UCI SMART Industrial Assessment Center

Sustainable Manufacturing Alliance for Research and Training (SMART)
Industrial Assessment Center
California Institute for Telecommunications and Information Technology (Calit2)
https://smartiac.calit2.uci.edu/

Report Number: CI0012

Assessment Date: March 16, 2023
Location: Laguna Woods, CA 92637
Building Type: Community Center
NAICS Code: 624120
SIC Code: 8322

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U.S. DEPARTMENT OF ENERGY

Preface

The work described in this report was performed by **Cypress College (CC-IAC)** under contract with the Office of Manufacturing and Energy Supply Chains division of the U.S. Department of Energy. The **IAC** program is managed by the Center for Advanced Energy Systems, Rutgers University, Piscataway, NJ, under contract with the U.S. Department of Energy.

The objective of the **IAC** program is to identify and evaluate, through site visits to industrial facilities, opportunities for energy efficiency improvements. The evaluation process is based on the data gathered during a **one-day site visit** and is thereby affected in detail and completeness by limitations on time at the site. In the event that the detailed operation conditions of a piece of equipment are of interest, the use of a data logger for the capture of data over a period of time is applied as it is deemed necessary. In cases where assessment recommendations (ARs) involving engineering design and capital investment are attractive to the company, it is recommended that the services of a consulting engineering firm be engaged (when in-house expertise is not available) to do detailed engineering design and to estimate implementation costs. Comments regarding this assessment report and information about plans to implement the ARs identified are solicited.

Disclaimer

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Industrial Assessment Center
U.S. DEPARTMENT OF ENERGY

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Executive Summary

Report Number: CI00012

Assessment Date: March 16, 2023

Location: Laguna Woods, CA 92637

S.I.C. Code: 8322

N.A.I.C.S. Code: 624120

Annual Sales: $100,000

Annual Production: N/A

Number of Recommendations: 8

Building Type: Community Center

Location	Operating Hours, hr	Plant Area, ft^2
Clubhouse 2	5,096	19,110
Clubhouse 4	2,834	8,590
Clubhouse 6	1,248	6,038
Community Center	3,900	32,292

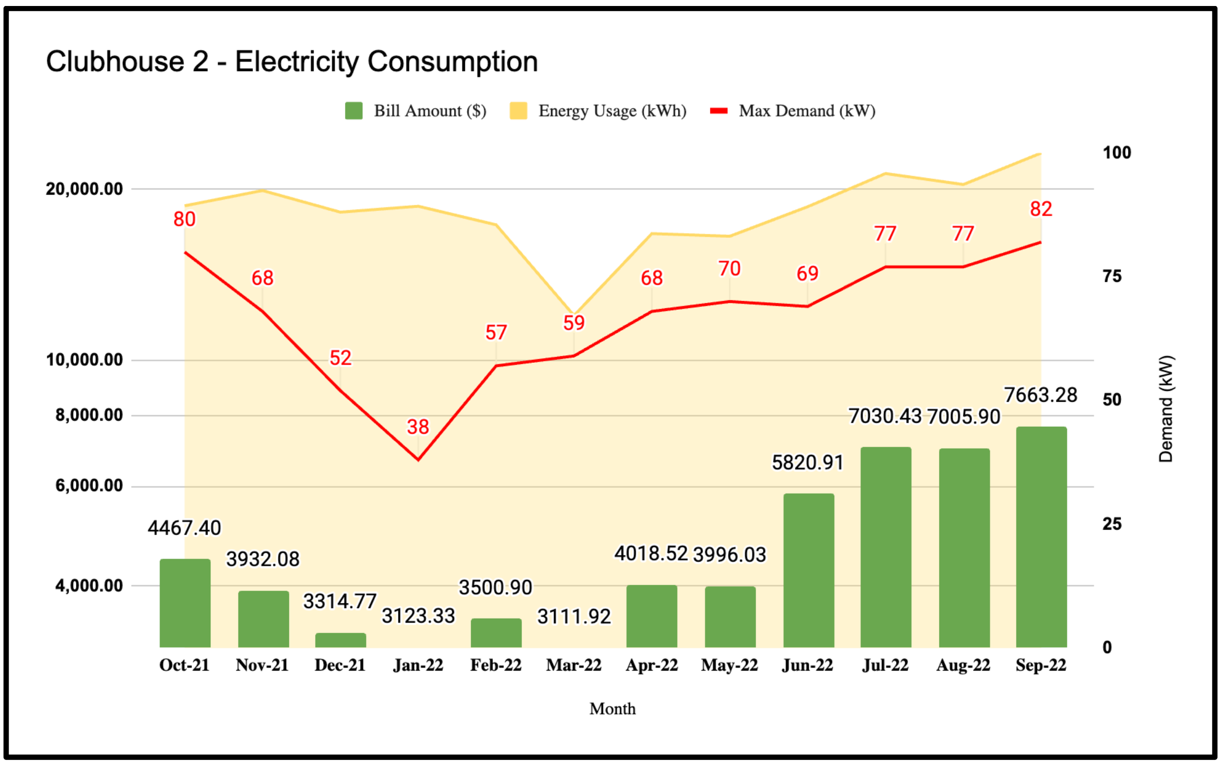
Summary of Assessment Recommendations

Assessment Recommendations		Energy Savings	TOTAL Cost Savings	Project Cost	Simple Payback
1	Replaced Current Lights with LEDs	290,071 kWh	$73,094	$83,743	1.14
2	Addition of Solar Energy Panels	193,170 kWh	$48,677	$330,808	6.80
3	Upgrade HVAC Equipment	146,521 kWh	$37,006	$28,350	0.77
4	Install Occupancy Sensors	97,425 kWh	$24,550	$9,000	0.37
5	Installation and Maintenance of CO2 Sensors	55,301 kWh	$13,935	$8,000	0.57
6	Turn Off Pilot Lights	39,594 kWh	$9,977	$1,040	0.10
7	Replace Gas Water Heaters with Heat Pump Water Heaters	22,279 kWh	$5,614	$8,200	1.46
8	Install High Efficiency Pumps	4,629 kWh	$1,166	$2,400	2.06
	Total	848,990 kWh/yr	$214,019/yr	$471,541	2.20 years

Utility Analysis

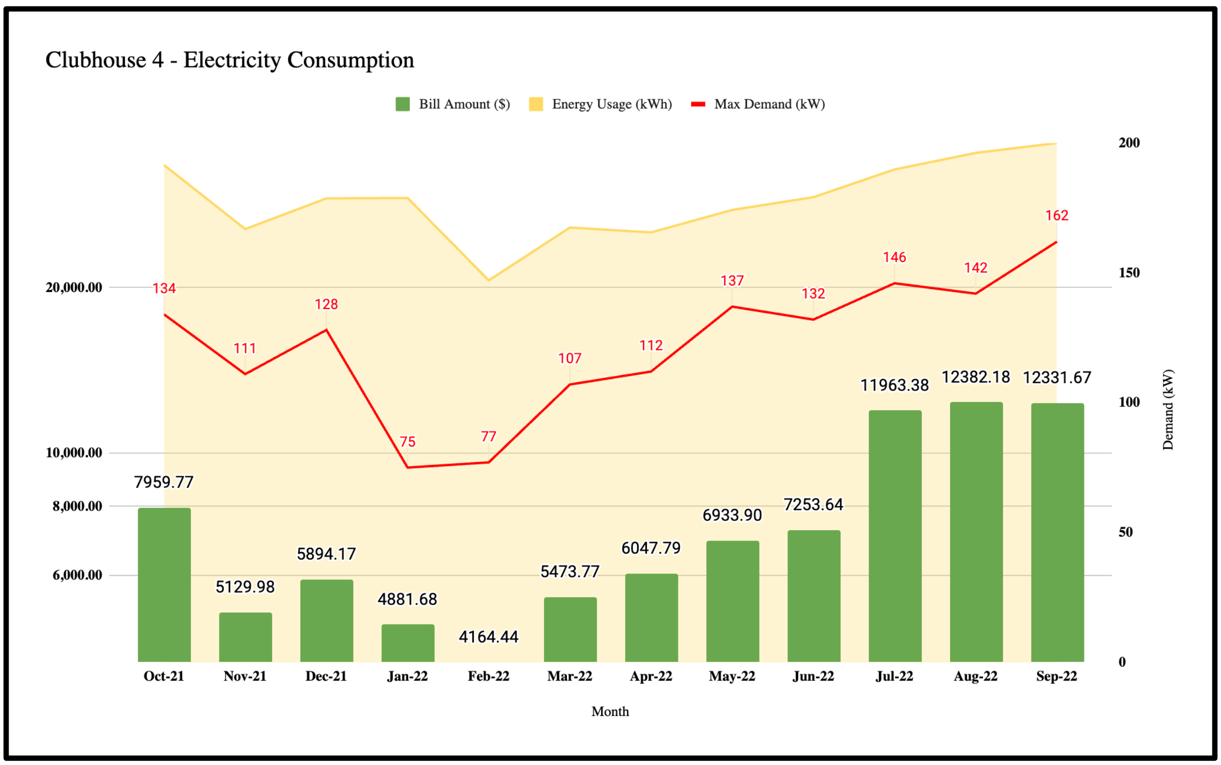
[Clubhouse 2]

Clubhouse 2	Month	Energy Usage (kWh)	Max Demand (kW)	Bill Amount ($)
	Oct-21	18728	80	4467.40
	Nov-21	19927	68	3932.08
	Dec-21	18251	52	3314.77
	Jan-22	18696	38	3123.33
	Feb-22	17338	57	3500.90
	Mar-22	11996	59	3111.92
	Apr-22	16731	68	4018.52
	May-22	16551	70	3996.03
	Jun-22	18657	69	5820.91
	Jul-22	21350	77	7030.43
	Aug-22	20419	77	7005.90
	Sep-22	23204	82	7663.28



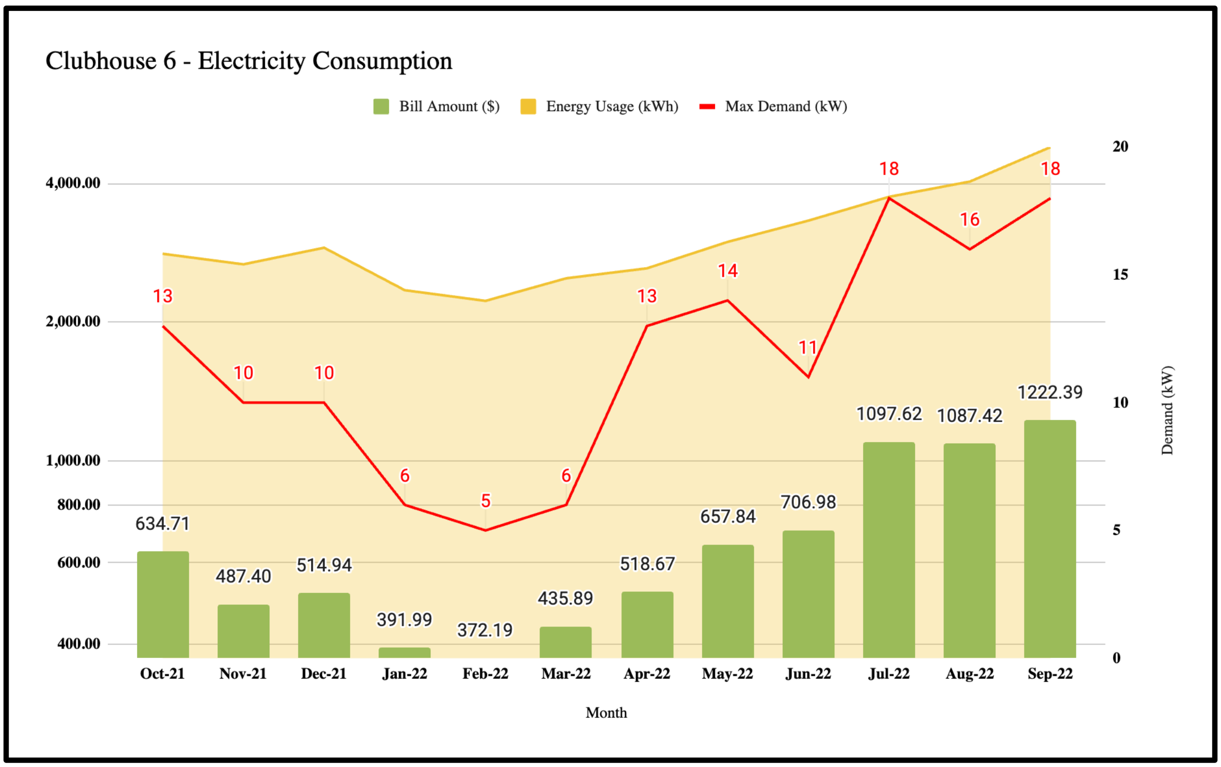
[Clubhouse 4]

Clubhouse 4	Month	Energy Usage (kWh)	Max Demand (kW)	Bill Amount ($)
	Oct-21	33411	134	7959.77
	Nov-21	25552	111	5129.98
	Dec-21	29061	128	5894.17
	Jan-22	29106	75	4881.68
	Feb-22	20610	77	4164.44
	Mar-22	25720	107	5473.77
	Apr-22	25200	112	6047.79
	May-22	27688	137	6933.90
	Jun-22	29206	132	7253.64
	Jul-22	32802	146	11963.38
	Aug-22	35159	142	12382.18
	Sep-22	36637	162	12331.67



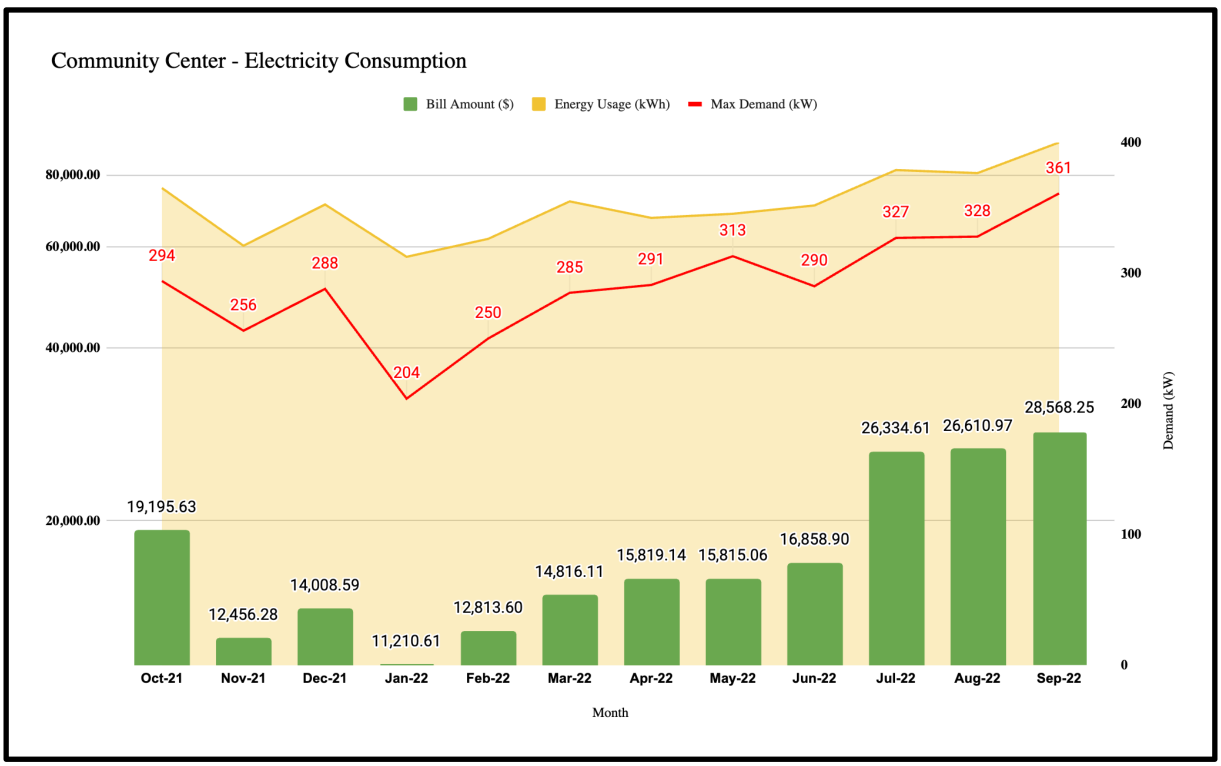
[Clubhouse 6]

Clubhouse 6	Month	Energy Usage (kWh)	Max Demand (kW)	Bill Amount ($)
	Oct-21	2814	13	634.71
	Nov-21	2669	10	487.40
	Dec-21	2900	10	514.94
	Jan-22	2345	6	391.99
	Feb-22	2223	5	372.19
	Mar-22	2489	6	435.89
	Apr-22	2616	13	518.67
	May-22	2986	14	657.84
	Jun-22	3321	11	706.98
	Jul-22	3741	18	1097.62
	Aug-22	4037	16	1087.42
	Sep-22	4797	18	1222.39



[Community Center]

Community Center	Month	Energy Usage (kWh)	Max Demand (kW)	Bill Amount ($)
	Oct-21	75,992	294	19,195.63
	Nov-21	60,295	256	12,456.28
	Dec-21	71,146	288	14,008.59
	Jan-22	57,676	204	11,210.61
	Feb-22	61,980	250	12,813.60
	Mar-22	72,028	285	14,816.11
	Apr-22	67,418	291	15,819.14
	May-22	68,540	313	15,815.06
	Jun-22	70,858	290	16,858.90
	Jul-22	81,677	327	26,334.61
	Aug-22	80,684	328	26,610.97
	Sep-22	91,222	361	28,568.25



Energy Summary for all Clubhouses

Energy Summary of Clubhouse 2,4,6,CC			
			Energy
	Month	kWh	Total$
Oct-21	10	130945	32257.51
Nov-21	11	108443	22005.74
Dec-21	12	121358	22005.74
Jan-22	1	107823	19607.61
Feb-22	2	102151	20851.13
Mar-22	3	112233	23837.69
Apr-22	4	111965	26404.12
May-22	5	115765	27402.83
Jun-22	6	122042	30640.43
Jul-22	7	139570	46426.04
Aug-22	8	140299	47086.47
Sep-22	9	155860	49785.59
Total		1468454	370037.63

Effective Energy Cost ($/kWh)	
0.251991	

Plant Energy Profiler Results

The Plant Energy Profiler (PEP) tool helps industrial plant managers understand how energy is being purchased and consumed at their plant and identifies potential energy and cost savings. Once the user has entered the basic plant info, energy and production data, energy intensive equipment used in the plant the tools helps to breakdown the energy consumption for the equipment in the plant, the cost of energy associated to operate the equipment, and the potential energy saving that can be achieved. The tool further gives the user a list of next steps or potential projects that might help the plant to reduce energy consumption. PEP is an excellent "first step" that industrial companies can use to identify opportunities for savings, improve their energy consumption , and help reduce the environmental emissions associated with energy production and use.

Table 1 shows plant's contact information and industry type.

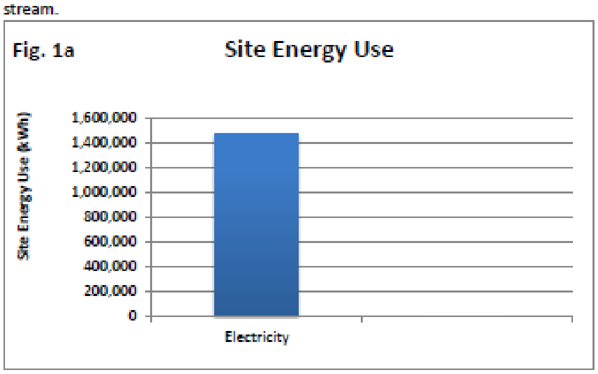
Table 1: Plant Contact Information	
Corporation Name:	
Plant Name:	
Primary Product:	
Industry Type:	
NAICS Code	
Primary Contact for Assessment:	
E-mail:	

Table 2 shows the annual purchased (site) electricity , natural gas, steam, and other fuels consumption data; the cost of each energy stream and their source power consumption for the baseline year.

Table 2: Annual Energy Use Summary

Energy Type	Site Energy Use	Site Energy Use (kWh)	Source Energy Use (kWh)	Energy Cost($)
Electricity	1,468,454 kWh	1,468,454	4,610,946	$370,038
Natural Gas	MMBTU			
Steam				
-				
Grand Total		1,468,454	4,610,946	$370,038

Figures 1a and 1b show the annual site electricity , natural gas, steam, and other fuels consumption in mega joules; and the cost of each energy stream.



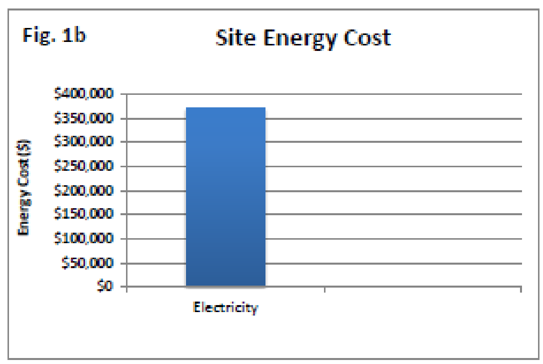


Table 3 shows the annual production for the different products that are produced in the plant along with the energy intensity for the baseline year.

Table 3: Production Energy Use

Production Stream	Quantity	Total Site Energy Use (kWh)	Energy Use per Unit of Production (kWh/Unit)
Product 1		1,468,454	
Product 2			
Product 3			

Fig. 2a shows the distribution of electricity , natural gas, and other fuel.

Total annual consumption for baseline year was estimated at 1,468,454 kWh with annual production of Unit

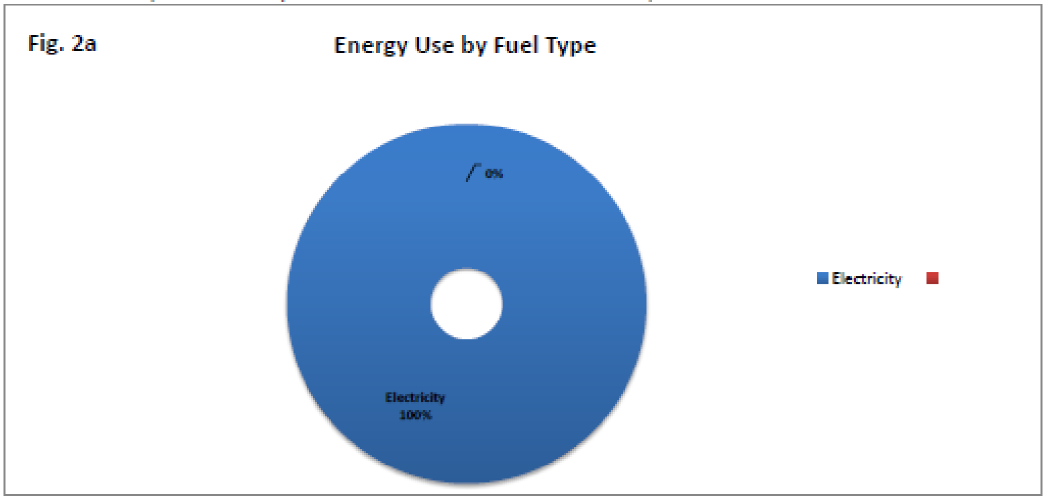


Fig. 2b shows the monthly energy consumption (electricity, natural gas, steam, and other fuels) of the plant along with their monthly production data.

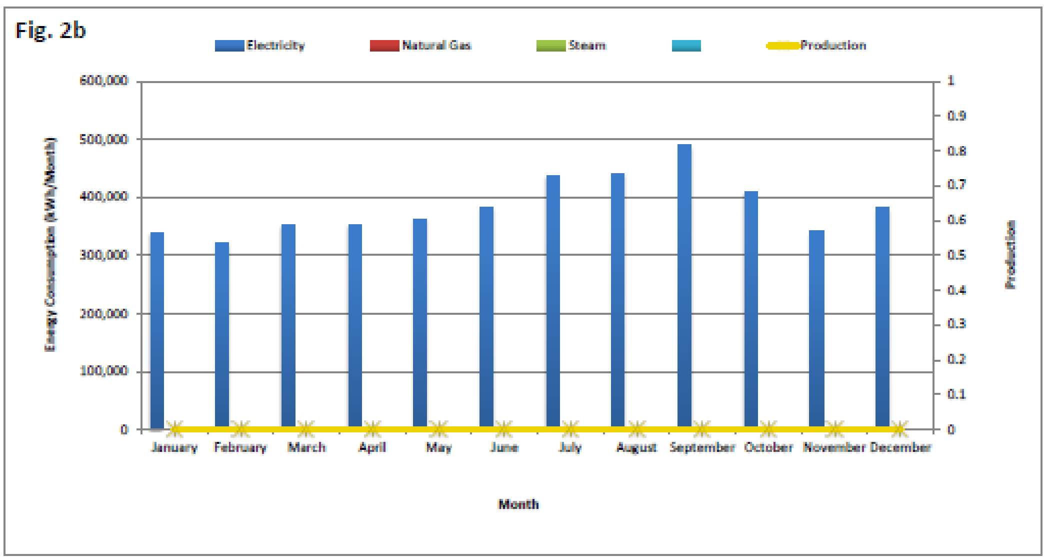


Figure 2c shows the correlation between Energy Intensity and production.

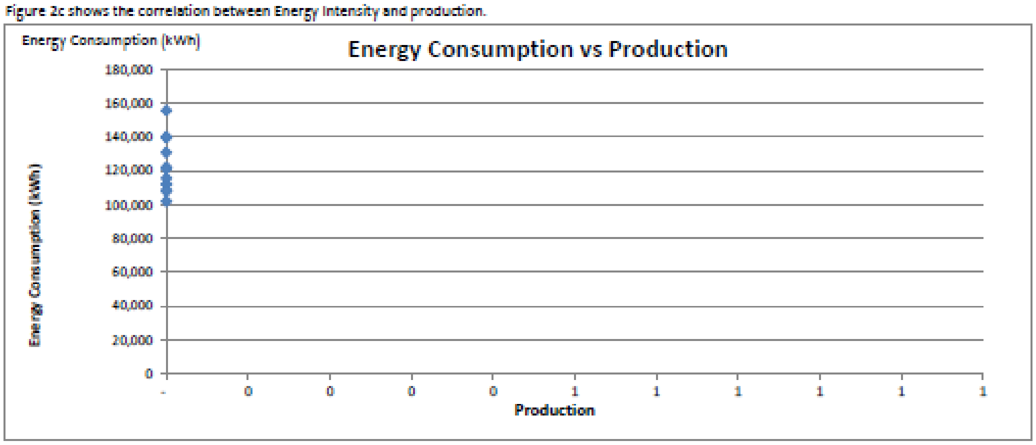


Figure 3a. shows the different energy type used by each system type present in the plant. This helps the user to understand how much energy each system is using.

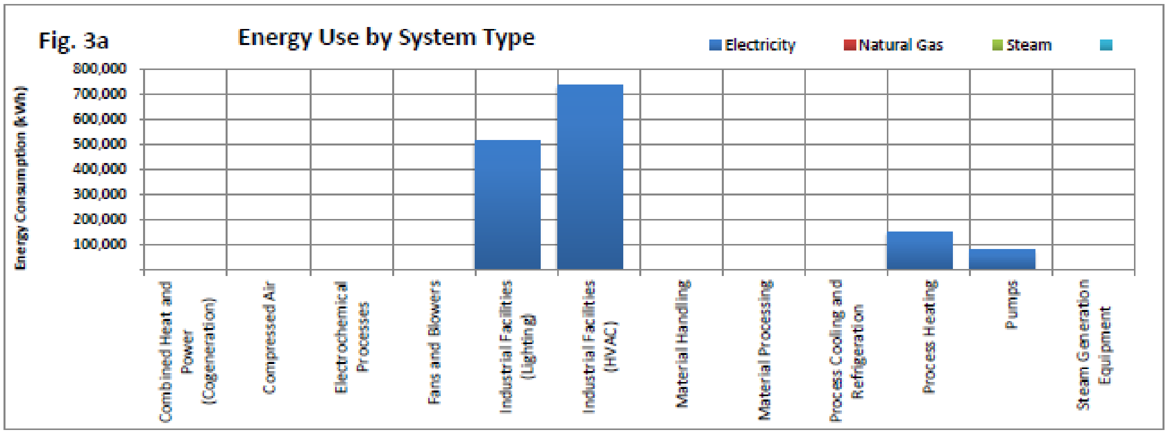


Fig 3b. shows the percentage energy consumption per system.

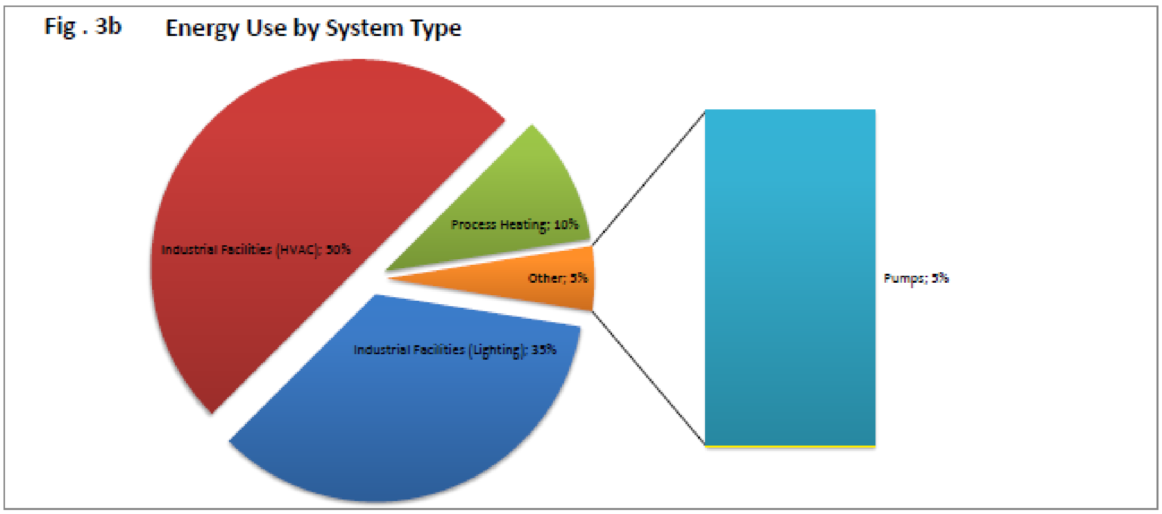


Table 4. summarizes the source energy consumption of each system. The user can see score from the scorecard if they have filled the forms for the system present in the plant. The tool uses the score from the scorecard (if the user has filled the scorecard) or the input from the "Energy saving opportunity" tab to categorize the energy saving opportunity and gives the energy saving that can be achieved.

Note:	The savings shown below correspond with the system and component recommendations shown in the suggested next steps table. The United Nations Industrial Development Organization Motor Systems Efficiency Supply Curves report shows that higher savings may be achievable for each system area.					
Table 4: Potential Annual Energy Savings(kWh)						
System Name	Site Energy Consumption (kWh)	Cost per System($)	% Energy Consumption by system	Potential Energy Savings by System (%)	Potential Site Energy Savings(kWh)	Potential Cost Saving($)
Industrial Facilities (Lighting)	513,959	$129,513	35.0%	15%	77,094	$19,427
Industrial Facilities (HVAC)	734,227	$185,019	50.0%	15%	110,134	$27,753
Process Heating	146,845	$37,004	10.0%	#N/A	#N/A	#N/A
Pumps	73,423	$18,502	5.0%	-	-	
Miscellaneous	0		0.0%			
Total	1,468,454	$370,038	100%		#N/A	#N/A

Fig. 4a shows the annual energy consumption and the potential energy saving for each system.

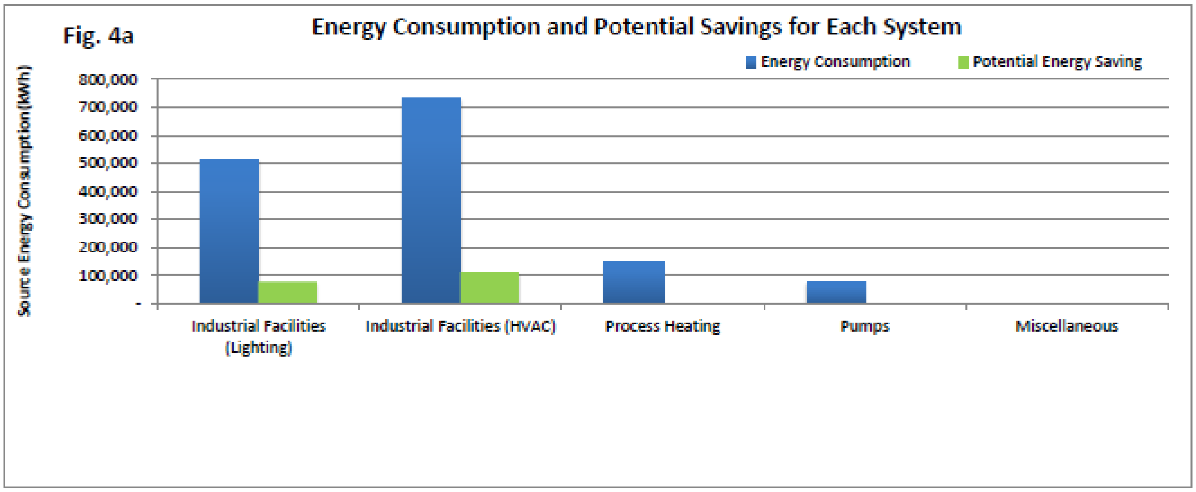
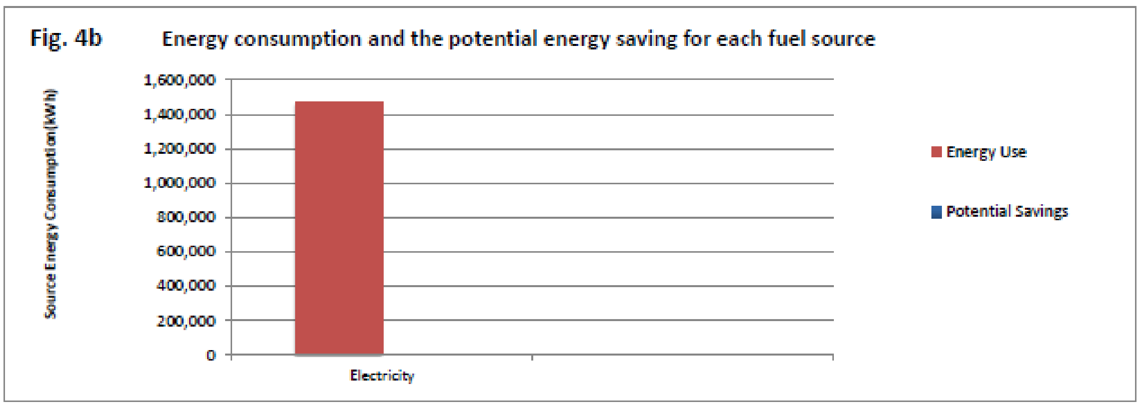
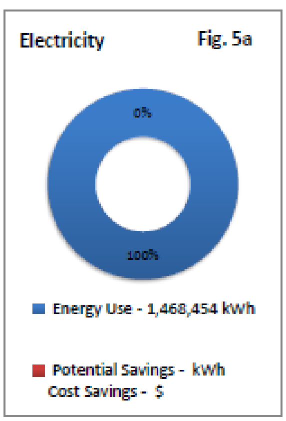
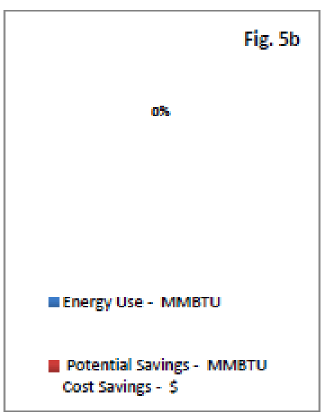


Fig. 4b shows the annual energy consumption and the potential energy saving for each fuel source.



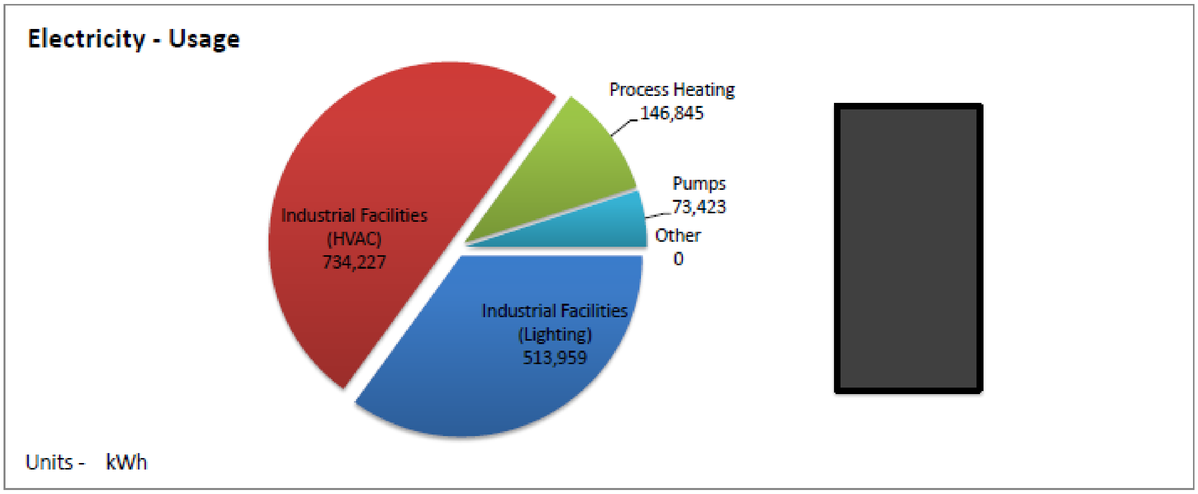
Figures 5a, 5b , 5c and 5d provide a breakdown of the annual energy consumption and the potential energy saving for each fuel source in its original units.



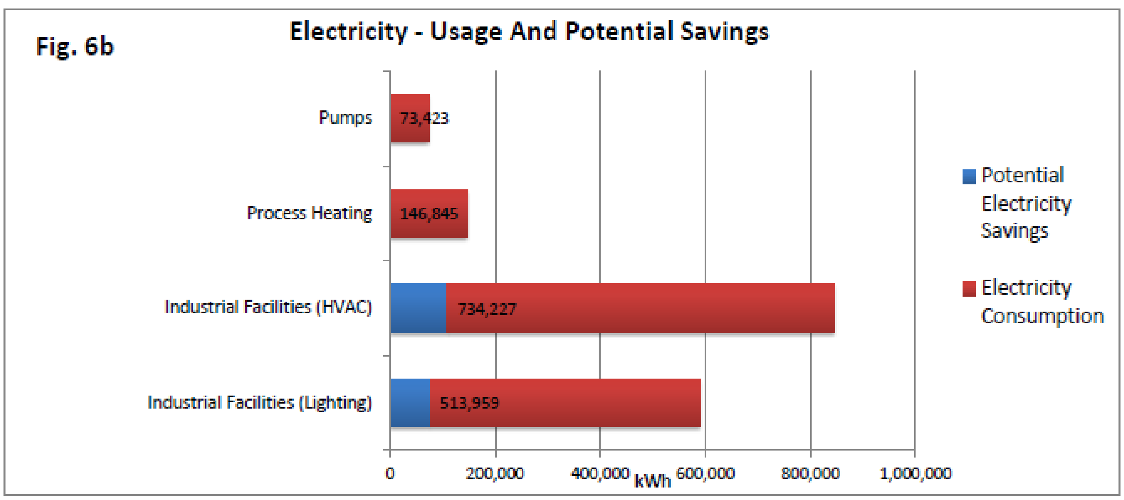


Electricity Use and Potential Savings by System

Figures 6a presents the breakdown of the annual electricity consumption a by system in a pie chart.

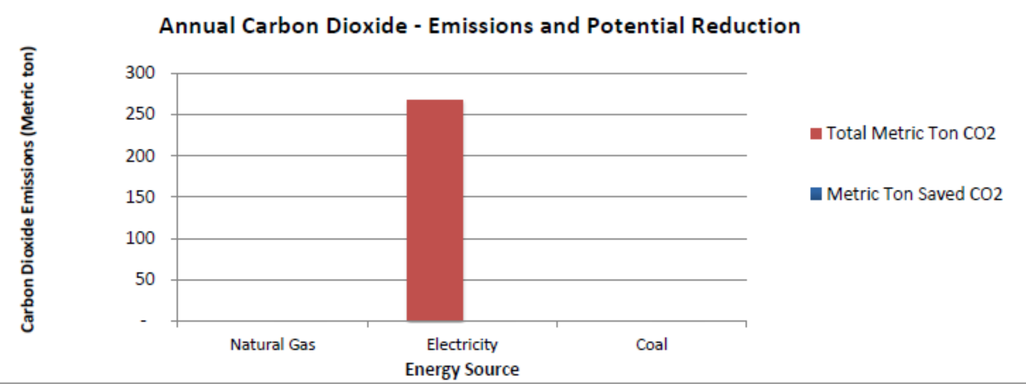


Figures 6b presents the breakdown of the annual electricity consumption and the potential electricity saving by system in a stacked bar chart.



Potential Annual CO_2 Emissions Savings		
Based on the potential energy savings identified above, your plant may be able to reduce emissions of CO2. The following potential annual CO2 emission savings numbers are broad estimates based on industry averages and are not meant to reflect actual realized savings at your plant. Factors such as CHP system or steam generator efficiency and primary fuel source for energy use systems such as furnaces and boilers make a large difference in the actual amount of CO2 emission saved. These numbers are presented as a broad estimate based on estimated savings and industry averages only. NOTE: Actual CO2 savings from fuel/steam energy savings are based on the primary fuel source. The exact breakdown of the individual primary fuels that are used at your plant for process heating, power generation and steam generation is beyond the scope of this tool. The table below shows a range of potential CO2 savings from fuel/steam use in your plant. The low end of the range is based on the use of fuels that contain relatively low amounts of carbon such as natural gas. The high end of the range is based on fuels that have a high amount of carbon such as coal (anthracite, bituminous or lignite). Your actual CO2 emission reduction will depend on the actual primary fuels that are used at your plant.		
Potential Annual CO2 from Electricity		Metric Ton
Potential Annual CO2 from Natural gas		Metric Ton
Potential Annual CO2 from Coal		Metric Ton

Fig. 10



Implemented Energy Efficiency Projects and Potential Opportunities	
Plant's energy management team is actively identifying and implementing energy efficiency projects. The plant has implemented the following energy efficiency projects and initiatives recently.	
Name of the Project	Description of the project

Based on the scores of system specific scorecards and/or the user selection in the 'Energy Saving Opportunity' section a ranking has been given to each system. This ranking helped us to determine the possible next steps the plant can take to further reduce their energy consumption.

Energy Efficiency Projects Identified or Potential Project Opportunities	
System Name	**Energy Efficiency Projects Identified or Potential Project Opportunities**
Industrial Facilities (Lighting)	2)Install occupancy sensors. 3)Perform a detailed Lighting Assessment at your site to identify and quantify energy saving opportunities
Industrial Facilities (HVAC)	1) Implement night setback and weekend/vacation temperature / ventilation controls 2) Perform a detailed HVAC System Assessment at your site to identify and quantify energy saving opportunities 3) Shut-off steam / chilled water flows to air handlers that are not needed or are out of service
Process Heating	1)Conduct a detail energy assessment for your heating equipment using tools such as Process Heating Survey and Assessment Tool (PHAST) to identify energy saving opportunities. 2)Keep heat transfer surfaces clean by eliminating build up of soot, scale or other material. 3)Measure oxygen (O_2) and Carbon Monoxide CO or combustible in flue gases and take actions to reduce O_2 in flue gases while maintaining near zero value for CO or combustibles. In certain cases safety requirements may require to have high values of O_2 in flue gases. Consult your equipment supplier before making any changes. 4)Operate the furnace at or close to design load by proper furnace scheduling and loading- avoid delays, waits, cooling between operations etc. as much a possible. 5)Reduce or eliminate openings in the furnace to reduce radiation heat losses. Repair cracks and damaged insulation in furnace walls, doors etc. Keep the door opening to minimum during operations.

Pumps	The system is not present in your plant
Energy Management	1.) Put together an energy management plan 2.) Form a cross functional energy team 3.) Construct a formal methodolgy to communicate energy management practices to the emplyees 4.) Make use of life cycle cost analysis to evaluate the energy efficiecy projects 5.) Establish a suitable payback period for energy efficiency projects

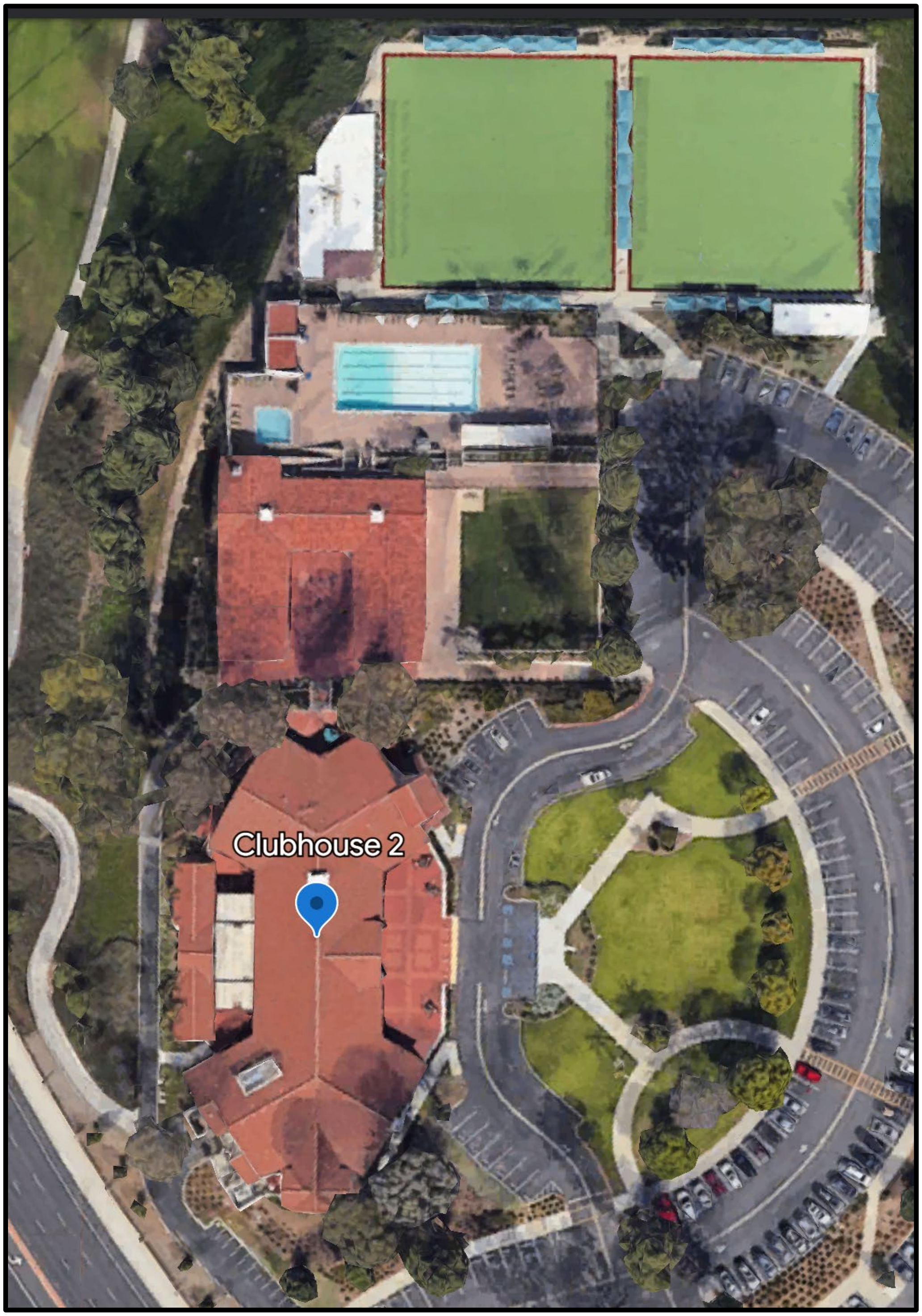
Facility Description- Community Center, Clubhouse 2, Clubhouse 4, & Clubhouse 6

The facility is located in Laguna Woods, California, and is a non-profit cooperative housing corporation which owns and manages all real property. This location is an elderly living community (ages 55+) that houses around 18,000 residents. This facility also includes 7 clubhouses total and a community center. This report covers clubhouses 2, 4, 6, and the three-story community center. The entire square feet of all four facilities is approximately 66,020 sq ft.

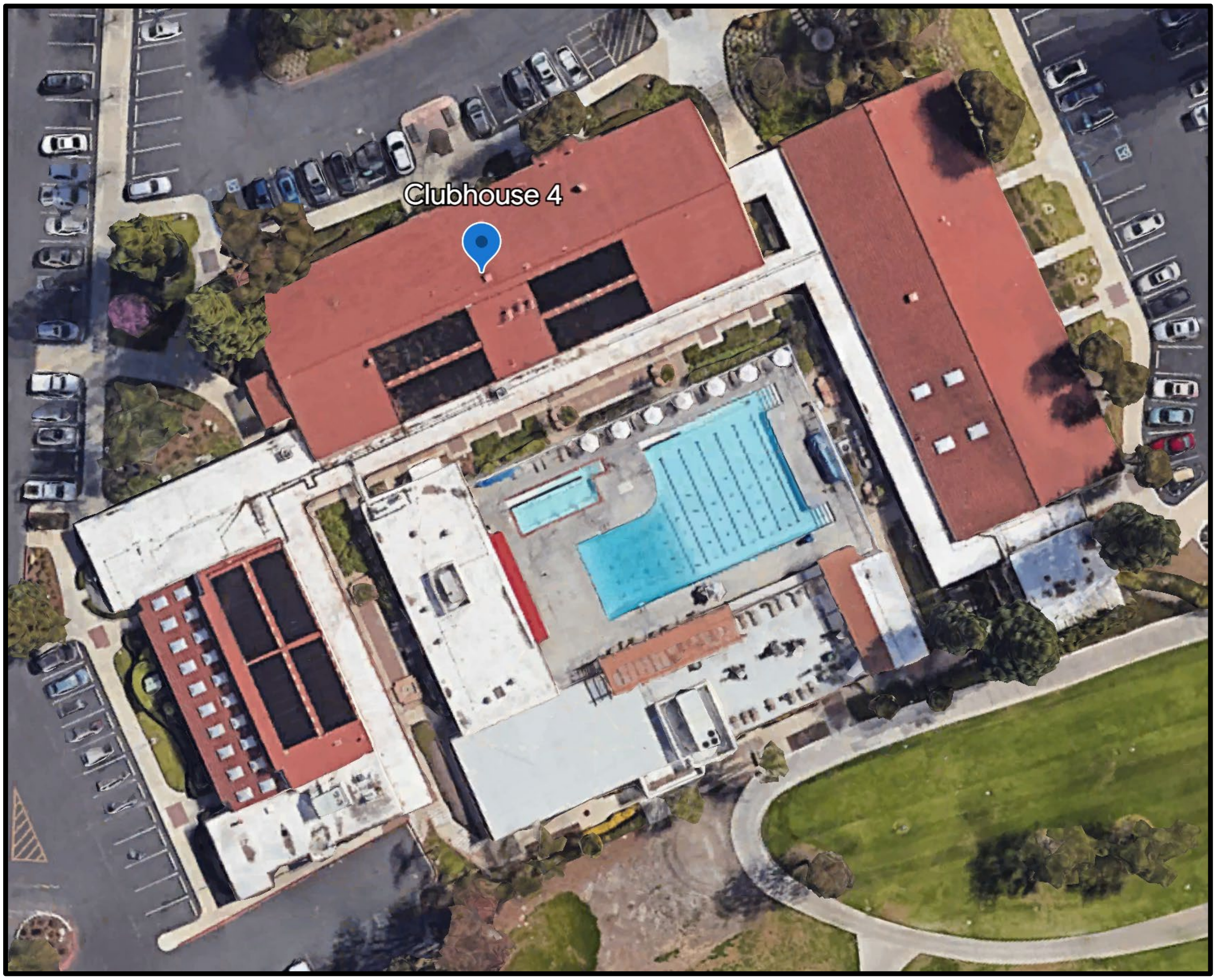
Clubhouse two is the second largest facility on this report and includes many rooms for hosting events, club activities, golf course, and restaurant nearby. Clubhouse four is mainly for classrooms involving lapidary, woodshop, art, swim, and a golf course directly located in the back. Clubhouse six is the smallest facility and is mainly used as a community pool in the summer and is equipped with a small lounge room, game room, and kitchen. The community center is a three-story facility where office employees work.

The first floor includes living services offices and a few conference rooms. The second floor is restricted to employees only and includes various departments with open offices, conference rooms, and other rooms for work use (i.e. copy room, CAD room, etc). The third floor is available to residents and employees only and includes activity rooms (TV studio & Table Tennis), classrooms (MAC room and Computer class), as well as the facility security.

Facility Layout



Clubhouse 2



Clubhouse 4

Clubhouse 6

Community Center

Best Practices

- **Outside lighting on timers**

  This facility has LEDs outside the buildings with timers to automatically turn on lights when it gets dark. This reduces their electric load by utilizing the most energy efficient light bulbs and turning outside lights off when not needed during the day.

- **Fuel Cell Cars, Electric Cars, Electric Golf Carts**

  Some residents have fuel cell cars and many have electric cars, with over 1,100 EVs in the community and growing.. Being a retirement community, many residents have golf carts. Residents not only use golf carts for golfing, but also for getting around the community. Most of these carts are electric, reducing the community's carbon footprint.

- **Recycling and Composting Program**

  This facility recycles much of its waste streams. They have a community recycling and composting program that helps reduce waste and prevent unnecessary landfill use. Each clubhouse has a recycling dumpster, making it even more convenient. This program is very successful in the community.

- **Training in Energy Efficiency**

  During training, employees are trained to turn off all lights when not in use. While this is a manual process (we would recommend installing occupancy sensors to automatically turn lights on and off) that might not always be followed, there is an emphasis on energy efficiency during onboarding. This will lead to energy savings when lights are turned off by employees. Employees are also trained to turn down/up the thermostat when rooms are not in use.

ASSESSMENT RECOMMENDATIONS

AR #1: Replace Fluorescent Lamps, Light Bulb and Halogen Can Light with LEDs

(ARC 2.7142)

TOTAL ENERGY SAVINGS

ARC: 2.7142	Estimated Annual Savings			Simple Payback
	Electric Energy Savings	Total Cost Savings	Estimated Implementation Cost	
T8 Fluorescent Lamp	194,133 kWh/yr (662.4 MMBtu/yr)	$48,919 /yr	$80,450	1.64 years
Incandescent Light Bulb	88,425 kWh/yr (301.7 MMBtu/yr)	$22,282 /yr	$625	0.03 years
Halogen Can Light	7,513 kWh/yr (25.6 MMBtu/yr)	$1,893 /yr	$2,668	1.41 years

CLUBHOUSE 2

Recommended Action

Replace the existing T8 Fluorescent lamps with LED lamps to reduce electrical energy consumption and monthly peak demand at this facility.

ARC: 2.7142	Estimated Annual Savings			Simple Payback
	Electric Energy Savings	Total Cost Savings	Estimated Implementation Cost	
T8 Fluorescent Lamp	23,803 kWh/yr (81.2 MMBtu/yr)	$5,998 /yr	$6,350	1.06 years
Incandescent Light Bulb	83,503 kWh/yr (284.9 MMBtu/yr)	$21,042 /yr	$500	0.02 years

Background

Currently, Clubhouse Two uses T8 Fluorescent lamps to illuminate most smaller areas and light bulbs on chandeliers for bigger areas such as the Sequoia Ballroom at this facility. Please see the charts below for applicable areas. These lights are currently on for a total of 5,096 hours per year. It is recommended to replace the current T8 Fluorescent lamps with 18.5 Watt LED lamps in an effort to reduce electrical energy usage and monthly peak demand. Energy savings will result from reduced electrical usage for lighting.

Room/Location	Type	Amount
Lobby Lounge	Incandescent Light Bulb	160
Palo Verde Lounge	Incandescent Light Bulb	20
Kitchen	Fluorescent	11
Locker rooms	Fluorescent	8
Grevillea Room	Fluorescent	32
Video Lab Room 1	Fluorescent	62
Video Lab Room 2	Fluorescent	32
Card Room	Fluorescent	16
Video Studio	Fluorescent	62
Los Olivos	Fluorescent	24

The existing T8 Fluorescent lamps have a Color Rendering Index (CRI)[1] of about 0.83, a lumen output of about 2,675 lumens per lamp, and a rated lamp life of about 31,000 hours. The recommended 18.5 W LED lamps have a CRI above 0.8, a lumen output of about 2,200, and a rated lamp life of about 50,000 hours of operation.

Anticipated Savings [T8 Fluorescent lamp]

To keep the same lighting level, the proposed number of fluorescent lamps, PN, is calculated as follow:

$$PN = (CN \times CL) / PL$$

where

CN = current number of metal halide lamps, 247 lamps
CL = lumen output of current lamps, 2,675 lumens/lamp
PL = lumen output of proposed lamps, 2,200 lumens/lamp

Thus, for the facility, the proposed number of fluorescent lamps is:

[1] CRI is a scale from 0 to 100 that indicates how well a given lamp renders color. A lamp with a CRI or 100 would make objects appear as they do in sunlight.

PN = (247 x 2,675) / 2,200
PN = 301 lamps

The annual energy savings, ES_i, and the annual demand reduction, DR_i, associated with this recommendation can be estimated as follows:

$$ES_i = [(CN \times CR \times (1 + CB) \times CH) - (PN \times PR \times (1 + PB) \times PH)] \times k$$

Where

CR = rating of the existing lamps, 32 Watts
CB = ballast fraction of current lamps, 100%
CH = operating hours of current lamps, 5,096 hrs/yr
PR = rating of the proposed lamps, 18.5 Watts
PB = ballast fraction of proposed lamps, 100%
PH = operation hours of proposed system, 5,096 hrs/yr
k = conversion factor, 0.001 kW/Watt

Thus, the annual energy savings, ES_1, for the maintenance area are estimated to be:

$$ES_1 = [(247 \times 32 \times (1 + 1) \times 5,096) - (301 \times 18.5 \times (1 + 1) \times 5,096)] \times 0.001$$
$$ES_1 = 23,803 \text{ kWh/yr}$$

Thus, the total electrical cost savings, CS_1, are estimated to be:

$$CS_1 = ES_1 \times (\text{effective energy cost})$$
$$CS_1 = TECS$$
$$CS_1 = 23,803 \text{ kWh/yr} \times (\$0.251991/\text{kWh})$$
$$CS_1 = \$5,998/\text{yr}$$

Where

TECS = Total Electric Cost Savings

<u>Anticipated Savings [Incandescent Light Bulb]</u>

To keep the same lighting level, the proposed number of fluorescent lamps, PN, is calculated as follow:

PN = (CN x CL) / PL

where

CN = current number of metal halide lamps, 181 lamps
CL = lumen output of current lamps, 890 lumens/lamp

PL = lumen output of proposed lamps, 4,700 lumens/lamp[1]

1 https://www.sust-it.net/incandescent-bulbs-lumens-to-watts-conversion-led.php

Thus, for the facility, the proposed number of fluorescent lamps is:

PN = (181 x 890) / 4,700
PN = 35 lamps

The annual energy savings, ES_i, and the annual demand reduction, DR_i, associated with this recommendation can be estimated as follows:

ES_i = [(CN x CR x (1 + CB) x CH) - (PN x PR x (1 + PB) x PH)] x k

Where

CR = rating of the existing lamps, 53 Watts
CB = ballast fraction of current lamps, 100%
CH = operating hours of current lamps,5,096 hrs/yr
PR = rating of the proposed lamps, 40 Watts
PB = ballast fraction of proposed lamps, 100%
PH = operation hours of proposed system, 5,096 hrs/yr
k = conversion factor, 0.001 kW/Watt

Thus, the annual energy savings, ES_1, for the maintenance area are estimated to be:

ES_1 = [(181 x 53 x (1 + 1) x 5,096) - (35 x 40 x (1 + 1) x 5,096)] x 0.001
ES_1 = 83,503 kWh/yr

Thus, the total electrical cost savings, CS_1, are estimated to be:

CS_1 = ES_1 x (effective energy cost)
CS_1 = TECS
CS_1 = 83,503 kWh/yr x ($0.251991/kWh)
CS_1 = $21,042/yr

Where

TECS = Total Electric Cost Savings

	Type	Rate/ Demond Watt	Output Brightness Lumen	Lifetime Hr
	T8 Fluorescent	32	2,675	31,000
Current Light	Incandescent	53	890	985.5
	Halogen	80	1,600	1,095
	LED 1	18.5	2,200	50,000
Proposed Light	LED 2	40	4,700	50,000
	LED 3	25	1,800	50,000

<u>Implementation Cost</u>

The cost of implementation is based on the replacement of existing lamp fixtures with high efficiency lighting. Costs include material, labor, as well as estimates from data provided by several lighting manufacturers. Implementation cost is estimated to be $25 per lamp.

The total implementation cost is found to be approximately $6,850. Yielded savings of $27,040/yr would see a return for the implementation cost within 0.25 years. The energy savings, cost savings and implementation costs presented in this analysis are based upon total replacement of all applicable lamps in the facility at once.

CLUBHOUSE 4

<u>Recommended Action</u>

Replace the existing T8 Fluorescent lamps with LED lamps to reduce electrical energy consumption and monthly peak demand at this facility.

ARC: 2.7142	**Estimated Annual Savings**			**Simple Payback**
	Electric Energy Savings	Total Cost Savings	Estimated Implementation Cost	
T8 Fluorescent Lamp	87,768 kWh/yr (299.5 MMBtu/yr)	$22,117/yr	$44,775	2.02 year

Background

Currently, Clubhouse Four uses T8 Fluorescent lamps to illuminate all areas at this facility including classrooms, offices, bathrooms, and the old bridge room now used for storage. Using the chart below for applicable areas. These lights are currently on for a total of 2,652 hours per year. It is recommended to replace the current T8 Fluorescent lamps with 18.5 Watt LED lamps in an effort to reduce electrical energy usage and monthly peak demand. Energy savings will result from reduced electrical usage for lighting.

Room/Location	Type	Amount
Art Studio	Fluorescent	155
Photo Instruction Room	Fluorescent	45
Office	Fluorescent	37
Locker Rooms	Fluorescent	48
Wood Shop	Fluorescent	238
Tool Storage	Fluorescent	16
Sewing Room	Fluorescent	120
Sewing Classroom	Fluorescent	113
Jewelry Room	Fluorescent	164
Lapidary Workshop	Fluorescent	257
Lapidary Classroom	Fluorescent	34
Ceramics Classroom	Fluorescent	31
Ceramics Studio	Fluorescent	96
Slipcast Room	Fluorescent	72
Grinding Room	Fluorescent	24
Bridge Room	Fluorescent	291

The existing T8 Fluorescent lamps have a Color Rendering Index (CRI)[2] of about 0.83, a lumen output of about 2,675 lumens per lamp, and a rated lamp life of about 31,000 hours. The recommended 18.5 W LED lamps have a CRI above 0.8, a lumen output of about 2,200, and a rated lamp life of about 50,000 hours of operation.

[2] CRI is a scale from 0 to 100 that indicates how well a given lamp renders color. A lamp with a CRI or 100 would make objects appear as they do in sunlight.

Anticipated Savings [T8 Fluorescent Lamp]

To keep the same lighting level, the proposed number of fluorescent lamps, PN, is calculated as follow:

$$PN = (CN \times CL) / PL$$

where

CN	=	current number of metal halide lamps, 1,741 lamps
CL	=	lumen output of current lamps, 2,675 lumens/lamp
PL	=	lumen output of proposed lamps, 2,200 lumens/lamp

Thus, for the facility, the proposed number of fluorescent lamps is:

$$PN = (1{,}741 \times 2{,}675) / 2{,}200$$
$$PN = 2{,}117 \text{ lamps}$$

The annual energy savings, ES_i, and the annual demand reduction, DR_i, associated with this recommendation can be estimated as follows:

$$ES_i = [(CN \times CR \times (1 + CB) \times CH) - (PN \times PR \times (1 + PB) \times PH)] \times k$$

Where

CR	=	rating of the existing lamps, 32 Watts
CB	=	ballast fraction of current lamps, 100%
CH	=	operating hours of current lamps, 2,652 hrs/yr
PR	=	rating of the proposed lamps, 18.5 Watts
PB	=	ballast fraction of proposed lamps, 100%
PH	=	operation hours of proposed system, 2,652 hrs/yr
k	=	conversion factor, 0.001 kW/Watt

Thus, the annual energy savings, ES_1, for the maintenance area are estimated to be:

$$ES_1 = [(1{,}741 \times 32 \times (1 + 1) \times 2{,}652) - (2{,}117 \times 18.5 \times (1 + 1) \times 2{,}652] \times 0.001$$
$$ES_1 = 87{,}768 \text{ kWh/yr}$$

Thus, the total electrical cost savings, CS_1, are estimated to be:

$$CS_1 = ES_1 \times (\text{effective energy cost})$$
$$CS_1 = TECS$$
$$CS_1 = 87{,}768 \text{ kWh/yr} \times (\$0.251991/\text{kWh})$$
$$CS_1 = \$22{,}117/\text{yr}$$

Where

TECS = Total Electric Cost Savings

	Type	Rate/ Demond Watt	Output Brightness Lumen	Lifetime Hr
	T8 Fluorescent	32	2,675	31,000
Current Light	Incandescent	53	890	985.5
	Halogen	80	1,600	1,095
	LED 1	18.5	2,200	50,000
Proposed Light	LED 2	40	4,700	50,000
	LED 3	25	1,800	50,000

Implementation Cost

The cost of implementation is based on the replacement of existing lamp fixtures with high efficiency lighting. Costs include material, labor, as well as estimates from data provided by several lighting manufacturers. Implementation cost is estimated to be $25 per lamp.

The total implementation cost is found to be approximately $44,775. Yielded savings of $22,117/yr would see a return for the implementation cost within 2.02 years. The energy savings, cost savings and implementation costs presented in this analysis are based upon total replacement of all applicable lamps in the facility at once.

CLUBHOUSE 6

Recommended Action

Replace the existing T8 Fluorescent lamps with LED lamps to reduce electrical energy consumption and monthly peak demand at this facility.

ARC: 2.7142	**Estimated Annual Savings**			**Simple Payback**
	Electric Energy Savings	Total Cost Savings	Estimated Implementation Cost	
T8 Fluorescent Lamp	865 kWh/yr (3.0 MMBtu/yr)	$218 /yr	$975	4.47 years

Incandescent Light Bulb	4,922 kWh/yr (16.8 MMBtu/yr)	$1,240 /yr	$125	0.10 years
Halogen Can Light	7,513 kWh/yr (25.6 MMBtu/yr)	$1,893 /yr	$2,668	1.41 years

<u>Background</u>

Currently, Clubhouse Six uses fewer T8 Fluorescent lamps than other clubhouses, mainly being the smallest facility. Most of the lighting fixtures used to illuminate many areas at this facility are chandeliers, halogen can lights, and stage lighting. Those rooms that do not use T8 lamps include the Assembly room, both Lobby Lounges, and the surrounding offices. Using the charts below for applicable areas. These lights are currently on for a total of 1,248 hours per year. It is recommended to replace the current T8 Fluorescent lamps with 18.5 Watt LED lamps in an effort to reduce electrical energy usage and monthly peak demand. Energy savings will result from reduced electrical usage for lighting.

Room/Location	Type	Amount
Lobby Lounge	Light bulb	12
	Wall light	5
Sale & Reception Room	Can light	32
Game Room	Fluorescent	24
	Wall light	8
Assembly Room	Wall light	2
	Can light	20
	Light bulb	12
	Stage light	6
Food Prep Room	Flourescent	12
	U-bend Fluorescent	2
Second Lounge Room	Wall light	2
	Light bulb	3
	Stage light	4

The existing T8 Fluorescent lamps have a Color Rendering Index (CRI)[3] of about 0.83, a lumen output of about 2,675 lumens per lamp, and a rated lamp life of about 31,000 hours. The

[3] CRI is a scale from 0 to 100 that indicates how well a given lamp renders color. A lamp with a CRI or 100 would make objects appear as they do in sunlight.

recommended 18.5 W LED lamps have a CRI above 0.8, a lumen output of about 2,200, and a rated lamp life of about 50,000 hours of operation.

Anticipated Savings [T8 Fluorescent lamp]

To keep the same lighting level, the proposed number of fluorescent lamps, PN, is calculated as follow:

$$PN = (CN \times CL) / PL$$

where

CN	=	current number of fluorescent lamps, 38 lamps
CL	=	lumen output of current lamps, 2,675 lumens/lamp
PL	=	lumen output of proposed lamps, 2,200 lumens/lamp

Thus, for the facility, the proposed number of fluorescent lamps is:

$$PN = (38 \times 2{,}675) / 2{,}200$$
$$PN = 47 \text{ lamps}$$

The annual energy savings, ES_i, and the annual demand reduction, DR_i, associated with this recommendation can be estimated as follows:

$$ES_i = [(CN \times CR \times (1 + CB) \times CH) - (PN \times PR \times (1 + PB) \times PH)] \times k$$

Where

CR	=	rating of the existing lamps, 32 Watts
CB	=	ballast fraction of current lamps, 100%
CH	=	operating hours of current lamps, 1,248 hrs/yr
PR	=	rating of the proposed lamps, 18.5 Watts
PB	=	ballast fraction of proposed lamps, 100%
PH	=	operation hours of proposed system, 1,248 hrs/yr
k	=	conversion factor, 0.001 kW/Watt

Thus, the annual energy savings, ES_1, for the maintenance area are estimated to be:

$$ES_1 = [(38 \times 32 \times (1 + 1) \times 1{,}248) - (47 \times 18.5 \times (1 + 1) \times 1{,}248)] \times 0.001$$
$$ES_1 = 865 \text{ kWh/yr}$$

Thus, the total electrical cost savings, CS_1, are estimated to be:

$$CS_1 = ES_1 \times (\text{effective energy cost})$$
$$CS_1 = \text{TECS}$$

CS_1 = 865 kWh/yr x ($0.251991/kWh)
CS_1 = $218/yr

Where

TECS = Total Electric Cost Savings

<u>Anticipated Savings [Incandescent Light Bulb]</u>

To keep the same lighting level, the proposed number of fluorescent lamps, PN, is calculated as follow:

PN = (CN x CL) / PL

where

CN = current number of metal halide lamps, 44 lamps
CL = lumen output of current lamps, 890 lumens/lamp
PL = lumen output of proposed lamps, 4,700 lumens/lamp

Thus, for the facility, the proposed number of fluorescent lamps is:

PN = (44 x 890) / 4,700
PN = 9 lamps

The annual energy savings, ES_i, and the annual demand reduction, DR_i, associated with this recommendation can be estimated as follows:

ES_i = [(CN x CR x (1 + CB) x CH) - (PN x PR x (1 + PB) x PH)] x k

Where

CR = rating of the existing lamps, 53 Watts
CB = ballast fraction of current lamps, 100%
CH = operating hours of current lamps, 1,248 hrs/yr
PR = rating of the proposed lamps, 40 Watts
PB = ballast fraction of proposed lamps, 100%
PH = operation hours of proposed system, 1,248 hrs/yr
k = conversion factor, 0.001 kW/Watt

Thus, the annual energy savings, ES_1, for the maintenance area are estimated to be:

ES_1 = [(44 x 53 x (1 + 1) x 1,248) - (9 x 40 x (1 + 1) x 1,248)] x 0.001
ES_1 = 4,922 kWh/yr

Thus, the total electrical cost savings, CS_1, are estimated to be:

CS_1 = ES_1 x (effective energy cost)
CS_1 = TECS
CS_1 = 4,922 kWh/yr x ($0.251991/kWh)
CS_1 = $1,240/yr

Where

TECS = Total Electric Cost Savings

Anticipated Savings [Halogen Can Light]

To keep the same lighting level, the proposed number of halogen can lights, PN, is calculated as follow:

PN = (CN x CL) / PL

where

CN = current number of metal halide lamps, 52 lamps
CL = lumen output of current lamps, 1,600 lumens/lamp
PL = lumen output of proposed lamps, 1,800 lumens/lamp

Thus, for the facility, the proposed number of halogen can lights is:

PN = (52 x 1,600) / 1,800
PN = 46 lamps

The annual energy savings, ES_i, and the annual demand reduction, DR_i, associated with this recommendation can be estimated as follows:

ES_i = [(CN x CR x (1 + CB) x CH) - (PN x PR x (1 + PB) x PH)] x k

where

CR = rating of the existing lamps, 80 Watts
CB = ballast fraction of current lamps, 100%
CH = operating hours of current lamps, 1,248 hrs/yr
PR = rating of the proposed lamps, 25 Watts
PB = ballast fraction of proposed lamps, 100%
PH = operation hours of proposed system, 1,248 hrs/yr
k = conversion factor, 0.001 kW/Watt

Thus, the annual energy savings, ES_1, for the maintenance area are estimated to be:

ES_1 = [(52 x 80 x (1 + 1) x 1,248) - (46 x 25 x (1 + 1) x 1,248)] x 0.001

ES_1 = 7,513 kWh/yr

Thus, the total electrical cost savings, CS_1, are estimated to be:

CS_1 = ES_1 x (effective energy cost)
CS_1 = 7,513 kWh/yr x ($0.251991/kWh)
CS_1 = $1,893/yr

	Type	Rate/ Demond Watt	Output Brightness Lumen	Lifetime Hr
	T8 Fluorescent	32	2,675	31,000
Current Light	Incandescent	53	890	985.5
	Halogen	80	1,600	1,095
	LED 1	18.5	2,200	50,000
Proposed Light	LED 2	40	4,700	50,000
	LED 3	25	1,800	50,000

Implementation Cost

The cost of implementation is based on the replacement of existing lamp fixtures with high efficiency lighting. Costs include material, labor, as well as estimates from data provided by several lighting manufacturers. Implementation cost is estimated to be $25 per lamp.

The total implementation cost is found to be approximately $3,768. Yielded savings of $3,351/yr would see a return for the implementation cost within 1.12 years. The energy savings, cost savings and implementation costs presented in this analysis are based upon total replacement of all applicable lamps in the facility at once.

COMMUNITY CENTER

Recommended Action

Replace the existing T8 Fluorescent lamps with LED lamps to reduce electrical energy consumption and monthly peak demand at this facility.

ARC: 2.7142	Estimated Annual Savings			Simple Payback
	Electric Energy Savings	Total Cost Savings	Estimated Implementation Cost	
T8 Fluorescent Lamp	81,697 kWh/yr (278.8 MMBtu/yr)	$20,586/yr	$28,350	1.38 years

Background

Currently, T8 Fluorescent lamps are used to illuminate almost all areas at this facility. With the exception of the TV Studio room that utilizes various stage lighting necessary for production. Please see the charts below for applicable areas. These lights are currently on for a total of 3,900 hours per year. It is recommended to replace the current T8 Fluorescent lamps with 18.5 Watt LED lamps in an effort to reduce electrical energy usage and monthly peak demand. Energy savings will result from reduced electrical usage for lighting.

Room/Location	Type	Amount
Elm Room	Fluorescent	24
Spruce Room	Fluorescent	20
Pine Room	Fluorescent	17
Social Services Offices	Fluorescent	74
Sycamore Room	Fluorescent	24
Floor 2 Open Office 1	Fluorescent	82
Floor 2 Open Office 2	Fluorescent	56
Floor 2 Open Office 3	Fluorescent	52
Cypress/Open office/Oak Room	Fluorescent	40
Coffee/Cop/CAD/Staff Break Room	Fluorescent	72
Southside Office	Fluorescent	24
Copy Room	Fluorescent	24
Floor 3 Table Tennis Room	Fluorescent	279
Floor 3 Office/Control Room	Fluorescent	74
Computer Lab/MAC Classroom	Fluorescent	144
Storage/South Office/Fitness Room	Fluorescent	96

The existing T8 Fluorescent lamps have a Color Rendering Index (CRI)[4] of about 0.83, a lumen output of about 2,675 lumens per lamp, and a rated lamp life of about 31,000 hours. The recommended 18.5 W LED lamps have a CRI above 0.8, a lumen output of about 2,200, and a rated lamp life of about 50,000 hours of operation.

Anticipated Savings [T8 Fluorescent Lamp]

To keep the same lighting level, the proposed number of fluorescent lamps, PN, is calculated as follow:

PN = (CN x CL) / PL

where

CN = current number of metal halide lamps, 1,102 lamps
CL = lumen output of current lamps, 2,675 lumens/lamp
PL = lumen output of proposed lamps, 2,200 lumens/lamp

Thus, for the facility, the proposed number of fluorescent lamps is:

PN = (1,102 x 2,675) / 2,200
PN = 1,340 lamps

The annual energy savings, ES_i, and the annual demand reduction, DR_i, associated with this recommendation can be estimated as follows:

ES_i = [(CN x CR x (1 + CB) x CH) - (PN x PR x (1 + PB) x PH)] x k

Where

CR = rating of the existing lamps, 32 Watts
CB = ballast fraction of current lamps, 100%
CH = operating hours of current lamps, 3,900 hrs/yr
PR = rating of the proposed lamps, 18.5 Watts
PB = ballast fraction of proposed lamps, 100%
PH = operation hours of proposed system, 3,900 hrs/yr
k = conversion factor, 0.001 kW/Watt

Thus, the annual energy savings, ES_1, for the maintenance area are estimated to be:

ES_1 = [(1,102 x 32 x (1 + 1) x 3,900) - (1,340 x 18.5 x (1 + 1) x 3,900] x 0.001
ES_1 = 81,697 kWh/yr

[4] CRI is a scale from 0 to 100 that indicates how well a given lamp renders color. A lamp with a CRI or 100 would make objects appear as they do in sunlight.

Thus, the total electrical cost savings, CS_1, are estimated to be:

CS_1 = ES_1 x (effective energy cost)
CS_1 = TECS
CS_1 = 81,697 kWh/yr x ($0.251991/kWh)
CS_1 = $20,586/yr

Where

TECS = Total Electric Cost Savings

	Type	Rate/ Demond Watt	Output Brightness Lumen	Lifetime Hr
	T8 Fluorescent	32	2,675	31,000
Current Light	Incandescent	53	890	985.5
	Halogen	80	1,600	1,095
	LED 1	18.5	2,200	50,000
Proposed Light	LED 2	40	4,700	50,000
	LED 3	25	1,800	50,000

Implementation Cost

The cost of implementation is based on the replacement of existing lamp fixtures with high efficiency lighting. Costs include material, labor, as well as estimates from data provided by several lighting manufacturers. Implementation cost is estimated to be $25 per lamp.

The total implementation cost is found to be approximately $28,350. Yielded savings of $20,586/yr would see a return for the implementation cost within 1.38 years. The energy savings, cost savings and implementation costs presented in this analysis are based upon total replacement of all applicable lamps in the facility at once.

AR #2: Addition of Solar Energy Panels

(ARC 2.9114)

TOTAL ENERGY SAVINGS

ARC: 2.9114	Estimated Annual Savings			Simple Payback
	Electric Energy Savings	Total Cost Savings	Estimated Implementation Cost	
Total	193,170 kWh/yr (659.1 MMBtu/yr)	$48,677 /yr	$330,808	6.80 years

CLUBHOUSE 2

Recommended Action

Addition of solar energy cells to available property around the facility. The addition will reduce the energy consumption and operation for the facility.

ARC: 2.9114	Estimated Annual Savings			Simple Payback
	Electric Energy Savings	Total Cost Savings	Estimated Implementation Cost	
Total	42,654 kWh/yr (145.5 MMBtu/yr)	$10,748 /yr	$129,415	12.04 years

Background

Current System

Currently, solar is not utilized at this facility. The client owns the building, so adding solar to the roof can be easily achieved without conflict between building owner and tenant. Over the past decade there have been considerable improvements in efficiency and reduction of startup costs of adding solar to existing structures and available underutilized vacant property. The plant management was receptive to the addition of solar energy as a possible option for this existing property.

Proposed System

The addition of solar energy cells has the following characteristics:

- Number of cells to be utilized **211 units**, energy output of each unit **72.8**

- Estimated to run **1,837 hours** per year.

- Connections to the facility.

- Structure and foundation mountings.

The estimated energy output is determined from 211 panels at 345 Watts each, with an estimated overall system efficiency of 70%. This is a conservative estimation.

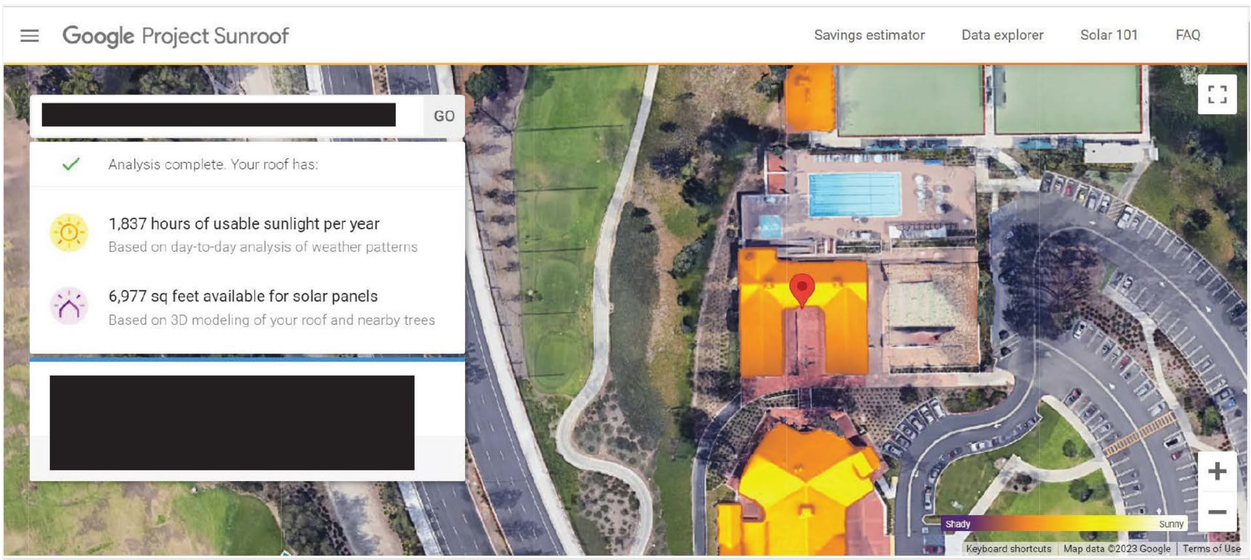


Figure 1. Google Project Sunroof, there are 1,837 hours of usable sun.

As indicated by Figure 1, according to Google Project Sunroof, there are 1,837 hours of usable sun light per year for this specific location. This facility operates 7 days per week.

<u>Anticipated Savings</u>

The energy production, EC, of an addition of solar cells can be calculated using the following relationship:

$$EC = US \times SC$$

Where

US	=	usable sunlight per year, hrs
SC	=	solar cell energy output, 72.8 kW/hr
DR	=	demand reduction
MN	=	months of operation

Therefore, the energy generated, EC from the use of solar cells, and DR, is estimated to be:

EC = (1,837 hrs) x (72.8 kW/h) x (0.70)
EC = 42,654 kWh/yr

Therefore, the total energy cost savings, ECS, addition of solar cells can be expressed by the following relationship:

ECS = EC x (effective energy cost)
ECS = 42,654 kWh/yr x ($0.251991/kWh)
ECS = $10,748/yr

<u>Implementation Cost</u>

The implementation cost of this measure includes the cost of purchasing and installing solar cells. According to manufacturers, a new unit can be purchased at a cost of $315. An additional $62,950 is estimated for installation, connection, and mounting structure, listed of costs are listed in the table below. Thus, the cost savings of $10,748/yr would pay for the total implementation cost of $129,415 in about 12.04 years.

	Units	Price	Price
		Per Unit (US-$)	Total (US-$)
Solar Cells	211	315	66,465
Power Grid Connection	1	1000	1,000
Installation	211	95.6	20,172
Universal Pole Mount	211	198	41,778
		Total =	**129,415**

Figure 1. Proposed system design mounted in the roof

CLUBHOUSE 4

Recommended Action

Addition of solar energy cells to available property around the facility. The addition will reduce the energy consumption and operation for the facility.

ARC: 2.9114	**Estimated Annual Savings**			**Simple Payback**
	Electric Energy Savings	Total Cost Savings	Estimated Implementation Cost	
Total	43,326 kWh/yr (147.8 MMBtu/yr)	$10,918	$58,807	5.39 years

Background

Current System

Currently, solar is not utilized at this facility. The client owns the building, so adding solar to the roof can be easily achieved without conflict between building owner and tenant. Over the past decade there have been considerable improvements in efficiency and reduction of startup costs of adding solar to existing structures and available underutilized vacant property. The plant management was receptive to the addition of solar energy as a possible option for this existing property.

Proposed System

The addition of solar energy cells has the following characteristics:

- Number of cells to be utilized **95 units**, total energy output of **32.8 kW/hr**
- Estimated to run **1,887 hours** per year.
- Connections to the facility.
- Structure and foundation mountings.

The estimated energy output is determined from 95 panels at 345 Watts each, with an estimated overall system efficiency of 70%. This is a conservative estimation.

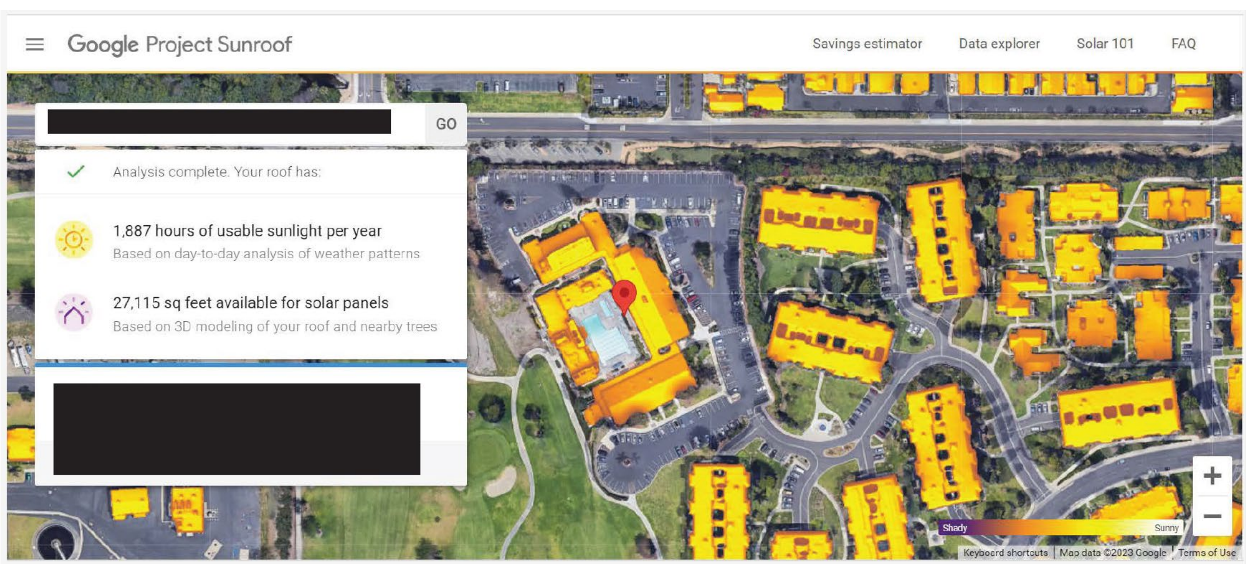


Figure 1. Google Project Sunroof, there are 1,887 hours or usable sun.

As indicated by Figure 1, according to Google Project Sunroof, there are 1,887 hours of usable sun light per year for this specific location. This facility operates 7 days a week.

Anticipated Savings

The energy production, EC, of an addition of solar cells can be calculated using the following relationship:

EC = US x SC

Where

US = usable sunlight per year, hrs
SC = solar cells energy output, kW/h
DR = demand reduction
MN = months of operation

Therefore, the energy generated, EC from the use of solar cells, and DR, is estimated to be:

EC = (1,887 hrs) x (32.8 kW/h) x (0.70)
EC = 43,326 kWh/yr

Therefore, the total energy cost savings, ECS, addition of solar cells can be expressed by the following relationship:

ECS = EC x (effective energy cost)
ECS = 43,326 kWh/yr x ($0.251991/kWh)
ECS = $10,918/yr

Implementation Cost

The implementation cost of this measure includes the cost of purchasing and installing solar cells. According to manufacturers, a new unit can be purchased at a cost of $315. An additional $28,892 is estimated for installation, connection, and mounting structure, listed of costs are listed in the table below. Thus, the cost savings of $10,918/yr would pay for the total implementation cost of $58,817 in about 5.39 years.

	Units	**Price**	**Price**
		Per Unit (US-$)	**Total (US-$)**
Solar Cells	95	315	29,925
Power Grid Connection	1	1000	1,000
Installation	95	95.6	9,082
Universal Pole Mount	95	198	18,810
		Total	**58,817**

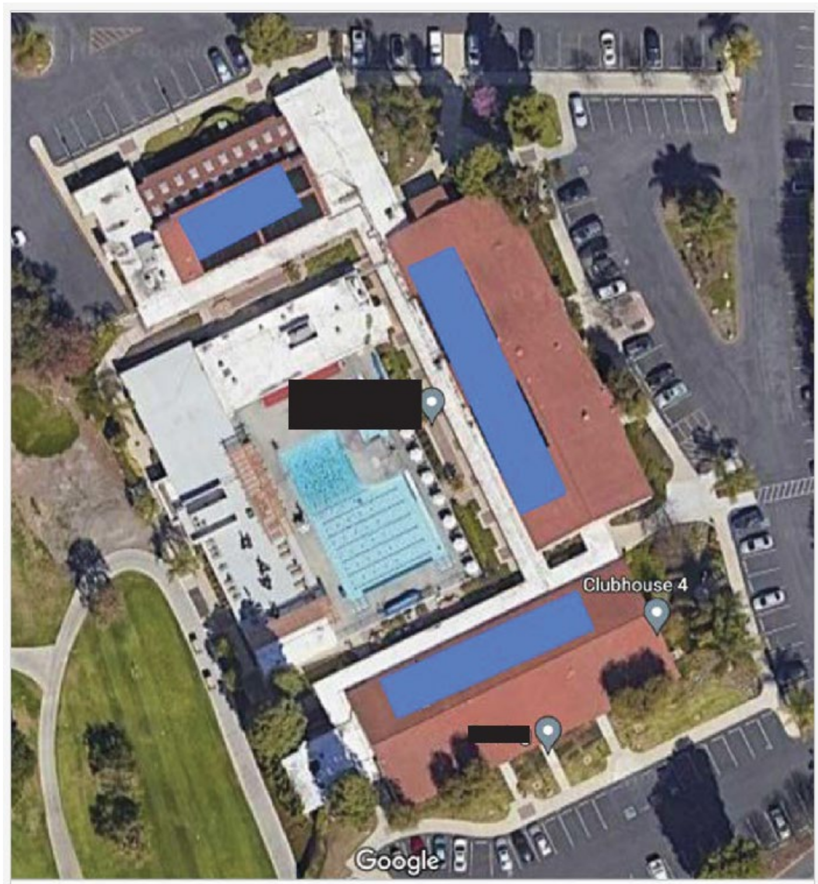


Figure 1. Proposed system design mounted in the roof

CLUBHOUSE 6

<u>Recommended Action</u>

Addition of solar energy cells to available property around the facility. The addition will reduce the energy consumption and operation for the facility.

ARC: 2.9114	Estimated Annual Savings			Simple Payback
	Electric Energy Savings	Total Cost Savings	Estimated Implementation Cost	
Total	30,367 kWh/yr (103.6 MMBtu/yr)	$7,652 /yr	$41,776	5.46 years

Background

Current System

Currently, solar is not utilized at this facility. The client owns the building, so adding solar to the roof can be easily achieved without conflict between building owner and tenant. Over the past decade there have been considerable improvements in efficiency and reduction of startup costs of adding solar to existing structures and available underutilized vacant property. The plant management was receptive to the addition of solar energy as a possible option for this existing property.

Proposed System

The addition of solar energy cells has the following characteristics:

- Number of cells to be utilized **67 units**, total energy output of **23.1 kW/hr**
- Estimated to run
- Connections to the facility.
- Structure and foundation mountings.

The estimated energy output is determined from 67 panels at 345 Watts each, with an estimated overall system efficiency of 70%. This is a conservative estimation.

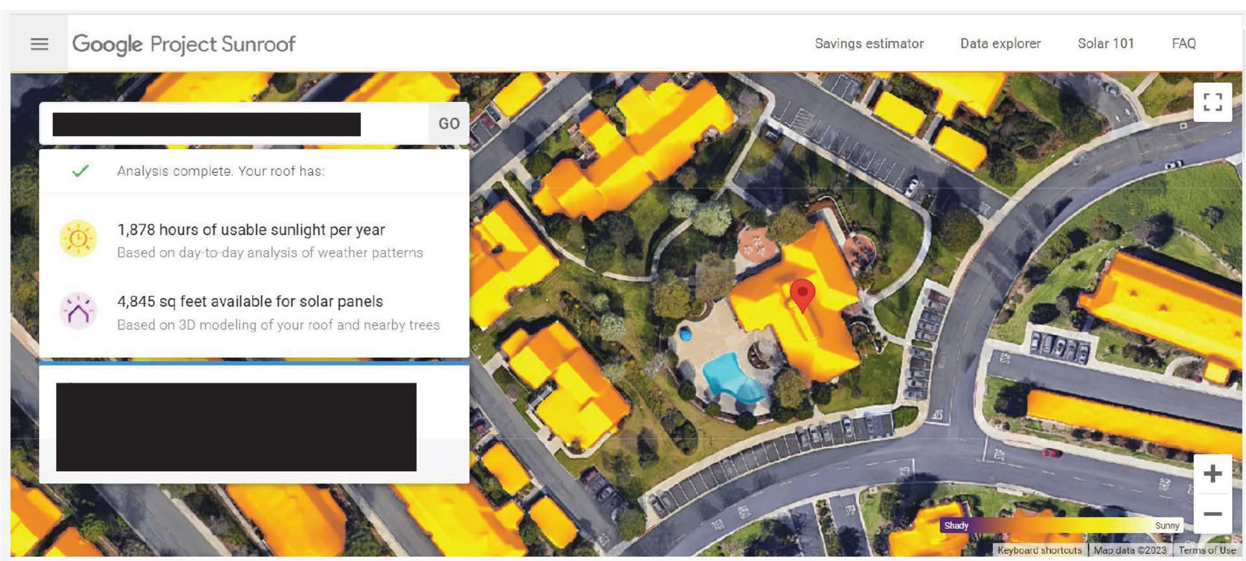


Figure 1. Google Project Sunroof, there are 1,878 hours or usable sun.

As indicated by Figure 1, according to Google Project Sunroof, there are 1,878 hours of usable sun light per year for this specific location. This facility operates 7 days a week.

Anticipated Savings

The energy production, EC, of an addition of solar cells can be calculated using the following relationship:

EC = US x SC

Where

US = usable sunlight per year, hrs
SC = solar cells energy output, kW/h
DR = demand reduction
MN = months of operation

Therefore, the energy generated, EC from the use of solar cells, and DR, is estimated to be:

EC = (1,878 hrs) x (23.1 kW/h) x (0.70)
EC = 30,367 kWh/yr

Therefore, the total energy cost savings, ECS, addition of solar cells can be expressed by the following relationship:

ECS = EC x (effective energy cost)
ECS = 30,367 kWh/yr x ($0.251991/kWh)
ECS = $7,652/yr

Implementation Cost

The implementation cost of this measure includes the cost of purchasing and installing solar cells. According to manufacturers, a new unit can be purchased at a cost of $315. An additional $20,671 is estimated for installation, connection, and mounting structure, listed of costs are listed in the table below. Thus, the cost savings of $7,652/yr would pay for the total implementation cost of $41,776 in about 5.46 years.

	Units	Price Per Unit (US-$)	Price Total (US-$)
Solar Cells	67	315	21,105
Power Grid Connection	1	1000	1,000
Installation	67	95.6	6,405
Universal Pole Mount	67	198	13,266
		Total	**41,776**

Figure 1. Proposed system design mounted in the roof

COMMUNITY CENTER

Recommended Action

Addition of solar energy cells to available property around the facility. The addition will reduce the energy consumption and operation for the facility.

ARC: 2.9114	Estimated Annual Savings			Simple Payback
	Electric Energy Savings	Total Cost Savings	Estimated Implementation Cost	
Total	76,823 kWh/yr (262.1 MMBtu/yr)	$19,359 /yr	$100,810	5.21 years

Background

Current System

Currently, solar is not utilized at this facility. The client owns the building, so adding solar to the roof can be easily achieved without conflict between building owner and tenant. Over the past decade there have been considerable improvements in efficiency and reduction of startup costs of adding solar to existing structures and available underutilized vacant property. The plant management was receptive to the addition of solar energy as a possible option for this existing property.

Proposed System

The addition of solar energy cells has the following characteristics:

- Number of cells to be utilized **164 units**, total energy output of **56.6 kW/hr**.
- Estimated to run **1,939 hours** per year.
- Connections to the facility.
- Structure and foundation mountings.

The estimated energy output is determined from 164 panels at 345 Watts each, with an estimated overall system efficiency of 70%. This is a conservative estimation.

Figure 1. Google Project Sunroof, there are 1,939 hours or usable sun.

As indicated by Figure 1, according to Google Project Sunroof, there are 1,939 hours of usable sun light per year for this specific location. This facility operates 7 days a week.

Anticipated Savings

The energy production, EC, of an addition of solar cells can be calculated using the following relationship:

EC = US x SC

Where

US = usable sunlight per year, hrs
SC = solar cells energy output, kW/h
DR = demand reduction
MN = months of operation

Therefore, the energy generated, EC from the use of solar cells, and DR, is estimated to be:

EC = (1,939 hrs) x (56.6 kW/h) x (0.70)
EC = 76,823 kWh/yr

Therefore, the total energy cost savings, ECS, addition of solar cells can be expressed by the following relationship:

ECS = EC x (effective energy cost)
ECS = 76,823 kWh/yr x ($0.251991/kWh)
ECS = $19,359/yr

Implementation Cost

The implementation cost of this measure includes the cost of purchasing and installing solar cells. According to manufacturers, a new unit can be purchased at a cost of $315. An additional $49,150 is estimated for installation, connection, and mounting structure, listed of costs are listed in the table below. Thus, the cost savings of $19,359/yr would pay for the total implementation cost of $100,810 in about 5.21 years.

	Units	**Price**	**Price**
		Per Unit (US-$)	**Total (US-$)**
Solar Cells	164	315	51,660
Power Grid Connection	1	1000	1,000
Installation	164	95.6	15,678
Universal Pole Mount	164	198	32,472
		Total	**100,810**

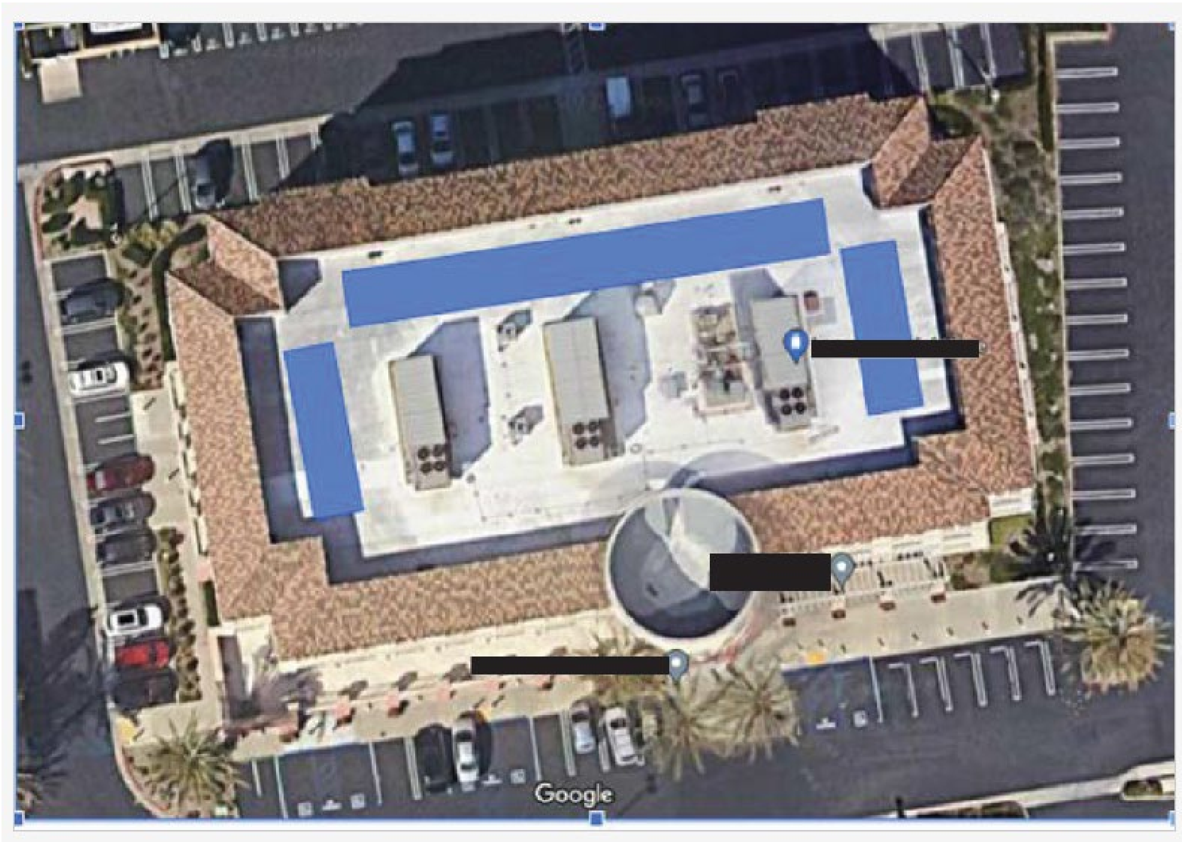


Figure 1. Proposed system design mounted in the roof

AR #3: Upgrade HVAC Equipment
(ARC 2.7226)

COMMUNITY CENTER

ARC: 2.7226	Estimated Annual Savings			Simple Payback
	Electric Energy Savings	Total Electric Cost Savings	Estimated Implementation Cost	
Total	146,521 kWh/yr (500 MBtu/yr)	$37,006 /yr	$28,350	0.77 years

Recommended Action

It is recommended to upgrade three HVAC unit by installing a variable speed drive to enhance efficiency. Currently there are three 50 ton air cooled condensing units that are brand new and use R410a ($8/lb). These units have an estimated Seasonal Energy Efficiency Ratio (SEER) of 16.1 on a scale of 8-21. A higher SEER rating means the piece of equipment uses less input power to operate normally. Upgrading this unit to operate more efficiently will reduce the energy consumption as well as increase savings cost. It is recommended to install a VSD in order to be able to change the speed of these units

Background

Current System

Currently the Community Center has three commercial rooftop condensing units servicing the entire facility. As well as three 11-14 ton Carrier heat pumps. This facility primes their HVAC systems 30 minutes before opening and totals around 4,082 hours a year. All units are monitored using wall mounted thermistors inside a digital Distech thermostat to allow for its occupants to manually set the unit for cooling, heating, and ventilation. The annual cost in electricity usage varies from each unit depending on the tonnage and power consumed. The following is how the relationship between efficiency rating, tonnage, and power consumed provide the current annual cost.

Current System Units: 3-York YLUA, 2-Carrier 38AU, 1-Carrier 25HC

Example: Energy Consumed per Year: York YLUA with a system wattage of 37.9 kilowatts, 50 tons & SEER 16.1 rating.

$$37.9kW * \frac{4{,}082\ hours}{1\ year} = 154{,}558 \frac{kWh}{yr.}$$

Estimated annual Cost: Using average cents per kWh from last electric bill from October 21 to September 2022 at 0.251991 $\frac{\$}{kWh}$.

$$154{,}558 \frac{kWh}{yr.} * 0.251991 \frac{\$}{kWh} = \$38{,}572.79/year$$

	Current Selected System Annual Costs	
Quantity	**Model**	**Annual Cost [$]**
3	York YLUA	123,354
2	Carrier 38AU	16,870
1	Carrier 25HC	2,651
Total		142,875

Proposed System

The proposed system includes installing three variable speed drive controllers to all 50 ton rooftop condensing units by the same manufacturer, Johnson Controls. By installing a York S1 VFD, the speed can be changed, and the annual energy consumption from each unit will lower by 30%.[1,2]

[1]https://www.equansmep.com/news/5-reasons-to-install-energy-saving-vfds/#:~:text=VFDs%20save%20energy%20by%20enabling,energy%20consumption%20by%20nearly%2090%25.

[2]https://www.energy.gov/sites/prod/files/2014/04/f15/motor_tip_sheet11.pdf

Proposed System Units: 3-York LUA equipped with 3-York S1 VFDs

Energy Consumed per Year: Trane with a system wattage of 26.5 kilowatts, 50 tons & SEER 16.1 rating.

$$26.5kW * \frac{4{,}082\ hours}{1\ year} = 108{,}190\ \frac{kWh}{yr.}$$

Estimated annual Cost: Using average cents per kWh from last electric bill from October 21 to September 2022 at 0.251991 $\frac{\$}{kWh}$.

$$108{,}190\ \frac{kWh}{yr.} * 0.251991\ \frac{\$}{kWh} = \$27{,}000.96/year$$

	Current Selected System Annual Costs	
Quantity	**Model**	**Annual Cost [$]**
3	York YLUA	$86,348
2	Carrier 38AU	16,870
1	Carrier 25HC	2,651
Total		105,869

Anticipated Saving

The amount of savings is based on the utility bill summary from 10/21-9/22 provided by Southern California Edison. The estimated implementation cost does include labor. The upgrade in HVAC will reduce the energy consumption and operation for the facility.

The current system costs a total of $142,875 per year to operate. The proposed system with VFDs installed costs a total of $105,869 per year to operate. Therefore, this recommendation will result in an estimated energy savings of 146,521 kWh of electricity and $37,006/yr.

Implementation Cost

The implementation cost of purchase and installation labor for all three VFDs to service the 50 ton rooftop condensing units is estimated at $28,350 total. Local market value for one York S1 VFD is $5,700 and with the new proposed system the total savings per year is estimated at $37,006 in utilities and will result in a payback period of 0.77 years.

AR #4: Install Occupancy Sensors

(ARC 2.7135)

TOTAL ENERGY SAVINGS

ARC: 2.7135	Annual Savings			Simple Payback
	Electric Energy Savings	Total Cost Savings	Implementation Cost	
Total	97,425 kWh/yr (332.4 MMBtu/yr)	$24,550 /yr	$9,000	0.37 years

CLUBHOUSE 2

Recommended Action

Install 25 occupancy sensors in rooms to reduce lighting electrical energy usage.

ARC: 2.7135	Annual Savings			Simple Payback
	Electric Energy Savings	Total Cost Savings	Implementation Cost	
Total	13,681 kWh/yr (46.68 MMBtu/yr)	$3,447 /yr	$2,500	0.73 years

Background

Lighting can be eliminated during unoccupied periods by installing occupancy sensors into the lighting circuits of the rooms. Energy savings and demand reduction will result from the reduced electrical usage for lighting. Currently, the lighting is turned on approximately 5,096 hrs/yr. According to facility personnel, these lights are needed approximately 50% of the total time.

Anticipated Savings

The annual energy savings, ES_i, and the annual demand reduction, DR_i, due to installing occupancy sensors in a given area *i* at this facility, are calculated by the following relations:

$DS = (L1 \times W1 + L2 \times W2 + L3 \times W3)$

and

$ES_i = DS \times (1 + FB_i) \times (1/K_1) \times (CH_i - PH_i)$

where

DS	=	demand summary of all LEDs in this facility
L1	=	number of lamps in area, 247
W1	=	rating of lamps in area, 18.5 Watts
L2	=	number of lamps in area, 20
W2	=	rating of lamps in area, 40 Watts
L3	=	number of lamps in area, 0
W3	=	rating of lamps in area, 25 Watts
FB_i	=	fractional increase in power draw due to ballasts in area, 0%
K_1	=	conversion constant, 1,000 W/kW
CH_i	=	current operating hours of lamps in area, 5,096 hrs/yr
PH_i	=	proposed operating hours of lamps in area 2,548 hrs/yr

Note that these values are calculated with the current lamps in place and that the savings would be even greater with more efficient lamps installed.

The annual energy savings, ES, for installing occupancy sensors into the lighting circuit of the office area with the current fluorescent lamps are estimated to be:

$DS = L1 \times W1 + L2 \times W2 + L3 \times W3$
$= 247 \times 18.5 + 20 \times 40 + 0 \times 25$
$= 5{,}369.50$ kW

$ES = 5{,}369.50 \times (1 + 0) \times (1/1{,}000) \times (5{,}096 - 2{,}548)$
$ES = 13{,}681$ kWh/yr

Therefore, the resulting total annual lighting cost savings, CS, are estimated to be:

CS = ES × (effective energy cost)
CS = 13,681 kWh/yr × ($0.251991/kWh)
CS = $3,447/yr

Implementation Cost

The estimated implementation cost to install an occupancy sensor is $100 including material and labor costs. The recommended occupancy sensors would operate using the existing switches.

Several types of controls are available including timer switches, door controls, and motion sensors. Recommendation includes an ultrasonic motion-sensing controller that produces a low intensity inaudible noise and detects changes in sound waves caused by any type of motion. The total implementation cost for installing 25 occupancy sensors is estimated to be $2,500. The total amount of savings calculated is $3,447/yr and will pay for the implementation cost of $2,500 in approximately 0.73 years.

CLUBHOUSE 4

Recommended Action

Install 25 occupancy sensors in rooms to reduce lighting electrical energy usage.

ARC: 2.7135	**Annual Savings**			**Simple Payback**
	Electric Energy Savings	Total Cost Savings	Implementation Cost	
Total	42,708 kWh/yr (145.73 MMBtu/yr)	$10,762 /yr	$2,500	0.23 years

Background

Lighting can be eliminated during unoccupied periods by installing occupancy sensors into the lighting circuits of the classrooms, bathrooms, and offices. Energy savings and demand reduction will result from the reduced electrical usage for lighting. Currently, the lighting is turned on approximately 2,652 hrs/yr. According to facility personnel, these lights are needed approximately 50% of the total time.

Anticipated Savings

The annual energy savings, ES_i, and the annual demand reduction, DR_i, due to installing occupancy sensors in a given area *i* at this facility, are calculated by the following relations:

$$DS = (L1 \times W1 + L2 \times W2 + L3 \times W3)$$

and

$$ES_i = DS \times (1 + FB_i) \times (1/K_1) \times (CH_i - PH_i)$$

where

DS = demand summary of all LEDs in this facility

L1	=	number of lamps in area, 1,741
W1	=	rating of lamps in area, 18.5 Watts
L2	=	number of lamps in area, 0
W2	=	rating of lamps in area, 40 Watts
L3	=	number of lamps in area, 0
W3	=	rating of lamps in area, 25 Watts
FB_i	=	fractional increase in power draw due to ballasts in area, 0%
K_1	=	conversion constant, 1,000 W/kW
CH_i	=	current operating hours of lamps in area, 2,652 hrs/yr
PH_i	=	proposed operating hours of lamps in area 1,326 hrs/yr

Note that these values are calculated with the current lamps in place and that the savings would be even greater with more efficient lamps installed.

The annual energy savings, ES, for installing occupancy sensors into the lighting circuit of the office area with the current fluorescent lamps are estimated to be:

$$DS = L1 \times W1 + L2 \times W2 + L3 \times W3$$
$$= 1,741 \times 18.5 + 0 \times 40 + 0 \times 25$$
$$= 32,208.5 \text{ kW}$$

$$ES = 32,208.5 \times (1 + 0) \times (1/1,000) \times (2,652 - 1,326)$$
$$ES = 42,708 \text{ kWh/yr}$$

Therefore, the resulting total annual lighting cost savings, CS, are estimated to be:

$$CS = ES \times (\text{effective energy cost})$$
$$CS = 42,708 \text{ kWh/yr} \times (\$0.251991/\text{kWh})$$
$$CS = \$10,762/\text{yr}$$

Implementation Cost

The estimated implementation cost to install an occupancy sensor is $100 including material and labor costs. The recommended occupancy sensors would operate using the existing switches.

Several types of controls are available including timer switches, door controls, and motion sensors. Recommendation includes an ultrasonic motion-sensing controller that produces a low intensity inaudible noise and detects changes in sound waves caused by any type of motion. The total implementation cost for installing 25 occupancy sensors is estimated to be $2,500. The total amount of savings calculated is $10,762/yr and will pay for the implementation cost of $2,500 in approximately 0.23 years.

CLUBHOUSE 6

Recommended Action

Install 15 occupancy sensors in rooms to reduce lighting electrical energy usage.

ARC: 2.7135	Annual Savings			Simple Payback
	Electric Energy Savings	Total Cost Savings	Implementation Cost	
Total	1,281 kWh/yr (4.37 MMBtu/yr)	$323 /yr	$1,500	4.64 year

Background

Lighting can be eliminated during unoccupied periods by installing occupancy sensors into the lighting circuits of the Game room, Assembly room, bathroom, kitchen, office and both lobbies. Energy savings and demand reduction will result from the reduced electrical usage for lighting. Currently, the lighting is turned on approximately 1,248 hrs/yr According to facility personnel, these lights are needed approximately 50% of the total time.

Anticipated Savings

The annual energy savings, ES_i, and the annual demand reduction, DR_i, due to installing occupancy sensors in a given area *i* at this facility, are calculated by the following relations:

$$DS = (L1 \times W1 + L2 \times W2 + L3 \times W3)$$

and

$$ES_i = DS \times (1 + FB_i) \times (1/K_1) \times (CH_i - PH_i)$$

where

DS = demand summary of all LEDs in this facility
L1 = number of lamps in area, 38
W1 = rating of lamps in area, 18.5 Watts
L2 = number of lamps in area, 5
W2 = rating of lamps in area, 40 Watts
L3 = number of lamps in area, 46
W3 = rating of lamps in area, 25 Watts
FB_i = fractional increase in power draw due to ballasts in area, 0%

K_1	=	conversion constant, 1,000 W/kW
CH_i	=	current operating hours of lamps in area, 1,248 hrs/yr
PH_i	=	proposed operating hours of lamps in area 624 hrs/yr

Note that these values are calculated with the current lamps in place and that the savings would be even greater with more efficient lamps installed.

The annual energy savings, ES, for installing occupancy sensors into the lighting circuit of the office area with the current fluorescent lamps are estimated to be:

DS	=	L1 x W1 + L2 x W2 + L3 x W3
	=	38 x 18.5 + 5 x 40 + 46 x 25
	=	2,053 kW

ES	=	2,053 x (1 + 0) x (1/1,000) x (1,248 – 624)
ES	=	1,281.1 kWh/yr

Therefore, the resulting total annual lighting cost savings, CS, are estimated to be:

CS	=	ES × (effective energy cost)
CS	=	1,281.1 kWh/yr × ($0.251991/kWh)
CS	=	$323/yr

Implementation Cost

The estimated implementation cost to install an occupancy sensor is $100 including material and labor costs. The recommended occupancy sensors would operate using the existing switches.

Several types of controls are available including timer switches, door controls, and motion sensors. Recommendation includes an ultrasonic motion-sensing controller that produces a low intensity inaudible noise and detects changes in sound waves caused by any type of motion. The total implementation cost for installing 15 occupancy sensors is estimated to be $1,500. The total amount of savings calculated is $323/yr and will pay for the implementation cost of $1,500 in approximately 4.64 years.

COMMUNITY CENTER

Recommended Action

Install 25 occupancy sensors in rooms to reduce lighting electrical energy usage.

ARC: 2.7135	Annual Savings			Simple Payback
	Electric Energy Savings	Total Cost Savings	Implementation Cost	
Total	39,755 kWh/yr (135.65 MMBtu/yr)	$10,018 /yr	$2,500	0.25 years

Background

Lighting can be eliminated during unoccupied periods by installing occupancy sensors into the lighting circuits of each floor with separate fixture schedules. Energy savings and demand reduction will result from the reduced electrical usage for lighting. The lights in the warehouse and receiving areas are currently turned on approximately 3,900 hrs/yr. According to facility personnel, these lights are needed approximately 50% of the total time.

Anticipated Savings

The annual energy savings, ES_i, and the annual demand reduction, DR_i, due to installing occupancy sensors in a given area *i* at this facility, are calculated by the following relations:

$$DS = (L1 \text{ x } W1 + L2 \text{ x } W2 + L3 \text{ x } W3)$$

and

$$ES_i = DS \text{ x } (1 + FB_i) \text{ x } (1/K_1) \text{ x } (CH_i - PH_i)$$

where

DS = demand summary of all LEDs in this facility
L1 = number of lamps in area, 1,102
W1 = rating of lamps in area, 18.5 Watts
L2 = number of lamps in area, 0
W2 = rating of lamps in area, 40 Watts
L3 = number of lamps in area, 0
W3 = rating of lamps in area, 25 Watts

FB_i = fractional increase in power draw due to ballasts in area, 0%
K_1 = conversion constant, 1,000 W/kW
CH_i = current operating hours of lamps in area, 3,900 hrs/yr
PH_i = proposed operating hours of lamps in area 1,950 hrs/yr

Note that these values are calculated with the current lamps in place and that the savings would be even greater with more efficient lamps installed.

The annual energy savings, ES, for installing occupancy sensors into the lighting circuit of the office area with the current fluorescent lamps are estimated to be:

DS	=	L1 x W1 + L2 x W2 + L3 x W3
	=	1,102 x 18.5 + 0 x 40 + 0 x 25
	=	20,387 kW
ES	=	20,387 x (1 + 0) x (1/1,000) x (3,900 – 1,950)
ES	=	39,755 kWh/yr

Therefore, the resulting total annual lighting cost savings, CS, are estimated to be:

CS	=	ES × (effective energy cost)
CS	=	39,755 kWh/yr × ($0.251991/kWh)
CS	=	$10,018/yr

Implementation Cost

The estimated implementation cost to install an occupancy sensor is $100. This includes material and labor costs. The occupancy sensors recommended would work in conjunction with the existing switches.

Several types of control are available including timer switches, door controls, and motion sensors. An ultrasonic motion-sensing controller which produces a low intensity inaudible sound and detects changes in the sound waves caused by any type of motion is recommended. The total implementation cost for installing 25 occupancy sensors is estimated to be $2,500. The total cost savings of $10,018/yr will pay for the implementation cost of $2,500 in about 0.25 years.

AR #5: Installation and Maintenance of CO2 Sensors

(ARC 2.7262)

TOTAL ENERGY SAVINGS

ARC: 2.7262	Annual Savings			Simple Payback
	Electric Energy Savings	Total Cost Savings	Implementation Cost	
Total	55,301 kWh/yr (188.7 MMBtu/yr)	$13,935/yr	$8,000	0.57 years

CLUBHOUSE 2

Recommended Action

It is recommended to install and maintain CO2 sensors that control the outside air dampers on the HVAC units. If CO2 sensors are installed, the energy code allows for diversity of patrons in retail spaces. By installing CO2 sensors, the outside air load can be reduced during summer and weekday hours when patron traffic is at a minimum, leading to energy savings.

ARC: 2.7262	Annual Savings			Simple Payback
	Electric Energy Savings	Total Cost Savings	Implementation Cost	
Total	16,005 kWh/yr (54.6 MMBtu/yr)	$4,033/yr	$2,000	0.50 years

Background

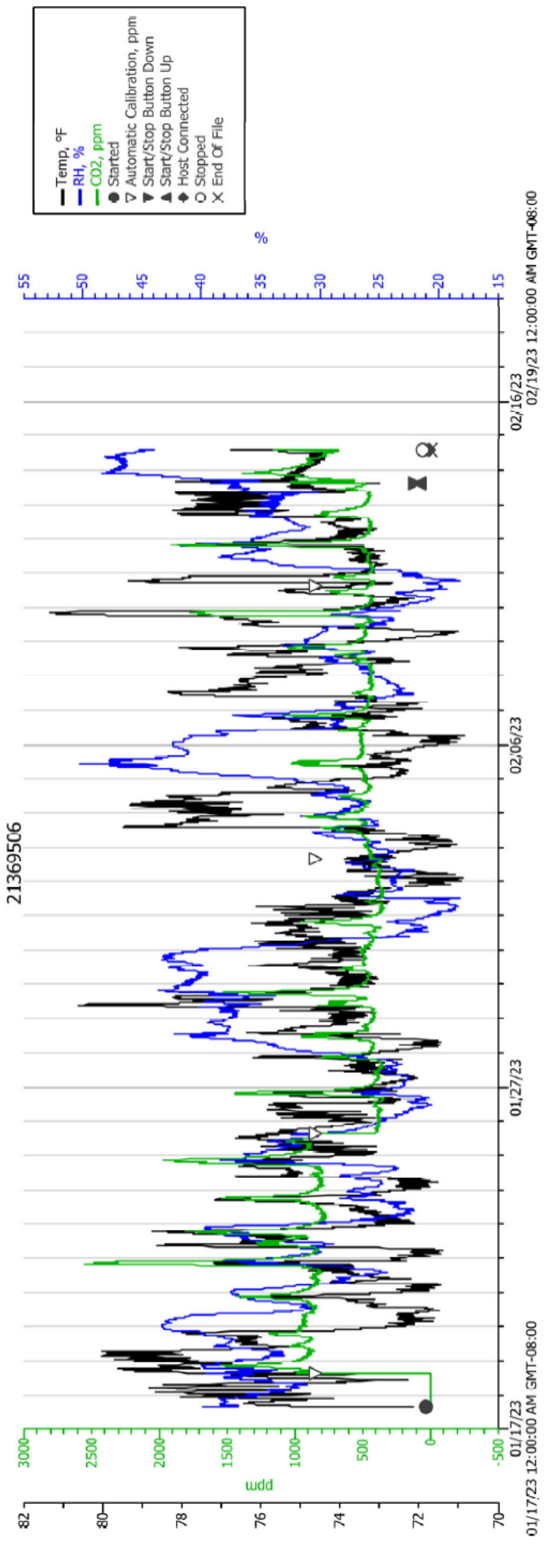
Currently at this facility, approximately 4 HVAC units are used for heating and cooling which serves 19,110 sq.ft total. Classrooms (ages 9+) requires 0.12 cfm of outside air per sq.ft and industry standard of 1 cfm per sq.ft of total cfm including outside air[1]. Please see table 6.2.2.1 below. The facility considered is 19,110 sq.ft, therefore 19,110 cfm is required, and 2,293.20 cfm of outside air is required. If CO2 sensors are installed, the energy code allows for diversity of patrons in retail space, allowing for using half of the required outside air. With proper training and strict maintenance of CO2 sensors controlling outside air, the outside air load can be reduced during summer weekday hours when patron traffic is at a minimum. We are using conservative values by only using the hot summer season on 90 days, and an average summer temperature for Laguna Woods of 90°F. The savings can be greater if the CO2 sensors are set for 800 ppm which is the industry standard and make allowance for infiltration and the very large building air volume. The outside dampers being controlled by only the CO2 sensors and enthalpy sensors (economizer control) can yield greater savings than our conservative estimate.

TABLE 6.2.2.1 Minimum Ventilation Rates in Breathing Zone
(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Notes	Default Values: Occupant Density (see Note 4)	Default Values: Combined Outdoor Air Rate (see Note 5)		Air Class
	cfm/ person	L/s· person	cfm/ft^2	L/s·m^2		#/1000 ft^2 or #/100 m^2	cfm/ person	L/s·person	
Correctional Facilities									
Cell	5	2.5	0.12	0.6		25	10	4.9	2
Dayroom	5	2.5	0.06	0.3		30	7	3.5	1
Guard stations	5	2.5	0.06	0.3		15	9	4.5	1
Booking/waiting	7.5	3.8	0.06	0.3		50	9	4.4	2
Educational Facilities									
Daycare (through age 4)	10	5	0.18	0.9		25	17	8.6	2
Daycare sickroom	10	5	0.18	0.9		25	17	8.6	3
Classrooms (ages 5–8)	10	5	0.12	0.6		25	15	7.4	1
Classrooms (age 9 plus)	10	5	0.12	0.6		35	13	6.7	1
Lecture classroom	7.5	3.8	0.06	0.3	H	65	8	4.3	1
Lecture hall (fixed seats)	7.5	3.8	0.06	0.3	H	150	8	4.0	1
Art classroom	10	5	0.18	0.9		20	19	9.5	2
Science laboratories	10	5	0.18	0.9		25	17	8.6	2
University/college laboratories	10	5	0.18	0.9		25	17	8.6	2
Wood/metal shop	10	5	0.18	0.9		20	19	9.5	2
Computer lab	10	5	0.12	0.6		25	15	7.4	1
Media center	10	5	0.12	0.6	A	25	15	7.4	1
Music/theater/dance	10	5	0.06	0.3	H	35	12	5.9	1
Multiuse assembly	7.5	3.8	0.06	0.3	H	100	8	4.1	1
Food and Beverage Service									
Restaurant dining rooms	7.5	3.8	0.18	0.9		70	10	5.1	2
Cafeteria/fast-food dining	7.5	3.8	0.18	0.9		100	9	4.7	2
Bars, cocktail lounges	7.5	3.8	0.18	0.9		100	9	4.7	2
Kitchen (cooking)	7.5	3.8	0.12	0.6		20	14	7.0	2
General									
Break rooms	5	2.5	0.06	0.3	H	25	7	3.5	1

[1] https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/standards%20addenda/62_1_2013_p_20150707.pdf

Please see below graph of CO2 levels for Clubhouse 2 over a two week period.



Anticipated Savings

The annual energy savings, ES, due to installing CO_2 sensors for entire facility are estimated to be:

$$ES = CFM \times CC \times (OSA - SA) \times H \times D$$

where

CFM	=	Outside air required, 2,293.20 cfm
CC	=	Conversion constant, 1.08
OSA	=	Outside air temperature, 90°F
SA	=	Supply air temperature, 55°F
H	=	Hours considered, 7 hours/day
D	=	Days considered, 90 days/yr

Thus, the annual energy savings, ES_g, for the two production areas are estimated to be:

ES	=	2,293.20 x 1.08 x (90 – 55) x 7 x 90
ES	=	54,610,264.80 Btu/yr
ES	=	16,005 kWh/yr

The energy cost savings, CS, due to this installation are estimated to be:

CS	=	ES x (effective energy cost)
CS	=	16,005 kWh/yr x ($0.251991 /kWh)
CS	=	$4,033 /yr

Implementation Cost

The cost of the purchase and installation of 10 CO_2 sensor units is estimated to be approximately $200 per CO_2 sensor, or $2,000 total. The total savings of $4,033 will pay for the new CO_2 sensors in 0.50 years.

CLUBHOUSE 4

Recommended Action

It is recommended to install and maintain CO_2 sensors that control the outside air dampers on the HVAC units. If CO_2 sensors are installed, the energy code allows for diversity of patrons in retail spaces. By installing CO_2 sensors, the outside air load can be reduced during summer and weekday hours when patron traffic is at a minimum, leading to energy savings.

ARC: 2.7262	**Annual Savings**			**Simple Payback**
	Electric Energy Savings	Total Cost Savings	Implementation Cost	
Total	7,194 kWh/yr (24.5 MMBtu/yr)	$1,813/yr	$2,000	1.10 year

Background

Currently at this facility, approximately 9 HVAC units are used for heating and cooling which serves 8,590 sq.ft total. Classroom spaces (ages 9+) require 0.12 cfm of outside air per sq.ft and industry standard of 1 cfm per sq.ft of total cfm including outside air[1]. Please see table 6.2.2.1 below. The retail space considered is 8,590 sq.ft, therefore 8,590 cfm is required, and 1,030.80 cfm of outside air is required. If CO_2 sensors are installed, the energy code allows for diversity of patrons in retail space, allowing for using half of the required outside air. With proper training and strict maintenance of CO_2 sensors controlling outside air, the outside air load can be reduced during summer weekday hours when patron traffic is at a minimum. We are using conservative values by only using the hot summer season on 90 days, and an average summer temperature for Laguna Woods of 90°F. The savings can be greater if the CO_2 sensors are set for 800 ppm which is the industry standard and make allowance for infiltration and the very large building air volume. The outside dampers being controlled by only the CO_2 sensors and enthalpy sensors (economizer control) can yield greater savings than our conservative estimate.

TABLE 6.2.2.1 Minimum Ventilation Rates in Breathing Zone
(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Notes	Default Values			Air Class
						Occupant Density (see Note 4)	Combined Outdoor Air Rate (see Note 5)		
	cfm/person	L/s·person	cfm/ft²	L/s·m²		#/1000 ft² or #/100 m²	cfm/person	L/s·person	
Correctional Facilities									
Cell	5	2.5	0.12	0.6		25	10	4.9	2
Dayroom	5	2.5	0.06	0.3		30	7	3.5	1
Guard stations	5	2.5	0.06	0.3		15	9	4.5	1
Booking/waiting	7.5	3.8	0.06	0.3		50	9	4.4	2
Educational Facilities									
Daycare (through age 4)	10	5	0.18	0.9		25	17	8.6	2
Daycare sickroom	10	5	0.18	0.9		25	17	8.6	3
Classrooms (ages 5–8)	10	5	0.12	0.6		25	15	7.4	1
Classrooms (age 9 plus)	10	5	0.12	0.6		35	13	6.7	1
Lecture classroom	7.5	3.8	0.06	0.3	H	65	8	4.3	1
Lecture hall (fixed seats)	7.5	3.8	0.06	0.3	H	150	8	4.0	1
Art classroom	10	5	0.18	0.9		20	19	9.5	2
Science laboratories	10	5	0.18	0.9		25	17	8.6	2
University/college laboratories	10	5	0.18	0.9		25	17	8.6	2
Wood/metal shop	10	5	0.18	0.9		20	19	9.5	2
Computer lab	10	5	0.12	0.6		25	15	7.4	1
Media center	10	5	0.12	0.6	A	25	15	7.4	1
Music/theater/dance	10	5	0.06	0.3	H	35	12	5.9	1
Multiuse assembly	7.5	3.8	0.06	0.3	H	100	8	4.1	1
Food and Beverage Service									
Restaurant dining rooms	7.5	3.8	0.18	0.9		70	10	5.1	2
Cafeteria/fast-food dining	7.5	3.8	0.18	0.9		100	9	4.7	2
Bars, cocktail lounges	7.5	3.8	0.18	0.9		100	9	4.7	2
Kitchen (cooking)	7.5	3.8	0.12	0.6		20	14	7.0	2
General									
Break rooms	5	2.5	0.06	0.3	H	25	7	3.5	1

[1] https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/standards%20addenda/62_1_2013_p_20150707.pdf

Anticipated Savings

The annual energy savings, ES, due to installing CO2 sensors for entire facility are estimated to be:

$$ES = CFM \times CC \times (OSA - SA) \times H \times D$$

where

CFM	=	Outside air required, 21,030.80 cfm
CC	=	Conversion constant, 1.08
OSA	=	Outside air temperature, 90°F
SA	=	Supply air temperature, 55°F
H	=	Hours considered, 7 hours/day
D	=	Days considered, 90 days/yr

Thus, the annual energy savings, ES_g, for the two production areas are estimated to be:

ES	=	1,030.80 x 1.08 x (90 – 55) x 7 x 90
ES	=	24,547,471.20 Btu/yr
ES	=	7,194 kWh/yr

The energy cost savings, CS, due to this installation are estimated to be:

CS	=	ES x (effective energy cost)
CS	=	7,194.16 kWh/yr x ($0.251991 /kWh)
CS	=	$1,813/yr

Implementation Cost

The cost of the purchase and installation of 10 CO2 sensor units is estimated to be approximately $200 per CO2 sensor, or $2,000 total. The total savings of $1,813 will pay for the new CO2 sensors in 1.10 years.

CLUBHOUSE 6

Recommended Action

It is recommended to install and maintain CO2 sensors that control the outside air dampers on the HVAC units. If CO2 sensors are installed, the energy code allows for diversity of patrons in retail spaces. By installing CO2 sensors, the outside air load can be reduced during summer and weekday hours when patron traffic is at a minimum, leading to energy savings.

ARC: 2.7262	**Annual Savings**			**Simple Payback**
	Electric Energy Savings	Total Cost Savings	Implementation Cost	
Total	5,057 kWh/yr (17.2 MMBtu/yr)	$1,274/yr	$2,000	1.57 year

Background

Currently at this facility, approximately 5 HVAC units are used for heating and cooling which serves 6,038 sq.ft total. Retail space requires 0.12 cfm of outside air per sq.ft and industry standard of 1 cfm per sq.ft of total cfm including outside air[1]. Please see table 6.2.2.1 below. The retail space considered is 6,038 sq.ft, therefore 6,038 cfm is required, and 724.56 cfm of outside air is required. If CO2 sensors are installed, the energy code allows for diversity of patrons in retail space, allowing for using half of the required outside air. With proper training and strict maintenance of CO2 sensors controlling outside air, the outside air load can be reduced during summer weekday hours when patron traffic is at a minimum. We are using conservative values by only using the hot summer season on 90 days, and an average summer temperature for Laguna Woods of 90°F. The savings can be greater if the CO2 sensors are set for 800 ppm which is the industry standard and make allowance for infiltration and the very large building air volume. The outside dampers being controlled by only the CO2 sensors and enthalpy sensors (economizer control) can yield greater savings than our conservative estimate.

TABLE 6.2.2.1 Minimum Ventilation Rates in Breathing Zone (Continued)
(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Notes	Default Values			Air Class
						Occupant Density (see Note 4)	Combined Outdoor Air Rate (see Note 5)		
	cfm/ person	L/s· person	cfm/ft^2	L/s·m^2		#/1000 ft^2 or #/100 m^2	cfm/ person	L/s·person	
Coffee stations	5	2.5	0.06	0.3	H	20	8	4	1
Conference/meeting	5	2.5	0.06	0.3	H	50	6	3.1	1
Corridors	—	—	0.06	0.3	H	—			1
Occupiable storage rooms for liquids or gels	5	2.5	0.12	0.6	B	2	65	32.5	2
Hotels, Motels, Resorts, Dormitories									
Bedroom/living room	5	2.5	0.06	0.3	H	10	11	5.5	1
Barracks sleeping areas	5	2.5	0.06	0.3	H	20	8	4.0	1
Laundry rooms, central	5	2.5	0.12	0.6		10	17	8.5	2
Laundry rooms within dwelling units	5	2.5	0.12	0.6		10	17	8.5	1
Lobbies/prefunction	7.5	3.8	0.06	0.3	H	30	10	4.8	1
Multipurpose assembly	5	2.5	0.06	0.3	H	120	6	2.8	1
Office Buildings									
Breakrooms	5	2.5	0.12	0.6		50	7	3.5	1
Main entry lobbies	5	2.5	0.06	0.3	H	10	11	5.5	1
Occupiable storage rooms for dry materials	5	2.5	0.06	0.3		2	35	17.5	1
Office space	5	2.5	0.06	0.3	H	5	17	8.5	1
Reception areas	5	2.5	0.06	0.3	H	30	7	3.5	1
Telephone/data entry	5	2.5	0.06	0.3	H	60	6	3.0	1
Miscellaneous Spaces									
Bank vaults/safe deposit	5	2.5	0.06	0.3	H	5	17	8.5	2
Banks or bank lobbies	7.5	3.8	0.06	0.3	H	15	12	6.0	1
Computer (not printing)	5	2.5	0.06	0.3	H	4	20	10.0	1

[1] https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/standards%20addenda/62_1_2013_p_20150707.pdf

Anticipated Savings

The annual energy savings, ES, due to installing CO2 sensors for entire facility are estimated to be:

$$ES = CFM \times CC \times (OSA - SA) \times H \times D$$

where

CFM	=	Outside air required, 724.56 cfm
CC	=	Conversion constant, 1.08
OSA	=	Outside air temperature, 90°F
SA	=	Supply air temperature, 55°F
H	=	Hours considered, 7 hours/day
D	=	Days considered, 90 days/yr

Thus, the annual energy savings, ES_g, for the two production areas are estimated to be:

ES	=	724.56 x 1.08 x (90 – 55) x 7 x 90
ES	=	17,254,671.84 Btu/yr
ES	=	5,057 kWh/yr

The energy cost savings, CS, due to this installation are estimated to be:

CS	=	ES x (effective energy cost)
CS	=	5,057 kWh/yr x ($0.251991 /kWh)
CS	=	$1,274/yr

Implementation Cost

The cost of the purchase and installation of 10 CO2 sensor units is estimated to be approximately $200 per CO2 sensor, or $2,000 total. The total savings of $1,274 will pay for the new CO2 sensors in 1.57 years.

COMMUNITY CENTER

Recommended Action

It is recommended to install and maintain CO2 sensors that control the outside air dampers on the HVAC units. If CO2 sensors are installed, the energy code allows for diversity of patrons in retail spaces. By installing CO2 sensors, the outside air load can be reduced during summer and weekday hours when patron traffic is at a minimum, leading to energy savings.

ARC: 2.7262	**Annual Savings**			**Simple Payback**
	Electric Energy Savings	Total Cost Savings	Implementation Cost	
Total	27,045 kWh/yr (92.3 MMBtu/yr)	$6,815/yr	$2,000	0.29 years

Background

Currently at this facility, approximately 6 HVAC units are used for heating and cooling which serves 32,292 sq.ft total. Office space requires 0.06 cfm of outside air per sq.ft and industry standard of 1 cfm per sq.ft of total cfm including outside air[1]. Please see table 6.2.2.1 below. The retail space considered is 32,292 sq.ft, therefore 32,292 cfm is required, and 3,875.04 cfm of outside air is required. If CO2 sensors are installed, the energy code allows for diversity of patrons in retail space, allowing for using half of the required outside air. With proper training and strict maintenance of CO2 sensors controlling outside air, the outside air load can be reduced during summer weekday hours when patron traffic is at a minimum. We are using conservative values by only using the hot summer season on 90 days, and an average summer temperature for Laguna Woods of 90°F. The savings can be greater if the CO2 sensors are set for 800 ppm which is the industry standard and make allowance for infiltration and the very large building air volume. The outside dampers being controlled by only the CO2 sensors and enthalpy sensors (economizer control) can yield greater savings than our conservative estimate.

TABLE 6.2.2.1 Minimum Ventilation Rates in Breathing Zone (Continued)
(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Notes	Default Values			Air Class
						Occupant Density (see Note 4)	Combined Outdoor Air Rate (see Note 5)		
	cfm/ person	L/s· person	cfm/ft^2	L/s·m^2		#/1000 ft^2 or #/100 m^2	cfm/ person	L/s·person	
Coffee stations	5	2.5	0.06	0.3	H	20	8	4	1
Conference/meeting	5	2.5	0.06	0.3	H	50	6	3.1	1
Corridors	—	—	0.06	0.3	H	—			1
Occupiable storage rooms for liquids or gels	5	2.5	0.12	0.6	B	2	65	32.5	2
Hotels, Motels, Resorts, Dormitories									
Bedroom/living room	5	2.5	0.06	0.3	H	10	11	5.5	1
Barracks sleeping areas	5	2.5	0.06	0.3	H	20	8	4.0	1
Laundry rooms, central	5	2.5	0.12	0.6		10	17	8.5	2
Laundry rooms within dwelling units	5	2.5	0.12	0.6		10	17	8.5	1
Lobbies/prefunction	7.5	3.8	0.06	0.3	H	30	10	4.8	1
Multipurpose assembly	5	2.5	0.06	0.3	H	120	6	2.8	1
Office Buildings									
Breakrooms	5	2.5	0.12	0.6		50	7	3.5	1
Main entry lobbies	5	2.5	0.06	0.3	H	10	11	5.5	1
Occupiable storage rooms for dry materials	5	2.5	0.06	0.3		2	35	17.5	1
Office space	5	2.5	0.06	0.3	H	5	17	8.5	1
Reception areas	5	2.5	0.06	0.3	H	30	7	3.5	1
Telephone/data entry	5	2.5	0.06	0.3	H	60	6	3.0	1
Miscellaneous Spaces									
Bank vaults/safe deposit	5	2.5	0.06	0.3	H	5	17	8.5	2
Banks or bank lobbies	7.5	3.8	0.06	0.3	H	15	12	6.0	1
Computer (not printing)	5	2.5	0.06	0.3	H	4	20	10.0	1

[1] https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/standards%20addenda/62_1_2013_p_20150707.pdf

Anticipated Savings

The annual energy savings, ES, due to installing CO2 sensors for entire facility are estimated to be:

$$ES = CFM \times CC \times (OSA - SA) \times H \times D$$

where

CFM	=	Outside air required, 3,875.04 cfm
CC	=	Conversion constant, 1.08
OSA	=	Outside air temperature, 90°F
SA	=	Supply air temperature, 55°F
H	=	Hours considered, 7 hours/day
D	=	Days considered, 90 days/yr

Thus, the annual energy savings, ES_g, for the two production areas are estimated to be:

ES	=	3,875.04 x 1.08 x (90 – 55) x 7 x 90
ES	=	92,280,202.56 Btu/yr
ES	=	27,045 kWh/yr

The energy cost savings, CS, due to this installation are estimated to be:

CS	=	ES x (effective energy cost)
CS	=	27,045 kWh/yr x ($0.251991 /kWh)
CS	=	$6,815/yr

Implementation Cost

The cost of the purchase and installation of 10 CO2 sensor units is estimated to be approximately $200 per CO2 sensor, or $2,000 total. The total savings of $6,815 will pay for the new CO2 sensors in 0.29 years.

AR #6: Turn Off Pilot Lights

(ARC 2.6214)

Recommended Action:

It is recommended to shut off the pilot lights for stoves during the times when they are not in use. This facility has 18 units with pilot lights.

ARC: 2.6214	Annual Savings			Simple Payback
	Energy Savings	Total Cost Savings	Implementation Cost	
Total	39,594 kWh/yr (135.1 MMBtu/yr)	$9,977/yr	$1,040	0.10 years

Background:

Currently at this facility, there are 18 pilot lights on stoves that remain lit year round. A single pilot light consumes anywhere between 600 to 1,200 btu/hr. Turning off the pilot lights when the stoves are not being used can reduce the facility's natural gas usage and costs. The stoves are currently used only for approximately 8 hours per week, or a total of 416 hours per year. The pilot lights are lit year round, for a total of 8,760 hours per year, but only needed for 416 hours per year, therefore we are proposing to shut the pilot lights off for a total of 8,344 hours per year. Training employees on safely turning the pilot lights on and off can significantly reduce usage and costs.

Anticipated Savings:

The annual energy savings, ESg, which may be realized by implementing the above recommendation, can be estimated as follows:

$$ESg = R \times H \times N$$

where

R = rating of pilot burner, 900 Btu/hr
H = hours during which pilot lights could be shut off, 8,344 hr
N = number of pilots, 18

Thus,

ESg = 900 x 8,344 x 18
ESg = 135.1 MMBtu/yr
ESg = 39,594 kWh/yr

The cost savings, CSg, are estimated as follows:

CSg = ESg x (effective natural gas cost)
CSg = 39,594 kWh/yr x ($0.251991/kWh)
CSg = $9,977/yr

Implementation Cost:

The implementation cost is estimated to be the labor cost for a worker to turn off the pilot lights at the end of use. This process is estimated to take 0.5 hours. The stoves are only used at max twice per week. At an hourly wage of $20/hr, the implementation cost would be $1,040/yr with an estimated payback period of 0.10 year.

AR #7: Install Heat Pump Water Heater

(ARC 2.1321)

Recommended Action

Due to the difference in efficiency between regular water heaters and heat pump water heaters, it is recommended that the current water heaters be replaced with heat pump water heaters.

ARC: 2.1321	**Estimated Annual Savings**			**Simple Payback**
	Electric Energy Savings	Total Cost Savings	Estimated Implementation Cost	
Total	22,279 kWh/yr (76.0 MMBtu/yr)	$5,614	$8,200	1.46 years

Background

Currently, a two water heaters are used at this facility. The rated power of the heaters are 12 kW (50 gallon unit) and 15 kW (98 gallon unit)

According to facility personnel, the water heaters are used for about 3,900 hours per year. Based on manufacturer literature, it is estimated that the fraction of the time when the water heaters are actually drawing energy is about 30%.

The operating cost and energy use can be estimated to be cut by 67% by replacing the current water heater with a heat pump water heater[1]. This is due to an increased efficiency. Additionally, these modern heat pump water heaters can be programmed to heat water during off-peak night hours, that would provide additional savings using off-peak rates.

Anticipated Savings

The estimated energy savings, ES, for replacing the gas water heater with an electric heat pump water heater can be estimated as shown below:

ES = TP x TF x H x PE / EFFe

1 https://sealed.com/resources/heat-pump-water-heater-guide/#:~:text=A%20heat%20pump%20water%20heater%20can%20be%20up%20to%203,STAR%20(3%2C%204).

Where

TP	=	total rated power of the water heaters, 27 kW
TF	=	estimated fraction of time heating elements are drawing power, 30%
H	=	average annual operating hours for the heaters, 3,900 hrs/yr
PE	=	efficiency gained by proposed heat pump water heater, 67%
EFFe	=	efficiency of current equipment, 95%

Thus, the estimated energy usage, ES, for replacing the gas water heater with an electric heat pump water heater is estimated to be:

ES = 27 x 0.30 x 3,900 x 0.67 / 0.95
ES = 22,279 kWh/yr

The proposed annual operating cost savings, CS, of the proposed heat pump water heater can be estimated to be:

CS = ES x (effective energy cost)
CS = 22,279 kWh/yr x ($0.251991/kWh)
CS = $5,614/yr

Implementation Cost

The cost of implementation is based on the capital cost for two new electric heat pump water heaters and installation costs. Given that there is existing electrical capacity, the installation would require a matching electrical connection and electrical breaker per code. The implementation cost is estimated to be $5,000 for the 98 gallon replacement and $3,200 for the 50 gallon replacement. The total implementation cost is $8,200 for both heat pump water heaters. The cost savings of $5,614/yr would pay for the implementation cost within about 1.46 years.

AR #8: Install High Efficiency Pump Motors

(ARC 2.4133)

Recommended Action

Install high efficiency electric pool pump motors to replace the existing standard pump motors currently used at this facility. It is recommended that more efficient motors be installed only as existing motors wear out (i.e. only on a replacement basis).

ARC: 2.4133	**Estimated Annual Savings**			**Simple Payback**
	Electric Energy Savings	Total Cost Savings	Estimated Implementation Cost	
Total	4,629 kWh/yr (15.8 MMBtu/yr)	$1,166	$2,400	2.06 years

Anticipated Savings

Depending on the horsepower rating of a given high efficiency motor, operating efficiencies may vary from 1% to 20% higher than the operating efficiencies of the existing pool pump motors. In general, the larger the motor, the smaller the efficiency increase. Normally, a cost premium (or cost differential) must be paid for the higher efficiency motors.

The annual energy savings, ES_i, and the annual demand reduction, DR, which could be realized by installing high efficiency motors on a replacement basis, can be estimated using the following relationships:

$$ES_i = HP_i \times N_i \times H_i \times LF_i \times UF_i \times C_1 \times (1/E_c - 1/E_p)$$

where

HP_i = horsepower of motor considered, hp
N_i = number of motors of a given size, no units
H_i = annual operating hours of equipment driven by motor, 8,760 hrs/yr
LF_i = estimated fraction of rated load at which motor normally operates, 75%
UF_i = fraction of operating time during which motor actually runs, no units
C_1 = conversion constant, 0.746 kW/hp
E_c = estimated efficiency of existing motor, no units
E_p = estimated efficiency of proposed motor, no units

As an example, the energy savings, ES_1, for the 2 hp motor is estimated to be:

ES_1 = 2 hp x 1 x 8760 x 0.75 x 1.0 x 0.746 x (1/0.8 - 1/0.9)
ES_1 = 1,361 kWh/yr

Therefore, the total annual cost savings, CS_1, for the same motor are estimated to be:

CS_1 = ES_1 x (effective energy cost)
CS_1 = 1,361 kWh/yr x ($0.251991/kWh)
CS_1 = $343/yr

A summary of savings calculations for all of the motors considered is given in the table on the following page. High efficiency motors and motors which have a simple payback period greater than three years are not considered.

Summary of Savings

Summary of Savings

Effective Electric Energy Cost =	$0.2520 /kWh
Effective Demand Cost =	$0.00 /kWm
Annual Production Hours (H) =	8,760 hrs/yr
Estimated Load Factor (LF) =	75.00 %
Estimated Average Motor Life =	9 yrs

Driven Equipment	Motor Horsepower (hp)	No. of Motors	Current Motor Efficiency	Proposed Motor Efficiency	Demand Factor	Utilization Factor	Annual Energy Savings (kWh/yr)	Annual Demand Reduction (kWm/yr)	Energy Cost Savings ($/yr)	Demand Cost Savings ($/yr)	Total Cost Savings ($/yr)
1 - Century Centurion	1 1/2	1	0.750	0.900	1.00	1.00	1,634	2.2	412	0	412
2 - Pentair (2hp)	2	1	0.800	0.900	1.00	1.00	1,361	1.9	343	0	343
3 - Pentair (1.5hp)	1 1/2	1	0.750	0.900	1.00	1.00	1,634	2.2	412	0	412
TOTALS	-----	**3**	-----	-----	-----	-----	**4,629**	**6.3**	**1,166**	**0**	**1,166**

From the table above, the total energy savings, ES, and their total associated cost savings, CS, are found to be 4,629 kWh/yr, and $1,166/yr, respectively.

Implementation Cost

Implementation cost is based on the difference between the cost for installing high efficiency motors and standard motors, assuming that the standard motors currently in use will be replaced with high efficiency motors as the standard motors wear out. The total implementation cost is estimated to be $2,400. On average, the cost savings of $4,629/yr would pay for the implementation cost within about 0.52 years.

Additional Items Considered

The purpose of this section of the report is to provide additional general information concerning energy, waste, and productivity recommendations at this facility, in order to make the report more complete. Measures considered by the assessment team but not recommended for various reasons, and other assessment services offered and performed are presented here to give more detail on the status of energy, waste, and productivity interests at this facility.

- **HVAC maintanence**

  To ensure the longevity of all HVAC units it is recommended to schedule maintenance work on them at least twice a year. One time in the year it is recommended to have all air conditioning units serviced in the Spring (one season before the hottest season) and the other scheduled service work for heat pumps (one season before the coldest season). This type of maintenance helps to maintain your HVAC equipment's performance and if needed, to recalibrate.

- **Replace older HVAC units**
  - It is recommended that the facility replaces older HVAC units with new, high-efficiency models. By installing units with the same capacity, but with lower kW ratings (because they are more efficient units), power consumption will be decreased with no change in comfort.
  - Based on our estimation using your current HVAC unit information, replacing these units would result in approximately 50-65% reduction in energy consumption for those units. This would result in approximately $35,000 per year in electrical cost savings. We estimate the implementation cost to be approximately $80,000. Therefore, the payback period for this recommendation would be 2.30 years. Please see additional details below.

  - Clubhouse 2
  - Recommended Action
    - It is recommended to upgrade three HVAC units with two newer models. Currently there are three units that were manufactured in 1995 and still use freon R22. This freon is a type of refrigerant that has been phased out and modern HVACR has retrofitted these units with a cheaper gas such as R404a ($6.25/lb) compared to R22 ($21/lb). These units have a Seasonal Energy Efficiency Ratio (SEER) of 8.7 which is on a scale of 8-21. A higher SEER rating means the piece of equipment uses less input power to

operate normally. Installing new and more efficient units will reduce the energy consumption as well as increase savings cost.

- Background
- Current System
  - Currently Clubhouse Two has a total of four HVAC units servicing the entire facility. This facility primes their HVAC systems 30 minutes before opening and totals around 5,278 hours a year. Only one of these units is relatively new and uses R410a ($8/lb) and that is the Trane RAUJ 30 ton air-cooled condensing unit by the Sequoia Ballroom. The other four smaller units are as old as 1995 and are in need of replacement. The large commercial Trane RAUJ is monitored using wall mounted thermistors inside a digital Distech thermostat to allow for its occupants to manually set the unit for cooling, heating, and ventilation. However, the older units use much older controls to manually monitor cooling and heating. The annual cost in electricity usage varies from each unit depending on the tonnage and power consumed. The following is how the relationship between efficiency rating, tonnage, and power consumed provide the current annual cost.
  - Current System Units: 1-Trane RAUJ, 1-BDP Co., 1-Trane TWA, & 1-Fujitsu AOU
  - Energy Consumed per Year: Trane TWA with a system wattage of 6.4 kilowatts, 5 tons & SEER 9.4 rating.
- Proposed System
  - The proposed system includes replacing the three smaller (1.5-5 ton) units with newer model units provided by the manufacturer Trane. This includes two Trane XL17i 4 and 5 ton units and installing a Trane TR200 variable frequency drive (VFD) to the existing Trane RAUJ 30 ton ac unit. The new units have a better Seasonal Energy Efficiency Ratio (SEER) rating at 17.2 and considering how old the current units are it is good practice to install a new air handler. Furthermore, installing a VFD to the existing 30 ton unit will allow for an annual energy consumption savings of up to 30%. The recommended VFD for the RAUJ 30 ton ac unit is the ATO GK300 capabilities include: 100hp (75kW) VFD, 3 phase 460V with a setting range of 0%-30%. See references for details on this specific model VFD.1

- "100 Hp (75 kW) VFD, 3 Phase 230V, 400V, 460V." *ATO.Com*, www.ato.com/100hp-vfd?affiliate=shopping. Accessed 17 Dec. 2023. [100 hp (75 kW) VFD, 3 Phase 230V, 400V, 460V | ATO.com]
- *Note: See user manual page 141.
- Proposed System Units: 2-Trane XV\L17i with 1-TEM 6 Air Handler
- Energy Consumed per Year: Trane XL17i with a system wattage of 3.49 kilowatts, 5 tons & SEER 17.2 rating.

- Clubhouse 4
- Recommended Action
  - It is recommended to upgrade eight HVAC units with newer models. Currently there are eight units that were manufactured in 2003 and still use freon R22. This freon is a type of refrigerant that has been phased out and modern HVACR has retrofitted these units with a cheaper gas such as R404a ($6.25/lb) compared to R22 ($21/lb). These units have an estimated Seasonal Energy Efficiency Ratio (SEER) of 13 on a scale of 8-21. A higher SEER rating means the piece of equipment uses less input power to operate normally. Installing new and more efficient units will reduce the energy consumption as well as increase savings cost.
- Background
- Current System
  - Currently Clubhouse Four has a total of nine HVAC units servicing the entire facility. This facility primes their HVAC systems 30 minutes before opening and totals around 2,834 hours a year. Only one of these units is relatively new and uses R410a ($8/lb) and that is the Trane TWE 7.5 ton air handling unit. The other eight units are between 28-20 years old and are in need of replacements. All units are monitored using wall mounted thermistors inside a digital Distech thermostat to allow for its occupants to manually set the unit for cooling, heating, and ventilation. The annual cost in electricity usage varies from each unit depending on the tonnage and power consumed. The following is how the relationship between efficiency rating, tonnage, and power consumed provide the current annual cost.
  - Current System Units: 4-Trane TXC, 3-Trane TTA & 1-Trane YC
  - Energy Consumed per Year: Trane YXC with a system wattage of 4.6 kilowatts, 5 tons & SEER 13 rating.

- Proposed System
    - The proposed system includes replacing the eight smaller units (5-10 ton) with newer model units provided by the manufacturer Trane. This includes seven Trane XV18 7-5 ton units and installing a Trane XV20i 10 ton unit. The new units have a better Seasonal Energy Efficiency Ratio (SEER) rating at 18-21.5.
    - Proposed System Units: 6-Trane XV18 & 2-Trane XV20i
    - Energy Consumed per Year: Trane XV20i with a system wattage of 5.8 kilowatts, 10 tons & SEER 21.5 rating.

- **Solar Water Cooling**
    - Photovoltaic (PV) systems convert sunlight into electricity [1]. This technology has an efficiency of up to ~20%, depending on the type of technology, materials, the system's final arrangement, location, and temperature of operation, among other conditions. Temperature can significantly affect the performance of the cells. It is estimated the efficiency and thus, the power output of the system decreases ~0.5% per temperature degree [2], hence considering different cooling techniques become important when the solar system is expected to work under high ambient temperatures, especially during the summer.

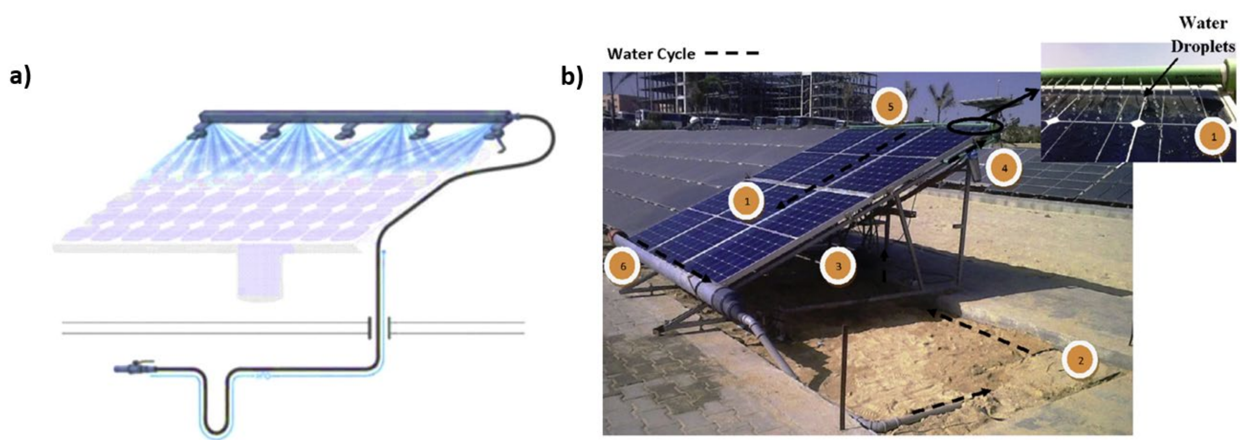


Figure 1. Water spraying system a) diagram taken from Dwivedi et al. [4] and b) experimental setup taken from Moharram et al. [5].

- Active cooling is a popular cooling technique implemented on these types of systems to reduce the surface temperature of the panels [3]. Usually, air or water is pumped over the cells to transfer its heat to the cooling fluid by forced convection to maintain the surface temperature of the cells below 30℃. Figure 1 shows an example of this cooling technique taken from Dwivedi et al. [4] and Moharram et al. [5]. Considering the amount of wastewater produced by the client, if a PV system is installed on the roof of the building, a second use of the water could be PV cooling. To implement this type of technique, the following need to be studied:

- There will be an increase in the electrical consumption from the pumps required to take water up to the roof, hence this needs to be considered during the design of the PV system to account for this extra energy production requirement.
- A detailed analysis needs to be performed to minimize the amount of water and energy required for cooling purposes. A collection system needs to be implemented as well to capture and return the water left after the process to the initial tank.
- A water filter should be considered to minimize the calcium build-up on the surface of the solar modules with time, which might also lead to a decrease in the system's efficiency.
- References

  - 1-. "Solar Photovoltaic Technology Basics | NREL." https://www.nrel.gov/research/re-photovoltaics.html (accessed Jun. 08, 2023).
  - 2-. Pathipooranam, P. (2022). An Enhancement of the Solar Panel Efficiency–A Comprehensive Review. Frontiers in Energy Research, 1090.
  - 3-. Sharaf, M., Yousef, M. S., & Huzayyin, A. S. (2022). Review of cooling techniques used to enhance the efficiency of photovoltaic power systems. Environmental Science and Pollution Research, 29(18), 26131-26159.
  - 4-. Dwivedi, P., Sudhakar, K., Soni, A., Solomin, E., & Kirpichnikova, I. (2020). Advanced cooling techniques of PV modules: A state of art. *Case studies in thermal engineering*, *21*, 100674.
  - 5-. Moharram, K. A., Abd-Elhady, M. S., Kandil, H. A., & El-Sherif, H. (2013). Enhancing the performance of photovoltaic panels by water cooling. *Ain Shams Engineering Journal*, *4*(4), 869-877.

- Install VSDs on pool pump motors
  - A variable speed drive (VSD) is an electronic device which enables a pump motor to be turns up or down, thereby increasing or decreasing pump speed. This will help to maximize energy efficiency of these pool pumps, resulting in cost savings. If a company operates a variable-speed pump at 50% of it's maximum speed, this results in 85-90% less energy use. This investment will likely pay for itself in less than 1 year.
- HVAC scheduling/controls
- Circulating pumps
- Door sensors

Cybersecurity

As systems to control energy-using manufacturing equipment become more connected to the internet, it is important for plant operations staff to have an understanding of cybersecurity risks and to coordinate risk management activities within their organization.

Small businesses may not consider themselves targets for cyber-attacks. However, they have valuable information cyber criminals seek, such as employee and customer records, bank account information, and access to larger networks. They can be at a higher risk for cybersecurity attack because they have fewer resources dedicated to cybersecurity.

By addressing risk areas, you can protect your business from damage to information or systems, intellectual property theft, regulatory fines/penalties, decreased productivity, or a loss of trust with customers.

IAC Cybersecurity Assessments

Industrial Assessment Centers work with manufacturing clients to increase awareness of cybersecurity risks and potential mitigation activities. As part of facility site visits, IAC clients may elect to receive cybersecurity risk assessments to identify security and privacy deficiencies to the business infrastructure, with a focus on vulnerabilities associated with industrial controls systems.

The IAC Industrial Control Systems Cybersecurity Assessment Tool includes 20 simple questions to characterize industrial controls systems and plant operations. The tool then provides a high level assessment of risk (high, medium, or low). The companion User Guide provides additional context for the questions included in the tool, to help clients understand how certain business practices lead to cybersecurity risk. Upon conclusion of the assessment, the tool generates a customized list of action items associated with the risks identified. For additional guidance, IACs refer clients to additional technical resource materials available through the NIST Manufacturing Extension Partnership (MEP) and other organizations.

Example Cybersecurity Assessment Tool:

Industrial Control Systems Cybersecurity Assesment Tool			
	People		
1	**Does your plant or facility provide basic cybersecurity awareness training to all employees?** *Yes*	Regular training of employees in proper conduct on company equipment can help prevent accidental downloads of viruses and other system vulnerabilities.	Medium Risk
2	**Are staff assigned and trained to take appropriate measures during a cybersecurity incident?** *No*	If a cybersecurity event were to occur, there could be issues with a safe and damage-free shutdown. Additionally, if roles are not properly articulated and no one knows who to contact regarding potential fixes for the system, the shutdown could be prolonged.	
	Process		
7	**Have you identified and inventoried critical equipment, data, or software in your plant or facility that would cause disruption to your operations if they were compromised?** *No*	Maintaining a list of your critical equipment, data, or software can help you prioritize actions during emergency shutdowns and other unplanned activities.	High Risk
8	**Does a plan exist to identify and isolate impacted assets, or shut down equipment as necessary in the event of a cybersecurity incident?** *No*	Without a plan to review IT and ICS assets, external consultants or IT staff may have difficulty working and may prolong the plant outage. Additionally, without an emergency shutdown plan, equipment could be accidentally damaged or destroyed.	
	Technology		
14	**Which of the following best describes the industrial controls in your plant or facility?** *Mainly using manual controls such as mechanical levers, pneumatic or electrical switches*	Manually operated machinery presents little risk in a cybersecurity environment due to its lack of connection with business systems and the broader internet.	Low Risk
15	**Are indicators or alerts set up on critical equipment to indicate unusual changes to operating parameters, multiple login attempts, or detect other anomalies in use?** *Yes*	These alarms will notify you if unauthorized users are changing equipment operating parameters or may be close to damaging equipment.	
	People: Medium Risk	Overall Risk: Medium	
	Process: High Risk		
	Technology: Low Risk		

Cybersecurity Fundamentals for Small and Medium Sized Enterprises

Most plant operations managers are not cybersecurity experts, but can benefit from a basic understanding of cybersecurity risks and mitigation activities. A guidance document provided by NIST, NIST Small Business Information Security: The Fundamentals, provides a thorough and easily readable overview of cybersecurity basics.

As a first step, organizations need to understand their cybersecurity risks, to determine where the organization is vulnerable and may be subject to disruption of systems and processes. Organizations can use helpful checklists from the NIST document, or other cybersecurity assessment tools, to conduct the following activities:

- Identify what information your business stores and uses
- Determine the value of your information
- Develop an inventory of technologies used to store and process information
- Understand your threats and vulnerabilities

Additional Resources

- Office of Manufacturing and Energy Supply Chains
    - Technical resources
    - Financial assistance – implementation grant program

- Better Plants Program
    - Technical assistance for energy goals

- Energy Management
    - CalPlug – Plug Load Management
    - Strategic Energy Management
    - ISO 50001

- DOE AMO Software Tools
    - Energy & Water Management
    - Systems & Equipment Management
    - Decarbonization

- Rebates
    - Utility rebates
    - Subsidies
    - Incentive Programs

- Cybersecurity
    - IAC Cybersecurity Assessment Too