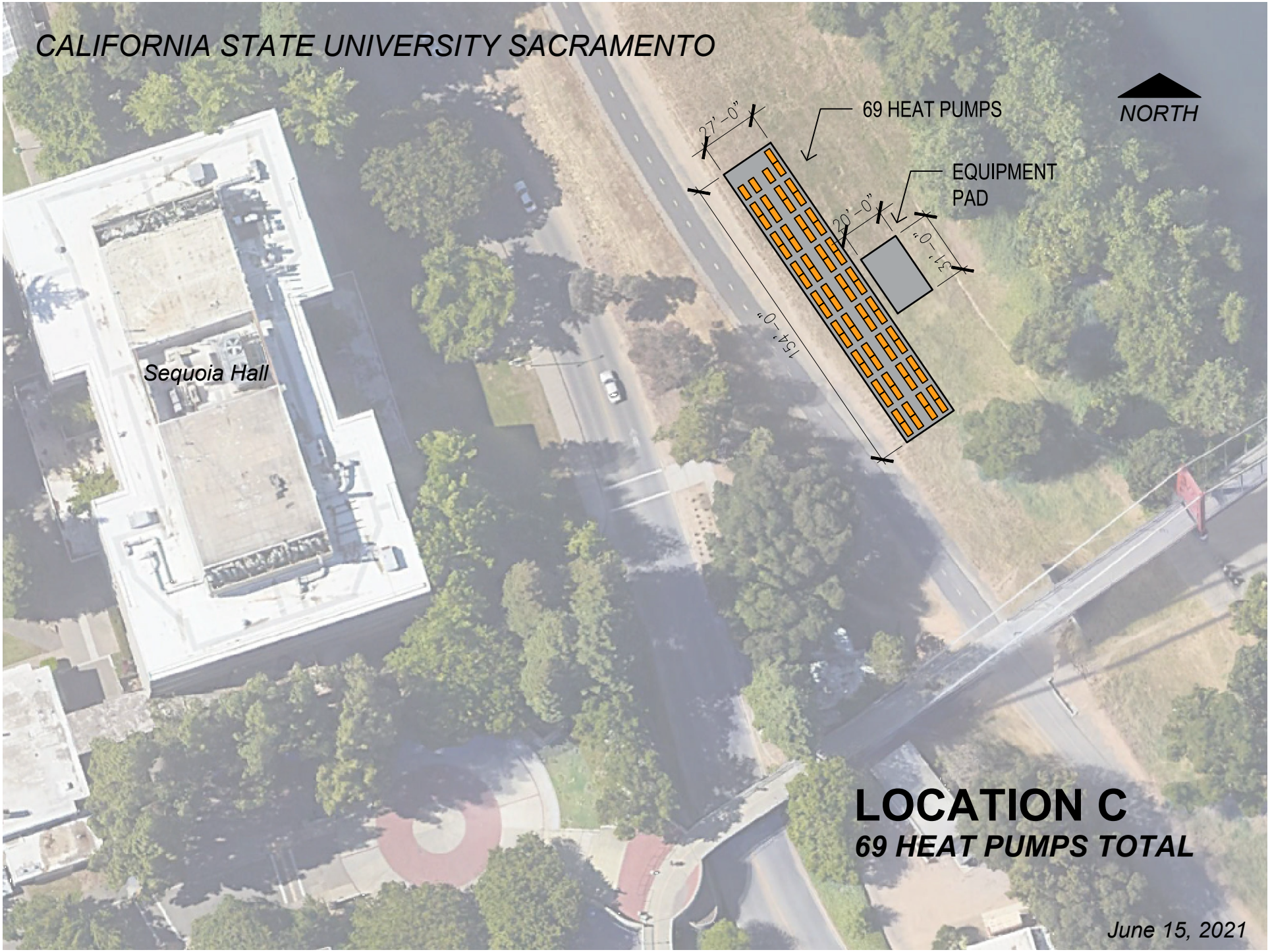
Detailed Construction Cost Summary



SATELLITE PLANT LOCATIONS & HW PIPING LAYOUT


CALIFORNIA STATE UNIVERSITY SACRAMENTO
NORTH
Amador Hall
W121°25'27.84"
18'-0"
25'-0"
20'-0"
107'-0"
EQUIPMENT PAD
42 HEAT PUMPS
Tahoe Hall
LOCATION A
42 HEAT PUMPS TOTAL
June 15, 2021


CALIFORNIA STATE UNIVERSITY SACRAMENTO
NORTH
162' –0"
50' –0"
180' –0"
18 HEAT PUMPS
EQUIPMENT PAD
20 HEAT PUMPS
Capistrano Hall
Parking Structure 1
LOCATION B
38 HEAT PUMPS TOTAL
June 15, 2021


CALIFORNIA STATE UNIVERSITY SACRAMENTO
NORTH
69 HEAT PUMPS
EQUIPMENT PAD
27'-0"
20'-0"
23'-0"
154'-0"
Sequoia Hall
LOCATION C
69 HEAT PUMPS TOTAL
June 15, 2021

Appendix D – Project Saving & Cost Summaries

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ID	Measure	Annual Electric Savings (kWh/Year)	Annual Natural Gas Savings (Therms/Year)	Total Project Costs ($)	Annual Total Energy Cost Savings ($)	Simple Payback Period (Years)	GHG Reduction (Metric Tons/Year)	Cost per GHG Metric Ton Reduction ($/Metric Ton)	Applicable Buildings: Academic Information Resource Center	Alpine Hall	Amador Hall	Athletics Center	Benicia Hall	Brighton Hall	Calaveras Hall	Capistrano Hall	Central Plant	Douglass Hall	Eureka Hall	Facilities Management	Kadema Hall	Lassen Hall	Mariposa Hall	Mendocino Hall	Placer Hall	University Print & Mail	Riverside Hall	Sacramento Hall	Shasta Hall	Tahoe Hall	Yosemite Hall	Library I & II	Sequoia Hall	Public Safety Building	Solano Hall	Public Safety Building	Solano Hall	Broad Field House	Basis for Cost Estimate *(Where Applicable)*
L-1	Building Interior Lighting System Modernization (Fixtures & Controls)	4,643,831	0	$8,302,298	$412,316	20.1	800	$10,372	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		$4.4 per sq.ft. for LED Fixtures & $2.8 per Sq.ft. for Smart Controls
L-2	LED Exit Signs	8,541	0	$9,750	$2,406	4.1	1	$6,622													✓						✓					✓						$250 per LED Exit Sign
L-3	Parking Structure Lighting Modernization	0	0	$0	$0	0.0	-	$0																														$21 per LED Watt
M-1	New VAV AHUs w/ economizers and integrated evaporator coolers. (Dual Duct Constant Volume to Single Duct Variable Volume Reheat System)	294,322	8,229	$5,324,900	$32,969	161.5	94	$56,475		✓		✓						✓			✓																	$70 per AHU CFM
M-2	Pneumatic to DDC controls	1,246,271	37,420	$4,923,279	$123,375	39.9	413	$11,924		✓	✓	✓		✓	✓			✓			✓	✓					✓	✓	✓			✓	✓	✓		✓		$7 per Sq.ft. for Hybrid Pneumatic to DDC $10 per Sq.ft. for Pneumatic to DDC
M-3	Demand controlled ventilation (DCV)	108,304	19,212	$462,662	$23,409	19.8	120	$3,845		✓		✓		✓	✓			✓											✓			✓						$2 per Sq.ft.
M-4	Occupancy-based HVAC	933,671	66,045	$1,079,163	$123,479	8.7	510	$2,114	✓	✓	✓	✓		✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓					$1 per Sq.ft.
M-5	Retro-commission HVAC System & Controls Optimization	1,056,852	35,255	$1,838,783	$106,029	17.3	369	$4,986	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	$1 per Sq.ft.
M-6	Replace Chillers	0	0	0	0	0	0	0																														$1,500 per Ton
M-7	Replace Boilers	0	0	0	0	0	0	0																														$173 per Mbtuh
Env-1	Vending machine occupancy controls for vending machines	20,675	0	$5,625	$6,035	0.9	4	$1,578	✓				✓									✓	✓	✓			✓			✓	✓		✓						$35 per Sq.ft. of Glazing
E-1	High Efficiency Windows	49,864	13,137	$715,357	$14,730	48.6	78	$9,158		✓				✓	✓	✓		✓				✓						✓					✓		✓			$225 per Unit
TOTAL:		8,362,331	179,298	$22,661,815	$844,747	26.8	2,390	$9,481																														

ID	Measure	Annual Electric Savings (kWh/Year)	Annual Natural Gas Savings (Therms/Year)	Total Project Costs ($)	Annual Total Energy Cost Savings ($)	Simple Payback Period (Years)	GHG Reduction (Metric Tons/Year)	Cost per GHG Metric Ton Reduction ($/Metric Ton)	Applicable Buildings																							Basis for Cost Estimate *(Where Applicable)*
									Alumni Center	American River Courtyard	Del Norte Hall	Desmond Hall	Dining Commons	Draper Hall	Hornet Bookstore	Jenkins Hall	Modoc Hall	Napa Hall	Parking Structure 1	Parking Structure 2	Parking Structure 3	Parking Structure 5	Riverfront Center	Riverview Hall	Sierra Hall	Sutter Hall	The Well	University Union	Child Development Center	Exterior Light	
L-1	**Building Interior Lighting System Modernization (Fixtures & Controls)**	2,167,137	0	$3,289,766	$198,696	16.6	374	$8,807	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		**$4.4 per sq.ft. for LED Fixtures & $2.8 per Sq.ft. for Smart Controls**
L-2	**LED Exit Signs**	0	0	$0	$0	0.0	-	$0																								**$250 per LED Exit Sign**
L-3	**Parking Structure Lighting Modernization & Exterior Lights**	2,256,846	0	$5,189,040	$180,543	28.7	389	$13,338					✓						✓	✓	✓	✓						✓		✓		**$21 per LED Watt**
M-1	**New VAV AHUs w/ economizers and integrated evaporator coolers. (Dual Duct Constant Volume to Single Duct Variable Volume Reheat System)**	0	0	$0	$0	0.0	-	$0																								**$70 per AHU CFM**
M-2	**Pneumatic to DDC controls**	0	0	$0	$0	0.0	-	$0																								**$7 per Sq.ft. for Hybrid Pneumatic to DDC $10 per Sq.ft. for Pneumatic to DDC**
M-3	**Demand controlled ventilation (DCV)**	0	0	$0	$0	0.0	-	$0																								**$2 per Sq.ft.**
M-4	**Occupancy-based HVAC**	109,159	2,953	$102,754	$10,871	9.5	34	$2,983	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			**$1 per Sq.ft.**
M-5	**Retro-commission HVAC System & Controls Optimization**	1,083,198	21,023	$1,252,926	$92,777	13.5	298	$4,204	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓	✓	✓	✓	✓			**$1 per Sq.ft.**
M-6	**Replace Chiller**	120,187		$945,000	$10,818	87.4	21	$45,617				✓		✓		✓	✓															**$1,500 per Ton**
M-7	**Replace Boiler**	0	6,151	$297,560	$4,324	68.8	33	$9,142				✓		✓		✓																**$173 per Mbtuh**
E-1	**Vending machine occupancy controls for vending machines**	6,616	0	$1,800	$3,557	0.5	1	$1,578										✓									✓	✓				**$225 per Unit**
Env-1	**High Efficiency Windows**	112,104	26,185	$232,789	$27,687	8.4	158	$1,474							✓		✓									✓	✓			✓		**$35 per Sq.ft. of Glazing**
TOTAL:		**5,855,247**	**56,313**	**$11,311,635**	**$529,273**	**21.4**	**1,307**	**$8,653**																								