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: CI0008

Assessment Date: February 13, 2023
Location: Laguna Woods, CA 92637
Building Type: Community Center
NAICS Code: 624120
SIC Code: 8322

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Preface

The work described in this report was performed by **University of California, Irvine (UCI-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.

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Industrial Assessment Center
U.S. DEPARTMENT OF ENERGY

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Executive Summary

Report Number: CI0008

Assessment Date: February 13, 2023

Location: Laguna Woods, CA 92637

S.I.C. Code: 8322

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

Annual Sales: N/A

Annual Production: N/A

Number of Recommendations: 7

Building Type: Community Center

Location	Operating Hours, hr	Plant Area, ft^2
Clubhouse 1	5,096	32,800
Clubhouse 3	2,080	17,400
Clubhouse 5	5,096	12,752
Clubhouse 7	5,096	26,407

Summary of Assessment Recommendations

Assessment Recommendations		Energy Savings	TOTAL Cost Savings	Project Cost	Simple Payback
1	Replaced Current Lights with LEDs	323,875 kWh	$78,899	$56,956	0.72 years
2	Addition of Solar Energy Panels	270,469 kWh	$65,889	$370,377	5.62 years
3	Install VSD on Existing HVAC Equipment	112,105 kWh	$27,340	$27,100	0.99 years
4	Upgrading Existing HVAC Equipment	110,838 kWh	$27,002	$37,785	1.40 years
5	Install Occupancy Sensors	85,298 kWh	$20,780	$10,000	0.48 years
6	Installation and Maintenance of CO2 Sensors	74,839 kWh	$18,232	$8,000	0.44 years
7	Install Triple Glazed Windows	33,432 kWh	$8,144	$15,610	1.92 years
	Total	1,010,856 kWh	$246,286	$525,828	2.14 years

AR #1: Replace Fluorescent lamp and Halogen can light with LEDs

The facility currently uses fluorescent and halogen lighting to illuminate parts of the building. It is recommended to upgrade these to LED to save on energy usage and costs. LED prices have come down to where it is possible to see payback periods shorter than one year. This would achieve an annual cost savings of $78,899, with an implementation cost of $56,956, and a simple payback of 0.72 years. The annual energy savings for this recommendation is 323,875 kWh of electricity.

AR #2: Addition of Solar Energy Panels

It is recommended to add solar energy cells to available property around the facility in order to reduce energy consumption and operation costs. The implementation cost of this measure includes the purchase and installation of solar cells at a total cost of $370,377, which will result in an estimated annual savings of $65,889. This savings is calculated based on the energy generated by the solar cells, estimated at 270,469 kWh per year, with a simple payback period of 5.62 years.

AR #3: Installing Variable Speed Drive to Existing HVAC Equipment

It is recommended to install a variable speed drive and upgraded controls for all of the air handling units located in the clubhouses. 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. This would achieve an annual cost savings of $27,340, with an implementation cost of $27,100, and a simple payback of 0.99 years. The annual energy savings for this recommendation is 112,105 kWh of energy.

AR #4: Upgrading Existing HVAC Equipment

It is recommended to remove those old heat pump units and install one new heat pump unit. There are 5 heat pump units manufactured in 2000, which have less than 10 EER claimed on their nameplate. Replacing them with a new 20 ton heat pump with at least 13.20 EER will lower the electrical energy consumption and save dollars from energy usage. This would achieve an annual cost savings of $27,002, with an implementation cost of $37,785, and a simple payback of 1.40 years. The annual energy savings for this recommendation is 110,838 kWh of energy.

AR #5: Install Occupancy Sensors

It is recommended to install occupancy sensors to save energy while not using lights in the rooms. Lighting can be eliminated during unoccupied periods by installing occupancy sensors into the lighting circuits in these areas. Energy savings and demand reduction will result from the reduced electrical usage for lighting. This would achieve an annual cost savings of $20,780, with an implementation cost of $10,000, and a simple payback of 0.48 years. The annual energy savings for this recommendation is 85,298 kWh of electricity.

AR #6: Installation and Maintenance of CO2 Sensors

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 weekday hours when patron traffic is at a minimum, leading to energy savings. This would achieve an annual cost savings of $18,232, with an implementation cost of $8,000, and a simple payback of 0.44 years. The annual energy savings for this recommendation is 74,839 kWh of energy.

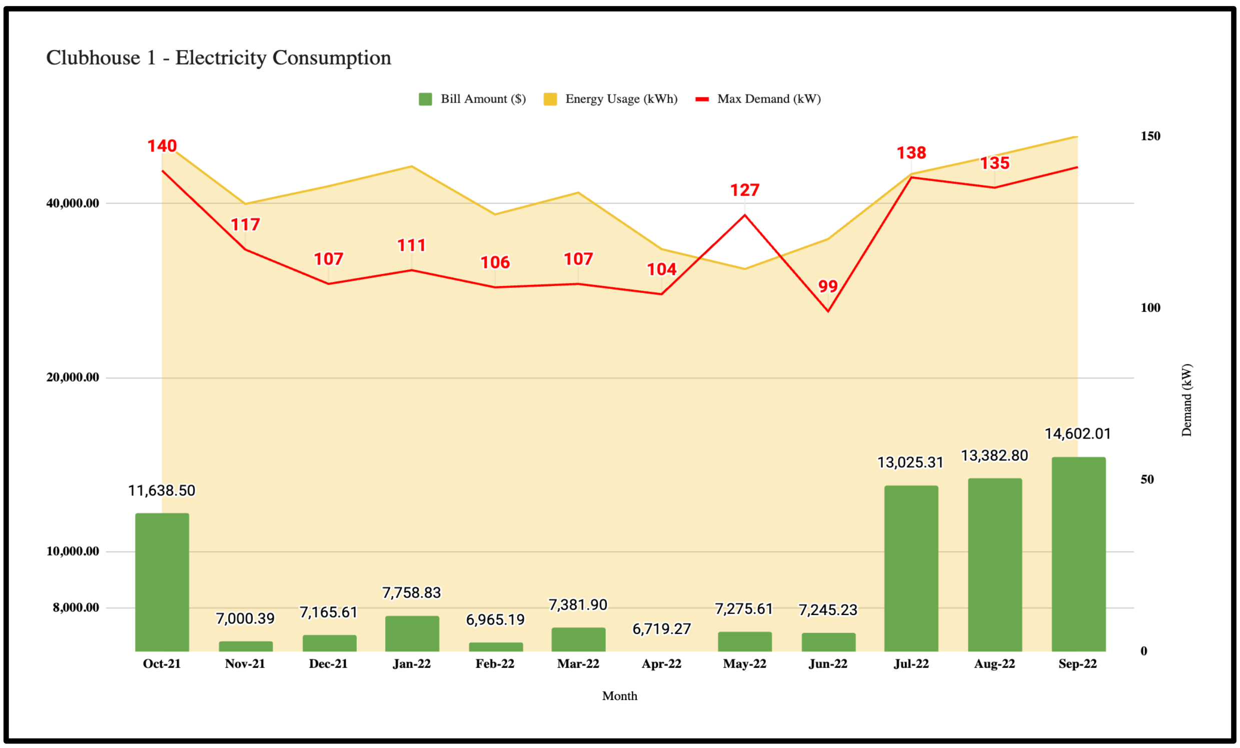
AR #7: Use Double or Triple Glazed Windows

Replace all windows in the facility with high-efficiency, triple glazed windows. Energy efficient windows are an important consideration in heating and cooling costs. This recommendation would achieve an annual cost savings of $8,144/yr with an implementation cost of $15,610, and a simple payback of 1.92 years. The annual energy savings for this recommendation is 33,432 kWh of electricity.

Utility Analysis

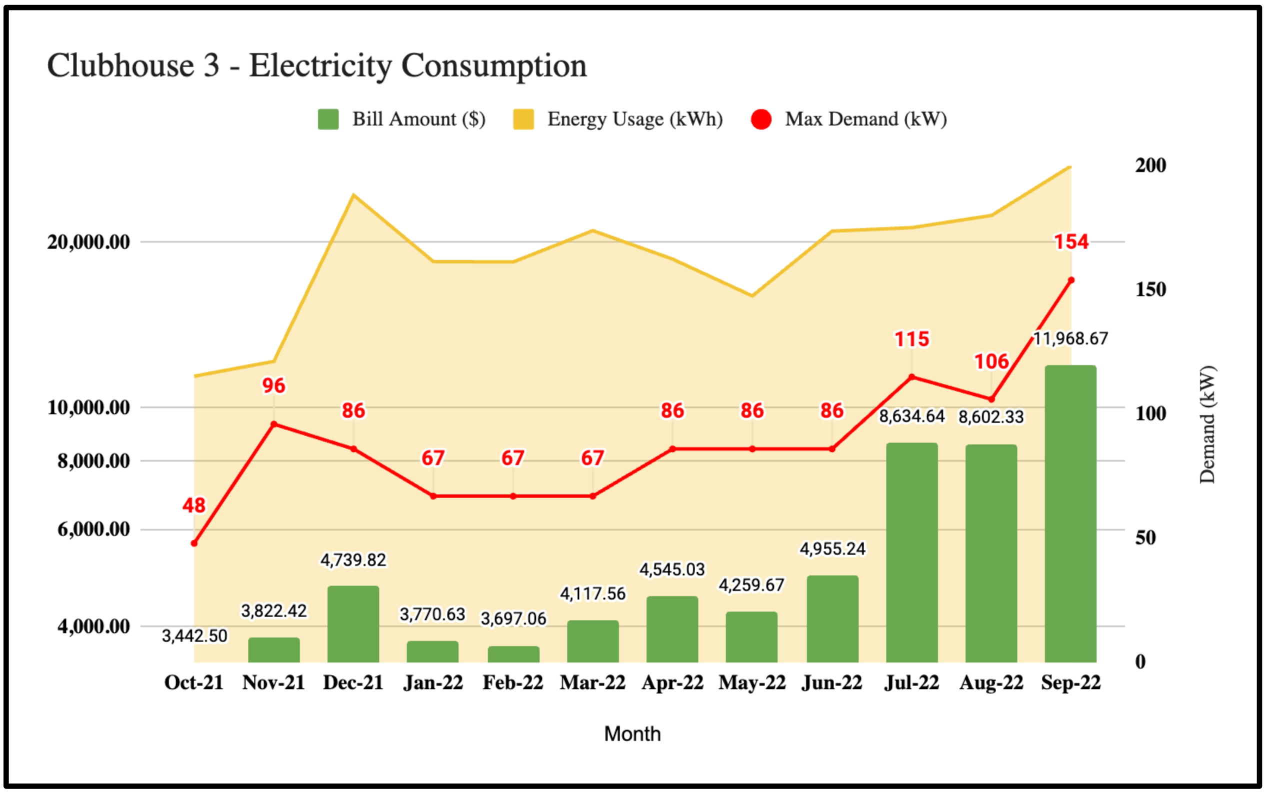
[Clubhouse 1]

Month	Energy Usage	Max Demand	Bill Amount
	kWh	kW	$
Oct-21	51,225	140	11,638.50
Nov-21	39,948	117	7,000.39
Dec-21	42,871	107	7,165.61
Jan-22	46,396	111	7,758.83
Feb-22	38,309	106	6,965.19
Mar-22	41,786	107	7,381.90
Apr-22	33,365	104	6,719.27
May-22	30,829	127	7,275.61
Jun-22	34,733	99	7,245.23
Jul-22	44,994	138	13,025.31
Aug-22	48,392	135	13,382.80
Sep-22	52,319	141	14,602.01



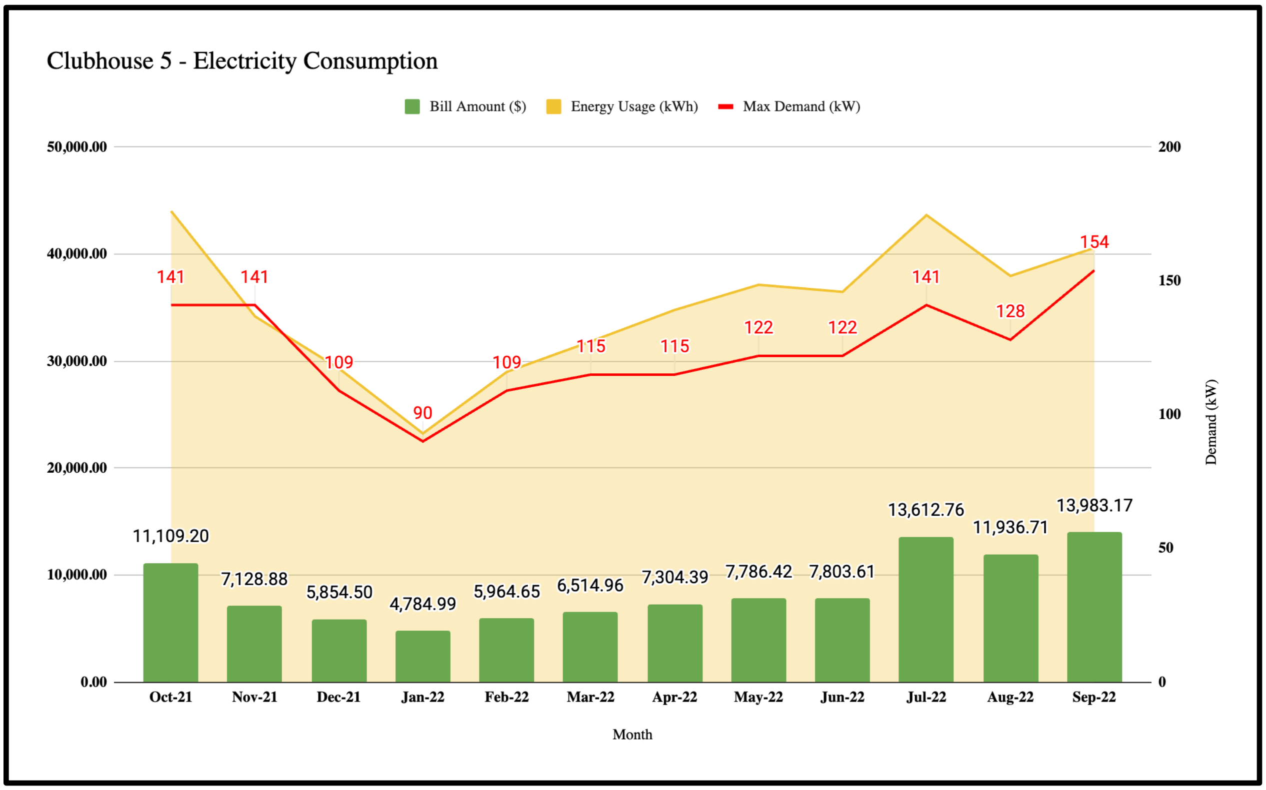
[Clubhouse 3]

Month	Energy Usage	Max Demand	Bill Amount
	kWh	kW	$
Oct-21	11,424	48	3,442.50
Nov-21	12,158	96	3,822.42
Dec-21	24,387	86	4,739.82
Jan-22	18,468	67	3,770.63
Feb-22	18,434	67	3,697.06
Mar-22	21,023	67	4,117.56
Apr-22	18,660	86	4,545.03
May-22	15,991	86	4,259.67
Jun-22	20,981	86	4,955.24
Jul-22	21,288	115	8,634.64
Aug-22	22,402	106	8,602.33
Sep-22	27,583	154	11,968.67



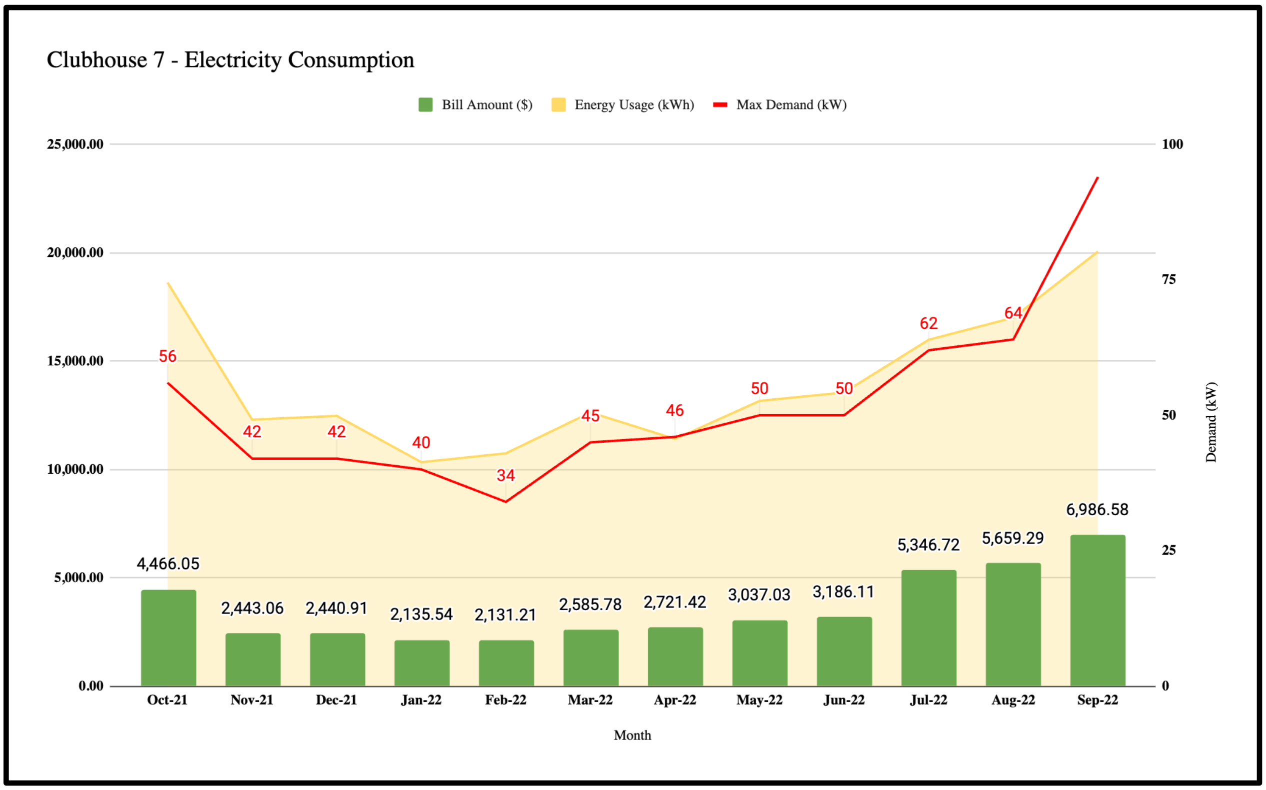
[Clubhouse 5]

Month	Energy Usage	Max Demand	Bill Amount
	kWh	kW	$
Oct-21	44,042	141	11,109.20
Nov-21	34,192	141	7,128.88
Dec-21	29,321	109	5,854.50
Jan-22	23,244	90	4,784.99
Feb-22	29,005	109	5,964.65
Mar-22	31,846	115	6,514.96
Apr-22	34,793	115	7,304.39
May-22	37,147	122	7,786.42
Jun-22	36,486	122	7,803.61
Jul-22	43,663	141	13,612.76
Aug-22	37,973	128	11,936.71
Sep-22	40,601	154	13,983.17



[Clubhouse 7]

Month	Energy Usage	Max Demand	Bill Amount
	kWh	kW	$
Oct-21	18,623	56	4,466.05
Nov-21	12,299	42	2,443.06
Dec-21	12,471	42	2,440.91
Jan-22	10,334	40	2,135.54
Feb-22	10,741	34	2,131.21
Mar-22	12,629	45	2,585.78
Apr-22	11,403	46	2,721.42
May-22	13,162	50	3,037.03
Jun-22	13,553	50	3,186.11
Jul-22	15,986	62	5,346.72
Aug-22	17,003	64	5,659.29
Sep-22	20,057	94	6,986.58



Energy Summary for all Clubhouses

Energy Summary of Clubhouse 1,3,5,7			
		Energy	
	Month	kWh	Total$
Oct-21	10	125314	30656.25
Nov-21	11	98597	20394.75
Dec-21	12	109050	20200.84
Jan-22	1	98442	18449.99
Feb-22	2	96489	18758.11
Mar-22	3	107284	20600.20
Apr-22	4	98221	21290.11
May-22	5	97129	22358.73
Jun-22	6	105753	23190.19
Jul-22	7	125931	40619.43
Aug-22	8	125770	39581.13
Sep-22	9	140560	47540.43
Total		1328540	323640.16

Effective Energy Cost ($/kWh)	
0.24361	

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	1,328,540 kWh	1,328,540	4,171,616	$323,640
Natural Gas	MMBTU			
Steam				
-				
Grand Total		**1,328,540**	**4,171,616**	**$323,640**

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.

Fig. 1a **Site Energy Use**

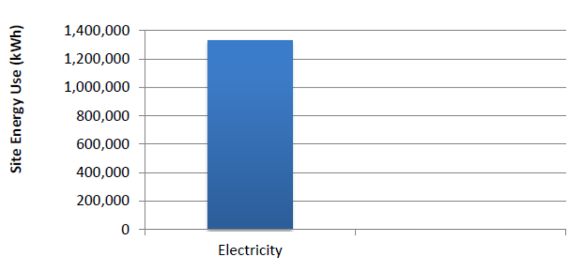


Fig. 1b **Site Energy Cost**

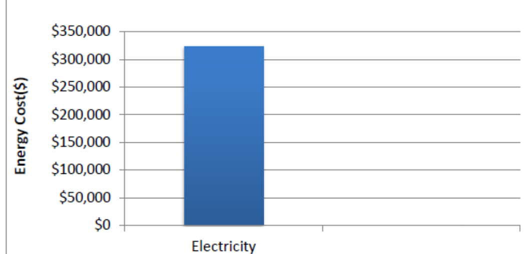


Table 3 shows the annual production for the different products that are produced in the plant along with the energy intensity for the baseline year.

Table 3: Production Energy Use

Production Stream	Quantity	Total Site Energy Use (kWh)	Energy Use per Unit of Production (kWh/Unit)
Product 1			
Product 2		1,328,540	
Product 3			

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

Total annual consumption for baseline year was estimated at 1,328,540 kWh with annual production of Unit

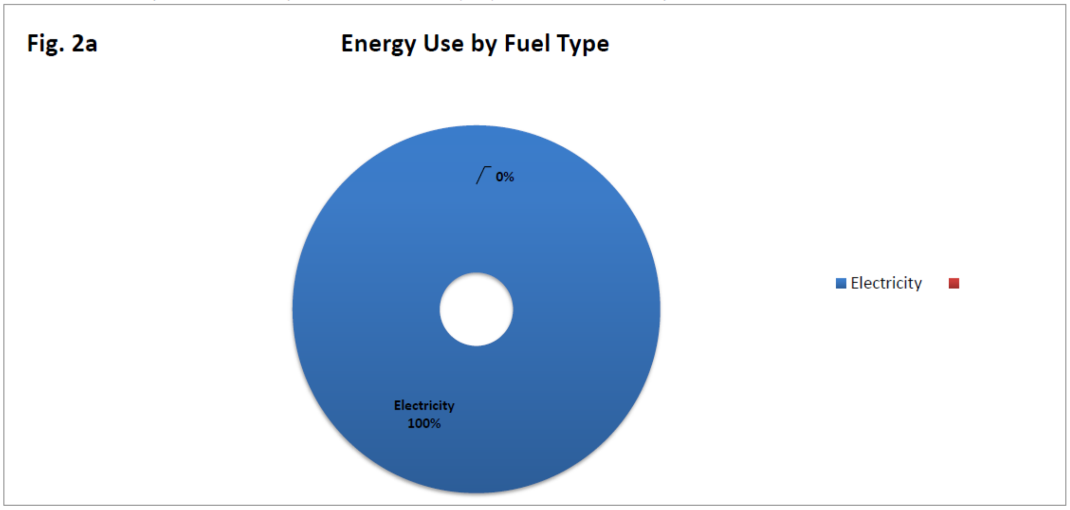


Fig. 2b shows the monthly energy consumption (electricity, natural gas, steam, and other fuels) of the plant along with their monthly production data.

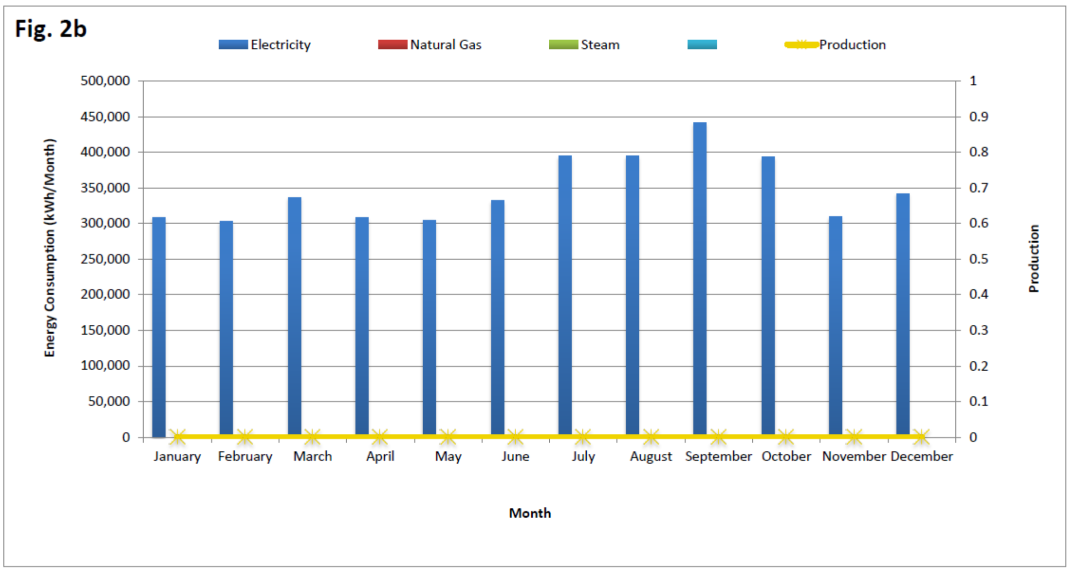


Figure 2c shows the correlation between Energy Intensity and production.

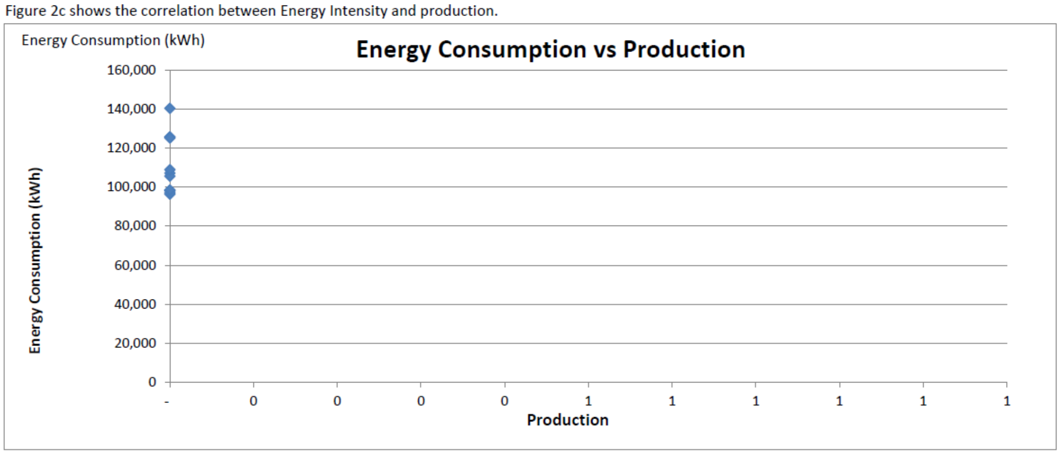


Figure 3a. shows the different energy type used by each system type present in the plant. This helps the user to understand how much energy each system is using.

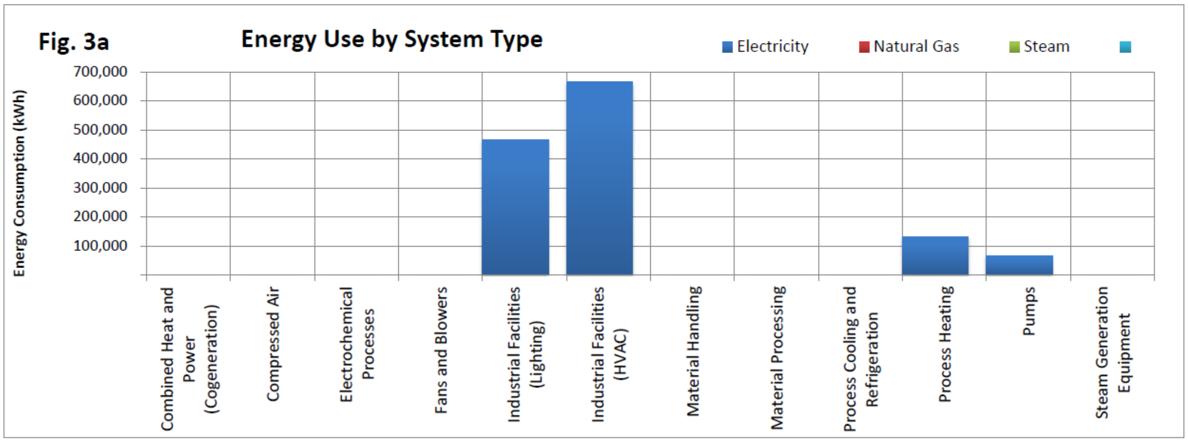


Fig 3b. shows the percentage energy consumption per system.

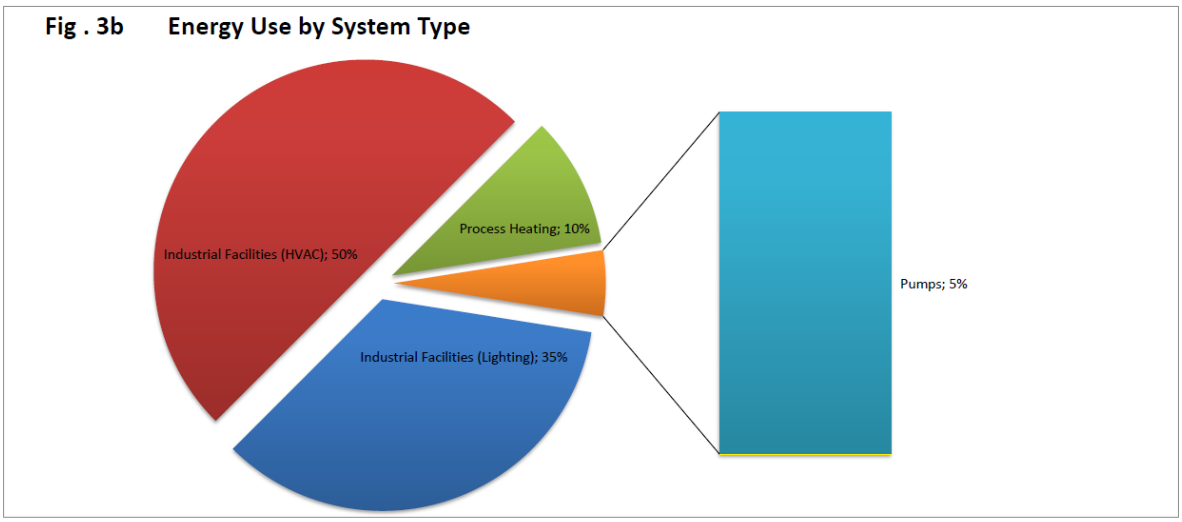


Table 4. summarizes the source energy consumption of each system. The user can see score from the scorecard if they have filled the forms for the system present in the plant. The tool uses the score from the scorecard (if the user has filled the scorecard) or the input from the "Energy saving opportunity" 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)	464,989	$113,274	35.0%	15%	69,748	$16,991
Industrial Facilities (HVAC)	664,270	$161,820	50.0%	15%	99,641	$24,273
Process Heating	132,854	$32,364	10.0%	#N/A	#N/A	#N/A
Pumps	66,427	$16,182	5.0%	-	-	
Miscellaneous	-					
Total	1,328,540	$323,640	100%		#N/A	#N/A

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

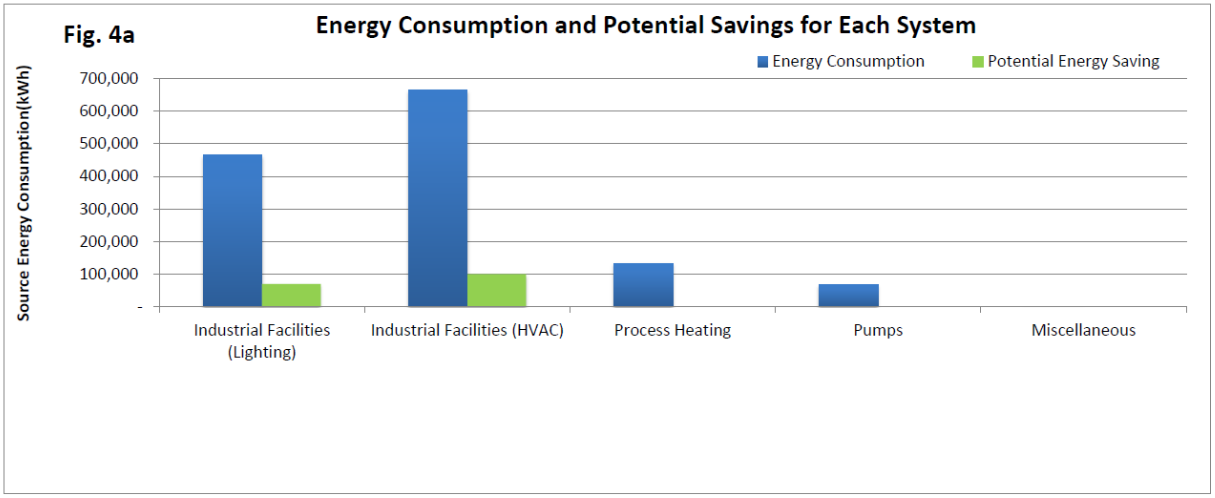
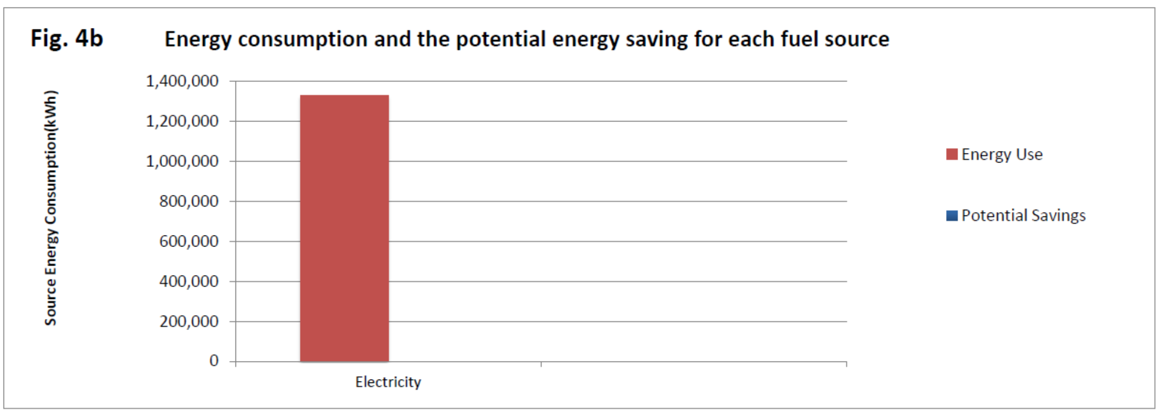
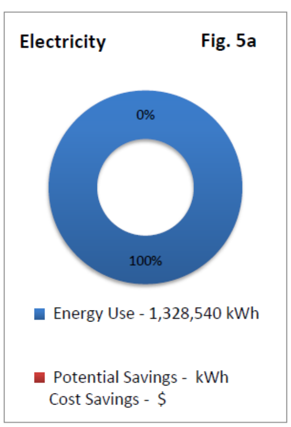
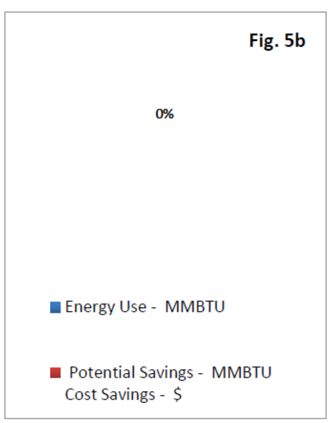


Fig. 4b shows the annual energy consumption and the potential energy saving for each fuel source.



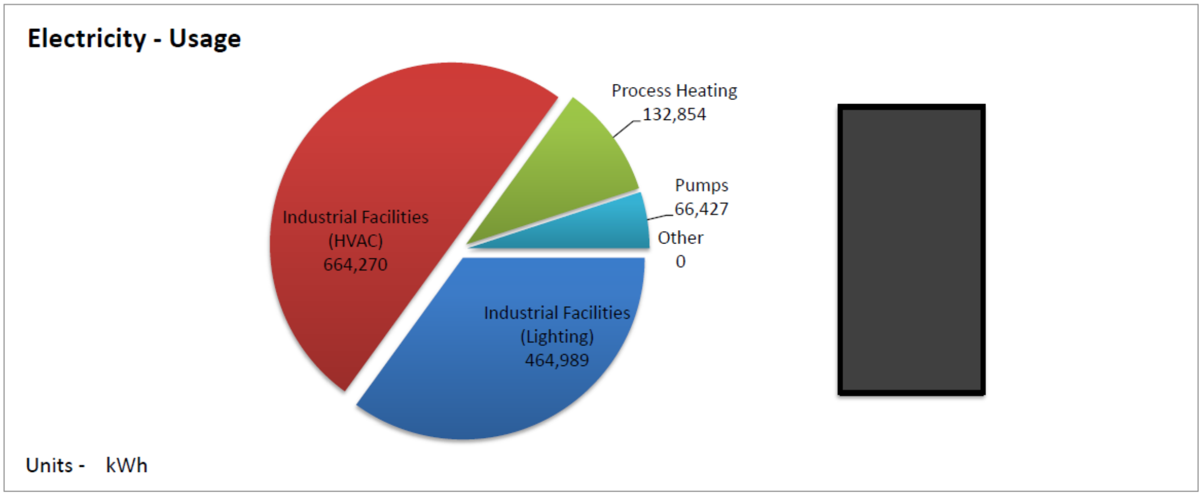
Figures 5a, 5b , 5c and 5d provide a breakdown of the annual energy consumption and the potential energy saving for each fuel source in its original units.



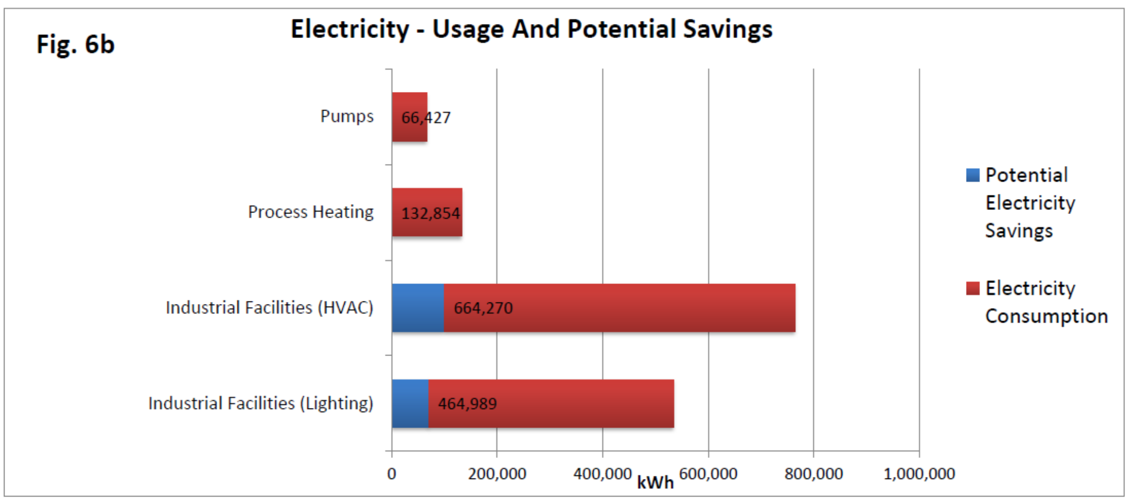


Electricity Use and Potential Savings by System

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

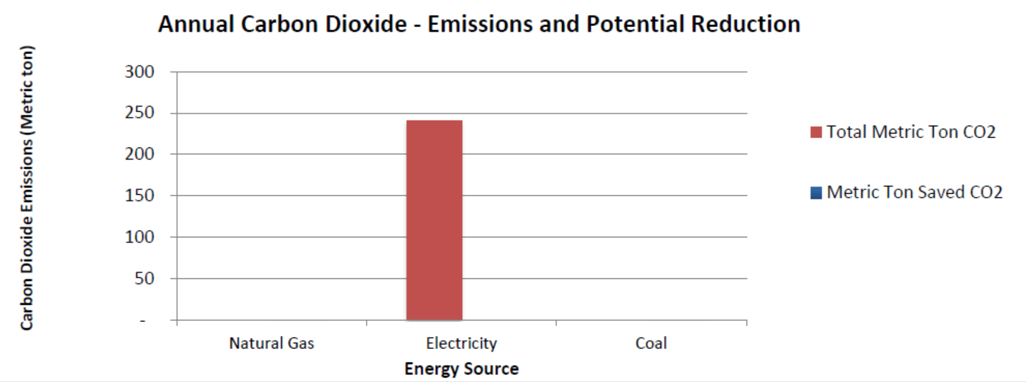


Figures 6b presents the breakdown of the annual electricity consumption and the potential electricity saving by system in a stacked bar chart.



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 (O2) and Carbon Monoxide CO or combustible in flue gases and take actions to reduce O2 in flue gases while maintaining near zero value for CO or combustibles. In certain cases safety requirements may require to have high values of O2 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.

Facility Description

This facility is a retirement community, located in Laguna Woods, California. It is a gated community with 24/7 patrols. It contains 8 main areas, 7 clubhouses and 1 community center. Clubhouse 1, 3, 5 and 7 were assessed during this visit. This community offers plenty of activities, such as golf classes, dancing clubs, fitness and so on.

Clubhouse 1 is a combination of gym and classroom. This facility is approximately 32,800 sq ft. Except for its swimming pool, this facility is focused on indoor activities only. This facility includes multiple courts for basketball, volleyball and badminton. Special playgrounds are included for shuffleboard and archery. Other indoor activities are offered by Clubhouse 1, such as billiards, card games and fitness. This facility is operating 7 days per week, from 8 am to 10 pm.

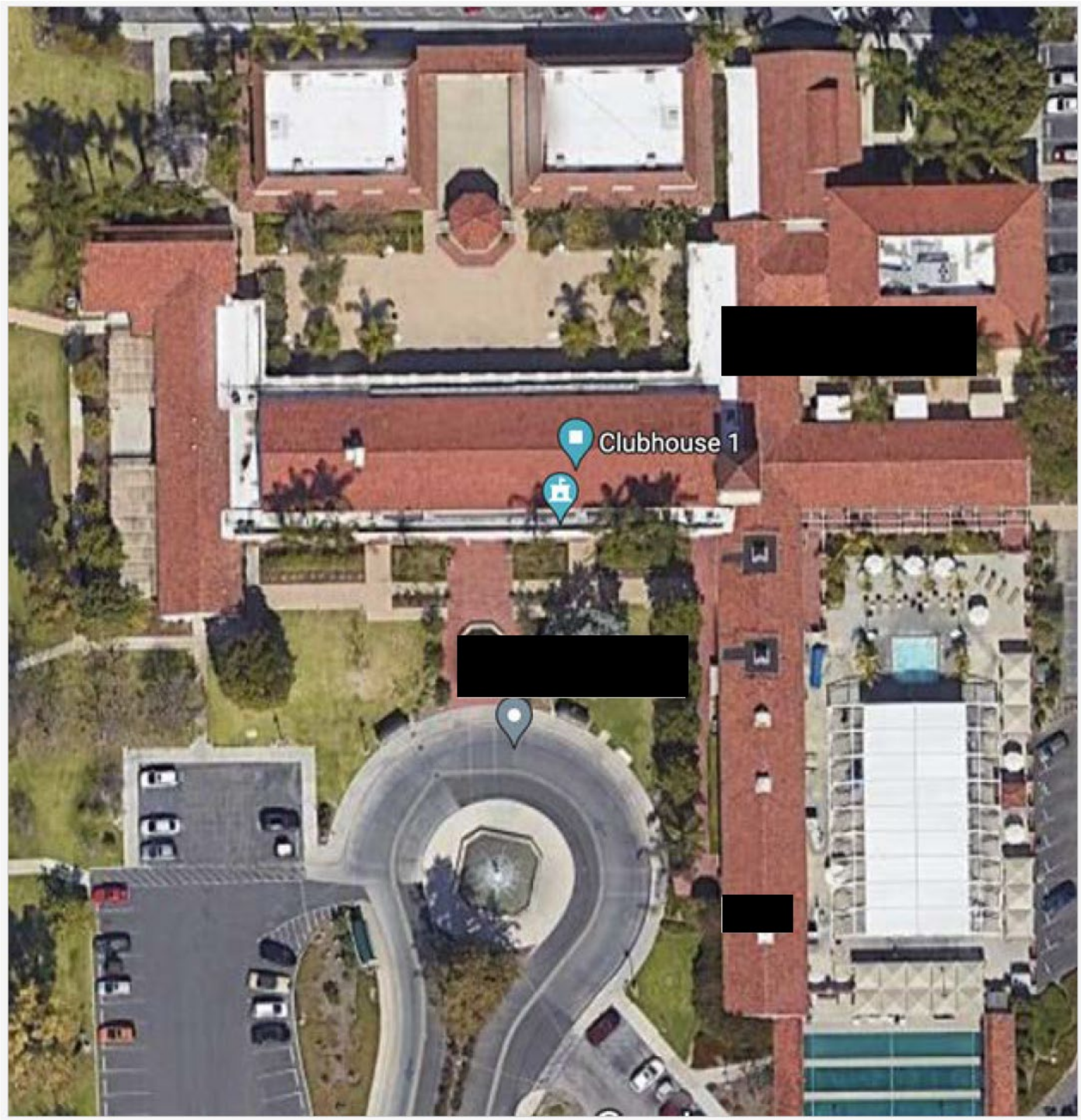
Clubhouse 3 is a theater focusing on performance and is also referred to as the Performing Arts Center. It is about 17,400 sq ft. Clubhouse 3 includes an 814-seat complete theater with dressing room and rehearsal room. It also includes two dining rooms with kitchens for events. One billiards room with 6 pool tables is also included. This facility is usually operating from Monday to Friday, 9 am to 5 pm.

Clubhouse 5 is mainly for fitness and events. It is approximately 12,752 sq ft. This facility has one large main lounge equipped with a stage, dancing floor and kitchen, for holding parties, dancing club or performance. For fitness activities, this clubhouse includes a gym and a swimming pool with pool heating function. This facility is normally running from 8 am to 10 pm, every day.

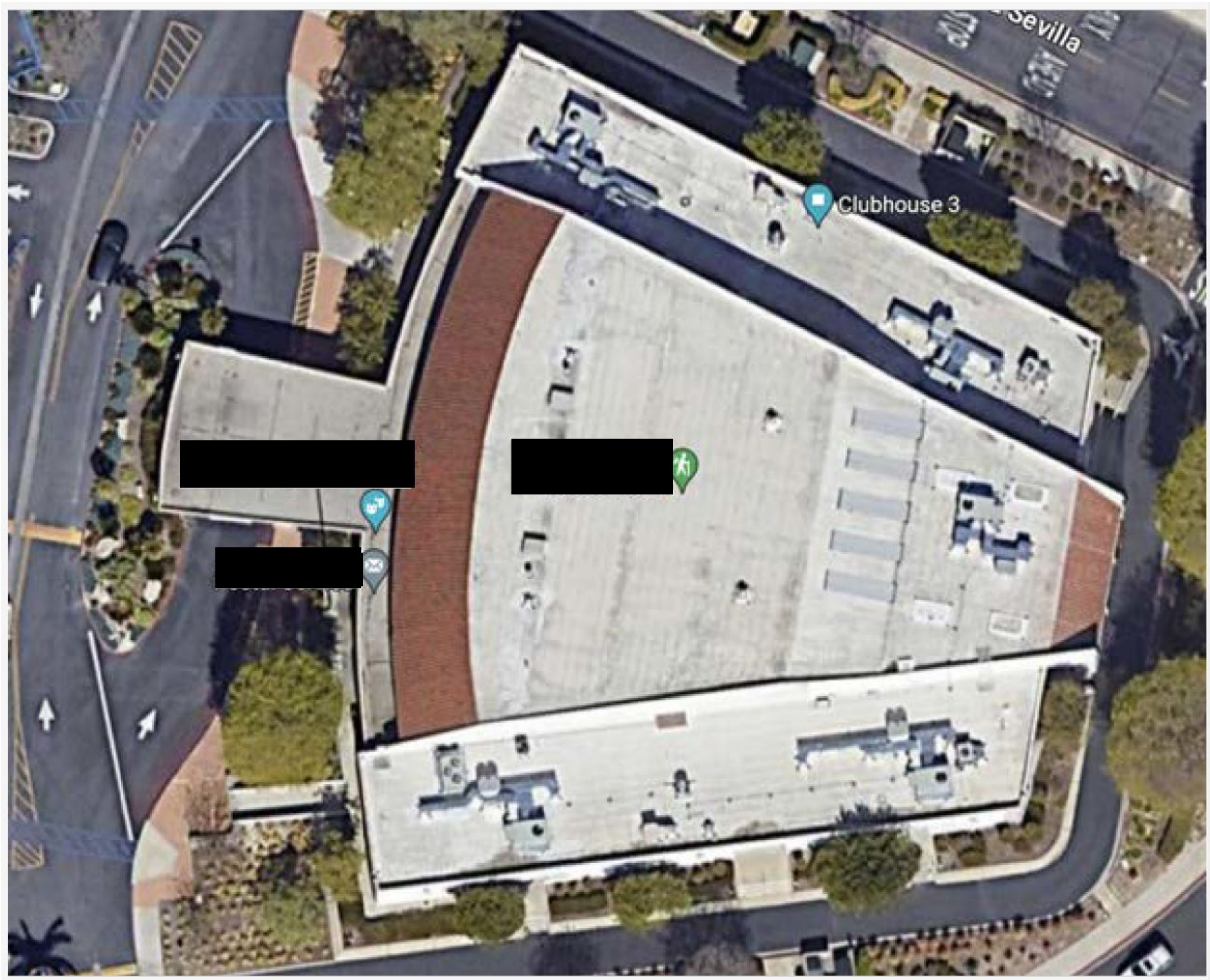
Clubhouse 7 is the facility for events. This facility contains 26,407 sq ft, including two large event rooms. One room is for card games, especially for Bridge, containing 60 tables. The other one is for private parties and club dancing, fitting 130 people dining and dancing. Its operation hours are 7 day per week, from 8 am to 10 pm.

Facility Layout

CLUBHOUSE 1

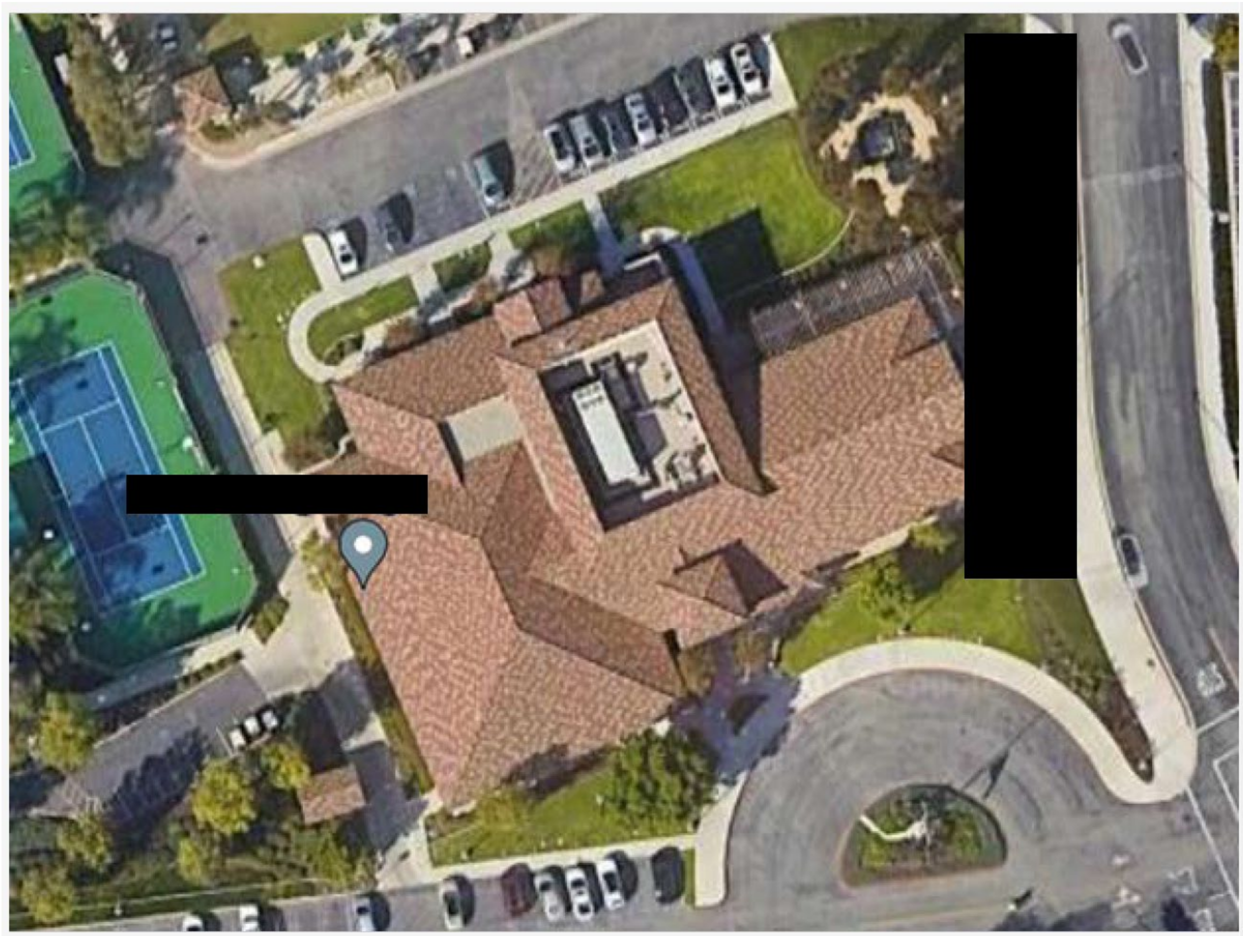


CLUBHOUSE 3



CLUBHOUSE 5

CLUBHOUSE 7



Best Practices

- **Outside lighting upgraded to LEDs**

  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.

- **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.

- **Electric Golf Carts and Cars**

  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. The community has also seen a shift to EVs in recent years as well, with over 1,100 EVs in the community and growing.

- **White Ceiling**

  The ceiling on these buildings are white. This results in high reflectivity and thus the coefficient of utilization is larger and less lighting is required in the facility.

- **High Efficiency Motors**

  This facility will replace motors with high efficiency motors once they burn out. They don't get the motors rewound. This results in more efficient motors being used, saving on electrical consumption and costs.

ASSESSMENT RECOMMENDATIONS

AR #1: Replace current Fluorescent Lamps and Halogen Can Lights 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	
ALL LAMPS	323,875 kWh/yr (1,105.1 MMBtu/yr)	$78,899 /yr	$56,956	0.72 years

CLUBHOUSE 1

Recommended Action

Replace the existing T8 Fluorescent lamps and Halogen can lights 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	88,054 kWh/yr (300.5 MMBtu/yr)	$21,451 /yr	$16,650	0.78
Halogen Can Light	12,842 kWh/yr (43.8 MMBtu/yr)	$3,128 /yr	$1,160	0.37

Background

Currently, Clubhouse 1 uses T8 Fluorescent lamps and Halogen can lights to illuminate most areas at this facility. Please see the chart below for applicable areas. These lights are currently on for a total fixture schedule of 5,096 hours per year. It is recommended to replace the current T8 Fluorescent lamps and Halogen can lights with 18.5 Watt LED lamps and 25 Watt LED can lights, 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
Main Lounge	Fluorescent	120
	Can Light	10
Gym	Fluorescent	72
	Can Light	12
Archery Room	Fluorescent	72
Shuffleboard Room	Fluorescent	72
Dining Room 3	Fluorescent	20
Billiard Room	Fluorescent	62
Game Room	Fluorescent	36
Multi-purpose Room	Fluorescent	96
Art Gallery	Fluorescent	92
Kitchen	Fluorescent	24

The chart below shows the characteristics of the (estimated) current lights and the proposed lights.

The existing T8 Fluorescent lamps have a lumen output of about 2,675 lumens per lamp, and a rated lamp life of about 31,000 hours. The recommended 18.5W LED lamps have a lumen output of about 2,200, and a rated lamp life of about 50,000 hours of operation.

The existing Halogen can lights have a lumen output of about 1,600 lumens per light, and a rated lamp life of about 1,095 hours. The recommended 25W LED can lights have a lumen output of about 1,800, and a rated lamp life of about 50,000 hours of operation.

	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	2,600	50,000
Proposed Light	LED 2	40	8,000	50,000
	LED 3	25	1,800	50,000

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, 536 lamps
CL	=	lumen output of current lamps, 2,675 lumens/lamp
PL	=	lumen output of proposed lamps, 2,600 lumens/lamp

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

$$PN = (666 \times 2{,}675) / 2{,}600$$
$$PN = 685 \text{ lamps}$$

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, 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:

$$ES_1 = [(666 \times 32 \times (1 + 1) \times 5{,}096) - (685 \times 18.5 \times (1 + 1) \times 5{,}096] \times 0.001$$
$$ES_1 = 88{,}054 \text{ kWh/yr}$$

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

$$CS_1 = ES_1 \times (\text{effective energy cost})$$
$$CS_1 = TECS$$
$$CS_1 = 88{,}054 \text{ kWh/yr} \times (\$0.24361/\text{kWh})$$
$$CS_1 = \$21{,}451/\text{yr}$$

Where

TECS = Total Electric Cost Savings
TDCS = Total Demand 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:

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

where

CN = current number of metal halide lamps, 22 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:

$$PN = (22 \times 1{,}600) / 1{,}800$$
$$PN = 20 \text{ lamps}$$

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, 80 Watts
CB = ballast fraction of current lamps, 100%
CH = operating hours of current lamps, 5,096 hrs/yr
PR = rating of the proposed lamps, 25 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:

$$ES_1 = [(22 \times 80 \times (1 + 1) \times 5{,}096) - (20 \times 25 \times (1 + 1) \times 5{,}096)] \times 0.001$$
$$ES_1 = 12{,}842 \text{ kWh/yr}$$

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

$$CS_1 = ES_1 \times (\text{effective energy cost})$$
$$CS_1 = 12{,}842 \text{ kWh/yr} \times (\$0.24361/\text{kWh})$$

$CS_1 = \$3,128/yr$

Implementation Cost

The cost of implementation is based on the replacement of existing lamp fixtures with high efficiency lighting. Costs include materials and labor. Implementation cost is estimated to be $25 per lamp and $58 per can light. The implementation cost for installing 666 LEDs (from T8s) will be approximately $16,650 and the implementation cost for installing 20 can lights will be $1,160. The total implementation cost is $17,810

Yielded savings of $24,579/yr would see a return for the implementation cost in 0.72 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 3

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	9,443 kWh/yr (32.2 MMBtu/yr)	$2,300/yr	$4,500	1.96 years
Halogen Can Light	10,130 kWh/yr (34.6 MMBtu/yr)	$2,468/yr	$2,146	0.87 years

Background

Currently, Clubhouse 3 uses T8 Fluorescent lamps and Halogen can lights to illuminate most areas at this facility. Please see the chart below for applicable areas. These lights are currently on for a total fixture schedule of 2,080 hours per year. It is recommended to replace the current T8 Fluorescent lamps and Halogen can lights with 18.5 Watt LED lamps and 25 Watt LED can lights, 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
Dining Room 2	Fluorescent	24
Dining Room 2 Kitchen	Fluorescent	30
Music Room	Fluorescent	25
Stage Hallway	Fluorescent	4
Auditorium	Can Light	42
Air Handler Room	Fluorescent	32
Dining Room 1	Fluorescent	24
Dining Room 1 Kitchen	Fluorescent	24
Billiard Room	Fluorescent	12

The chart below shows the characteristics of the (estimated) current lights and the proposed lights.

The existing T8 Fluorescent lamps have a lumen output of about 2,675 lumens per lamp, and a rated lamp life of about 31,000 hours. The recommended 18.5W LED lamps have a lumen output of about 2,200, and a rated lamp life of about 50,000 hours of operation.

The existing Halogen can lights have a lumen output of about 1,600 lumens per light, and a rated lamp life of about 1,095 hours. The recommended 25W LED can lights have a lumen output of about 1,800, and a rated lamp life of about 50,000 hours of operation.

	Type	Rate/ Demond Watt	Output Brightness Lumen	Lifetime Hr
Current Light	T8 Fluorescent	32	2,675	31,000
	Incandescent	53	890	985.5
	Halogen	80	1,600	1,095
Proposed Light	LED 1	18.5	2,600	50,000
	LED 2	40	8,000	50,000
	LED 3	25	1,800	50,000

<u>Anticipated Savings [T8 Fluorescent Lamp]</u>

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, 175 lamps
CL	=	lumen output of current lamps, 2,675 lumens/lamp
PL	=	lumen output of proposed lamps, 2,600 lumens/lamp

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

$$PN = (175 \times 2{,}675) / 2{,}600$$
$$PN = 180 \text{ lamps}$$

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, 2,080 hrs/yr
PR	=	rating of the proposed lamps, 18.5 Watts
PB	=	ballast fraction of proposed lamps, 100%
PH	=	operation hours of proposed system, 2,080 hrs/yr
k	=	conversion factor, 0.001 kW/Watt

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

$$ES_1 = [(175 \times 32 \times (1 + 1) \times 2{,}080) - (180 \times 18.5 \times (1 + 1) \times 2{,}080] \times 0.001$$
$$ES_1 = 9{,}443 \text{ kWh/yr}$$

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

$$CS_1 = ES_1 \times (\text{effective energy cost})$$
$$CS_1 = TECS + TDCS$$
$$CS_1 = 9{,}443 \text{ kWh/yr} \times (\$0.24361/\text{kWh})$$
$$CS_1 = \$2{,}300/\text{yr}$$

Where

TECS	=	Total Electric Cost Savings
TDCS	=	Total Demand 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:

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

where

CN	=	current number of metal halide lamps, 42 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:

$$PN = (42 \times 1{,}600) / 1{,}800$$
$$PN = 37 \text{ lamps}$$

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, 80 Watts
CB	=	ballast fraction of current lamps, 100%
CH	=	operating hours of current lamps, 2,080 hrs/yr
PR	=	rating of the proposed lamps, 25 Watts
PB	=	ballast fraction of proposed lamps, 100%
PH	=	operation hours of proposed system, 2,080 hrs/yr
k	=	conversion factor, 0.001 kW/Watt

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

$$ES_1 = [(42 \times 80 \times (1 + 1) \times 2{,}080) - (37 \times 25 \times (1 + 1) \times 2{,}080)] \times 0.001$$
$$ES_1 = 10{,}130 \text{ kWh/yr}$$

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

$$CS_1 = ES_1 \times (\text{effective energy cost})$$
$$CS_1 = 10{,}130 \text{ kWh/yr} \times (\$0.24361/\text{kWh})$$
$$CS_1 = \$2{,}468/\text{yr}$$

Implementation Cost

The cost of implementation is based on the replacement of existing lamp fixtures with high efficiency lighting. Costs include material and labor. Implementation cost is estimated to be $25 per lamp and $58 per can light. The implementation cost for replacing T8 lamps is $4,500 and the implementation cost for replacing can lights is $2,146 for a total implementation cost of $6,646.

The total implementation cost is found to be approximately $6,646. Yielded savings of $4,768 /yr would see a return for the implementation cost in 1.39 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 5

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	39,993 kWh/yr (101.7 MMBtu/yr)	$9,743	$7,800	0.80 years
Incandescent Light Bulb	12,944 kWh/yr (44.2 MMBtu/yr)	$3,153	$4,175	1.32 years
Halogen Can Light	44,641 kWh/yr (152.3 MMBtu/yr)	$10,875	$3,944	0.36 years

Background

Currently, Clubhouse 5 uses T8 Fluorescent lamps, Incandescent light bulbs, and Halogen can lights to illuminate most areas at this facility. Please see the chart below for applicable areas. These lights are currently on for a total fixture schedule of 5,096 hours per year. It is recommended to replace the current T8 Fluorescent lamps, Incandescent light bulbs, and Halogen can lights with 18.5 Watt LED lamps, 40 Watt LED light bulbs, and 25 Watt LED can lights, 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
Main Office	Fluorescent	8
Room 1 (classroom)	Fluorescent	100
Ballroom	Light Bulb	126
	Can Light	60
Storage Room	Fluorescent	20
Dressing Room	Fluorescent	9
	Light Bulb	24
Beverage Room	Can Light	16
Ballroom Kitchen	Fluorescent	40

The chart below shows the characteristics of the (estimated) current lights and the proposed lights.

The existing T8 Fluorescent lamps have a lumen output of about 2,675 lumens per lamp, and a rated lamp life of about 31,000 hours. The recommended 18.5W LED lamps have a lumen output of about 2,200, and a rated lamp life of about 50,000 hours of operation.

The existing Incandescent light bulbs have a lumen output of about 890 lumens per lamp, and a rated lamp life of about 985.5 hours. The recommended 40W LED lamps have a lumen output of about 8,000, and a rated lamp life of about 50,000 hours of operation.

The existing Halogen can lights have a lumen output of about 1,600 lumens per light, and a rated lamp life of about 1,095 hours. The recommended 25W LED can lights have a lumen output of about 1,800, and a rated lamp life of about 50,000 hours of operation.

	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	2,600	50,000
Proposed Light	LED 2	40	8,000	50,000
	LED 3	25	1,800	50,000

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, 303 lamps
CL	=	lumen output of current lamps, 2,675 lumens/lamp
PL	=	lumen output of proposed lamps, 2,600 lumens/lamp

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

$$PN = (303 \times 2{,}675) / 2{,}600$$
$$PN = 312 \text{ lamps}$$

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, 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:

$$ES_1 = [(303 \times 32 \times (1 + 1) \times 5{,}096) - (312 \times 18.5 \times (1 + 1) \times 5{,}096)] \times 0.001$$
$$ES_1 = 39{,}993 \text{ kWh/yr}$$

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

$$CS_1 = ES_1 \times (\text{effective energy cost})$$
$$CS_1 = TECS + TDCS$$
$$CS_1 = 39{,}993 \text{ kWh/yr} \times (\$0.24361/\text{kWh})$$
$$CS_1 = \$9{,}743/\text{yr}$$

Where

TECS = Total Electric Cost Savings
TDCS = Total Demand Cost Savings

Anticipated Savings [Incandescent Light Bulb]

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, 150 lamps
CL = lumen output of current lamps, 8,900 lumens/lamp
PL = lumen output of proposed lamps, 8,000 lumens/lamp

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

PN = (150 x 8,900) /8,000
PN = 167 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 = [(150 x 53 x (1 + 1) x 5,096) - (167 x 40 x (1 + 1) x 5,096)] x 0.001
ES_1 = 12,944 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 + TDCS
CS_1 = 12,944 kWh/yr x ($0.24361/kWh)
CS_1 = $3,153/yr

Where

TECS	=	Total Electric Cost Savings
TDCS	=	Total Demand 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:

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

where

CN	=	current number of metal halide lamps, 76 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:

$$PN = (76 \times 1{,}600) / 1{,}800$$
$$PN = 68 \text{ lamps}$$

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, 80 Watts
CB	=	ballast fraction of current lamps, 100%
CH	=	operating hours of current lamps, 5,096 hrs/yr
PR	=	rating of the proposed lamps, 25 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:

$$ES_1 = [(76 \times 80 \times (1 + 1) \times 5{,}096) - (68 \times 25 \times (1 + 1) \times 5{,}096)] \times 0.001$$
$$ES_1 = 44{,}641 \text{ kWh/yr}$$

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

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

$CS_1 = 44{,}641 \text{ kWh/yr} \times (\$0.24361/\text{kWh})$

$CS_1 = \$10{,}875/\text{yr}$

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, $25 per light bulb, and $58 per light. The implementation cost of replacing the T8 is $7,800, the cost of replacing the incandescent bulbs are $4,175, and the cost of replacing the can lights are $3,944.

The total implementation cost is found to be approximately $15,919. Yielded savings of $23,771/yr would see a return for the implementation cost in 0.67 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 7

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	68,169 kWh/yr (232.6 MMBtu/yr)	$16,607 /yr	$13,275	0.80 years
Halogen Can Light	37,659 kWh/yr (128.5 MMBtu/yr)	$9,174 /yr	$3,306	0.36 years

Background

Currently, Clubhouse 7 uses T8 Fluorescent lamps and Halogen can lights to illuminate most areas at this facility. Please see the chart below for applicable areas. These lights are currently on for a total fixture schedule of 5,096 hours per year. It is recommended to replace the current T8

Fluorescent lamps and Halogen can lights with 18.5 Watt LED lamps and 25 Watt LED can lights, 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
Bridge Room	Fluorescent	420
Main Room	Fluorescent	96
Lounge Room	Can Light	64

The chart below shows the characteristics of the (estimated) current lights and the proposed lights.

The existing T8 Fluorescent lamps have a lumen output of about 2,675 lumens per lamp, and a rated lamp life of about 31,000 hours. The recommended 18.5W LED lamps have a lumen output of about 2,200, and a rated lamp life of about 50,000 hours of operation.

The existing Halogen can lights have a lumen output of about 1,600 lumens per light, and a rated lamp life of about 1,095 hours. The recommended 25W LED can lights have a lumen output of about 1,800, and a rated lamp life of about 50,000 hours of operation.

	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	2,600	50,000
Proposed Light	LED 2	40	8,000	50,000
	LED 3	25	1,800	50,000

<u>Anticipated Savings [T8 Fluorescent Lamp]</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, 516 lamps
CL = lumen output of current lamps, 2,675 lumens/lamp

PL = lumen output of proposed lamps, 2,600 lumens/lamp

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

PN = (516 x 2,675) / 2,600
PN = 531 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, 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 = [(516 x 32 x (1 + 1) x 5,096) - (531 x 18.5 x (1 + 1) x 5,096] x 0.001
ES_1 = 68,169 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 + TDCS
CS_1 = 68,169 kWh/yr x ($0.24361/kWh)
CS_1 = $16,607/yr

Where

TECS = Total Electric Cost Savings
TDCS = Total Demand 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, 64 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:

$$PN = (64 \times 1{,}600) / 1{,}800$$
$$PN = 57 \text{ lamps}$$

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, 80 Watts
CB	=	ballast fraction of current lamps, 100%
CH	=	operating hours of current lamps, 5,096 hrs/yr
PR	=	rating of the proposed lamps, 25 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:

$$ES_1 = [(64 \times 80 \times (1 + 1) \times 5{,}096) - (57 \times 25 \times (1 + 1) \times 5{,}096)] \times 0.001$$
$$ES_1 = 37{,}659 \text{ kWh/yr}$$

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

$$CS_1 = ES_1 \times (\text{effective energy cost})$$
$$CS_1 = 37{,}659 \text{ kWh/yr} \times (\$0.24361/\text{kWh})$$
$$CS_1 = \$9{,}174/\text{yr}$$

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 and $58 per light. The implementation cost of replacing the T8s is $13,275 and the implementation cost of replacing the can lights is $3,306.

The total implementation cost is found to be approximately $16,581. Yielded savings of $25,781/yr would see a return for the implementation cost in 0.67 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	270,469 kWh/yr (922.9 MMBtu/yr)	$65,889 /yr	$370,377	5.62 years

CLUBHOUSE 1

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	30,867 kWh/yr (105.3 MMBtu/yr)	$7,520 /yr	$46,036	6.12 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 facility 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 **74 units**, energy output of each unit **26 kW/hr**
- Estimated to run **6 hours** per year
- Connections to the facility.
- Structure and foundation mountings.
-

The estimated energy output is determined from 74 panels at 345 Watts each, with an estimated overall system efficiency of 70%. This is a conservative estimation.

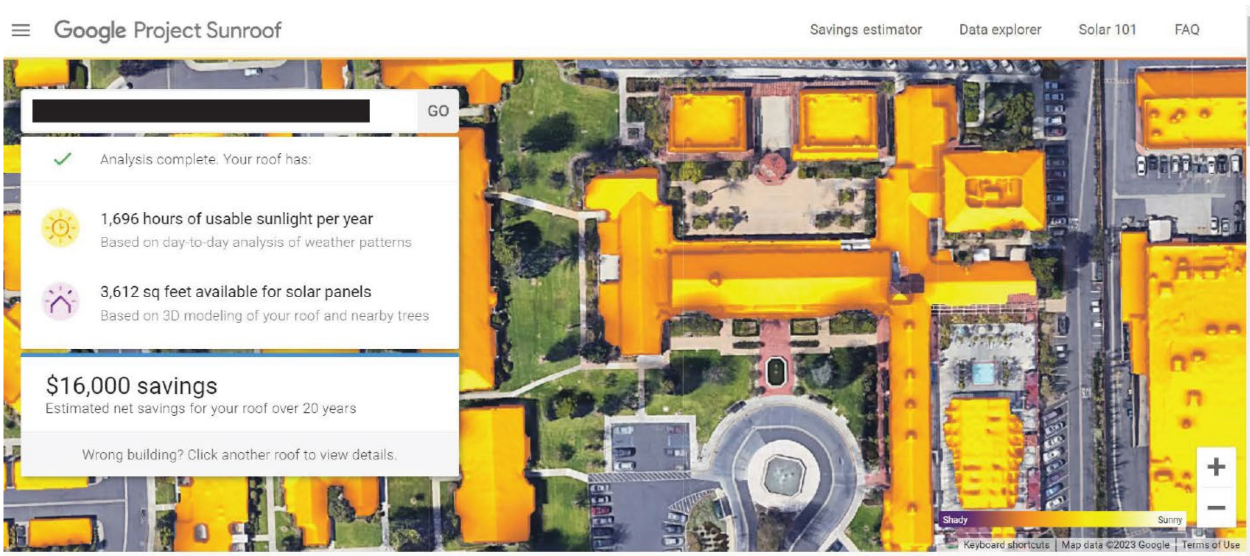


Figure 1. Google Project Sunroof, there are 1,696 hours of usable sun.

As indicated by Figure 1, according to Google Project Sunroof, there are 1,696 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 x SC

Where

US	=	usable sunlight per year, hrs
SC	=	solar cell energy output, 26 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 = (1,696 hrs) x (26 kW/h) x (0.70)
EC = 30,867 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 = 30,867 kWh/yr x ($0.24361/kWh)
ECS = $7,520/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 $22,726 is estimated for installation, connection, and mounting structure, listed of costs are listed in the table below. Thus, the cost savings of $7,520/yr would pay for the total implementation cost of $46,036 in about 6.12 years.

	Units	**Price**	**Price**
		Per Unit (US-$)	**Total (US-$)**
Solar Cells	74	314	23,310
Power Grid Connection	1	1000	1,000
Installation	74	95.6	7,074
Universal Pole Mount	74	198	14,652
		Total =	**46,036**

Figure 2 . Proposed system design mounted in the roof

CLUBHOUSE 3

Recommended Action

Addition of solar energy cells to available property around the facility of Clubhouse 3. 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	62,083 kWh/yr (211.8 MMBtu/yr)	$15,124 /yr	$87,421	5.78 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 **142 units**, total energy output of **49 kW/hr.**
- Estimated to run **1,810 hours** per year.
- Connections to the facility.
- Structure and foundation mountings.

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

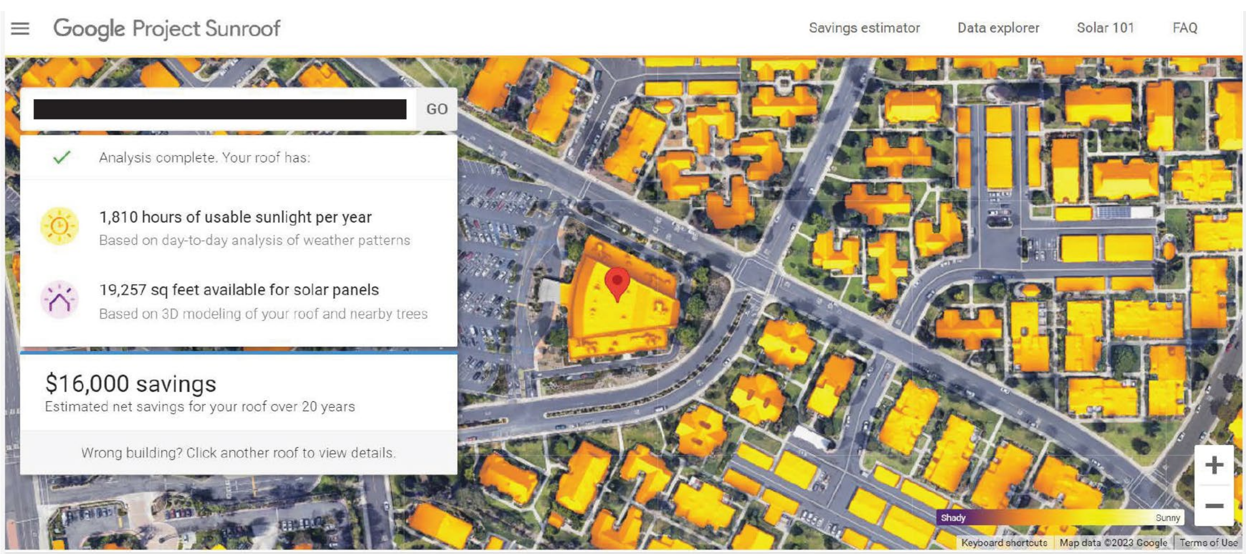


Figure 1. Google Project Sunroof, there are 1,810 hours of usable sun.

As indicated by Figure 1, according to Google Project Sunroof, there are 1,810 hours of usable sun light per year for this specific location. This facility operates 7 days per 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 = (1,810 hrs) x (49 kW/h) x (0.70)
EC = 62,083 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 = 62,083kWh/yr x ($0.24361/kWh)
ECS = $15,124/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 $42,691 is estimated for installation, connection, and mounting structure, listed of costs are listed in the table below. Thus, the cost savings of $15,124/yr would pay for the total implementation cost of $87,421 in about 5.78 years.

	Units	Price	Price
		Per Unit (US-$)	Total (US-$)
Solar Cells	142	315	44,730
Power Grid Connection	1	1000	1,000
Installation	142	95.6	13,575
Universal Pole Mount	142	198	28,116
		Total =	**87,421**

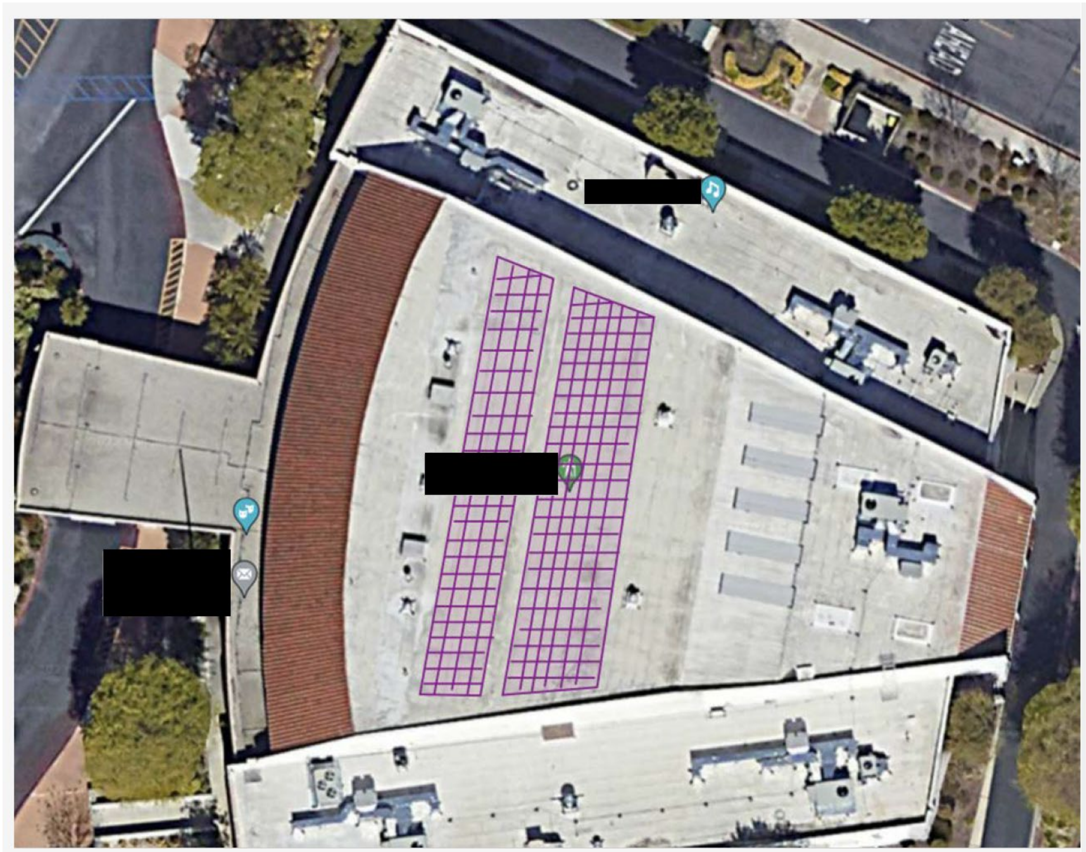


Figure 2. Proposed system design mounted in the roof

CLUBHOUSE 5

<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	44,029 kWh/yr (150.6 MMBtu/yr)	$10,726 /yr	$58,817	5.48 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**, energy output of each unit **33 kW/hr.**
- Estimated to run **1,906 hours** per year.
- Connections to the facility.
- Structure and foundation mountings.

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

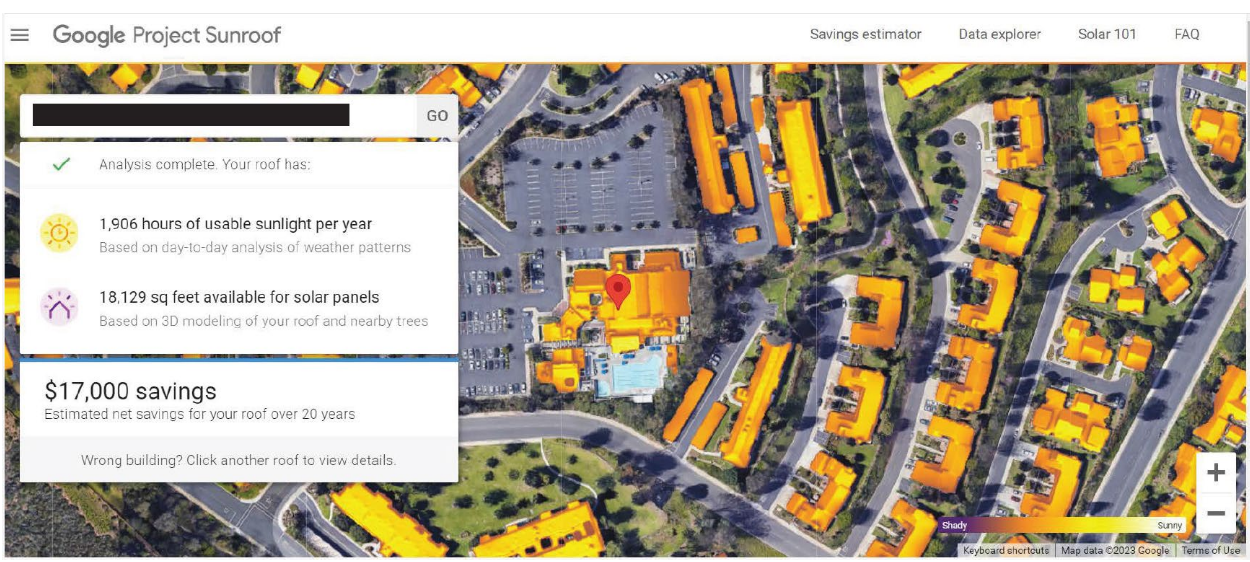


Figure 1. Google Project Sunroof, there are 1,906 hours of usable sun.

As indicated by Figure 1, according to Google Project Sunroof, there are 1,906 hours of usable sun light per year for this specific location. This facility operates 7 days per 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 = (1,906 hrs) x (33 kW/h) x (0.70)
EC = 44,029 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 = 44,029 kWh/yr x ($0.24361/kWh)
ECS = $10,726/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 $10,726/yr would pay for the total implementation cost of $58,817 in about 5.48 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**

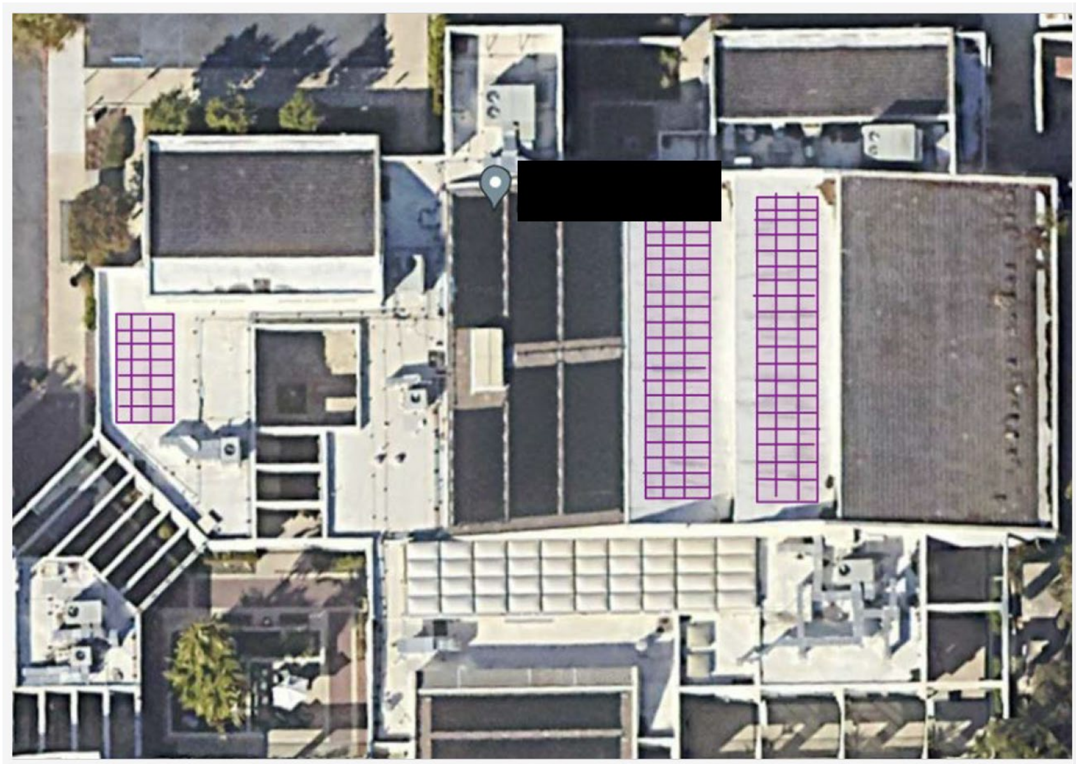


Figure 2. Proposed system design mounted in the roof

CLUBHOUSE 7

<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	133,490 kWh/yr (455.5 MMBtu/yr)	$32,519 /yr	$178,103	5.48 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 **291 units**, total energy output of **100 kW/hr**
- Estimated to run **1,907 hours** per year.
- Connections to the facility.
- Structure and foundation mountings.

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

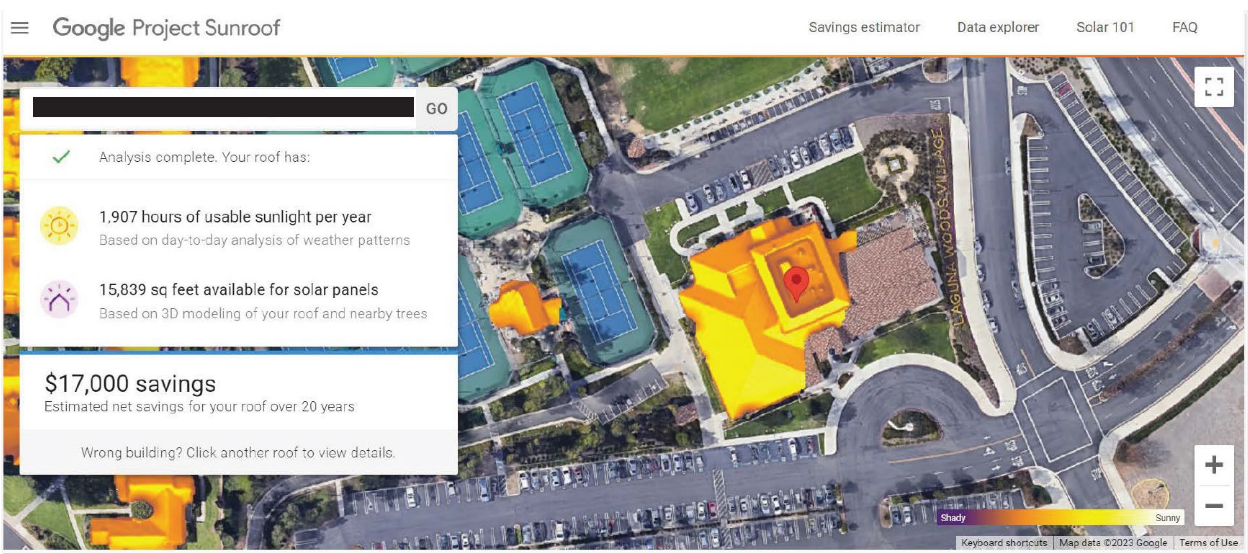


Figure 1. Google Project Sunroof, there are 1,907 hours or usable sun.

As indicated by Figure 1, according to Google Project Sunroof, there are 1,907 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 = (1,907 hrs) x (100 kW/h) x (0.70)
EC = 133,490 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 = 133,490 kWh/yr x ($0.24361/kWh)
ECS = $32,519/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 $86,438 is estimated for installation, connection, and mounting structure, listed of costs are listed in the table below. Thus, the cost savings of $32,519/yr would pay for the total implementation cost of $178,103 in about 5.48 years.

	Units	Price	Price
		Per Unit (US-$)	Total (US-$)
Solar Cells	291	315	91,665
Power Grid Connection	1	1000	1,000
Installation	291	95.6	27,820
Universal Pole Mount	291	198	57,618
		Total	**178,103**

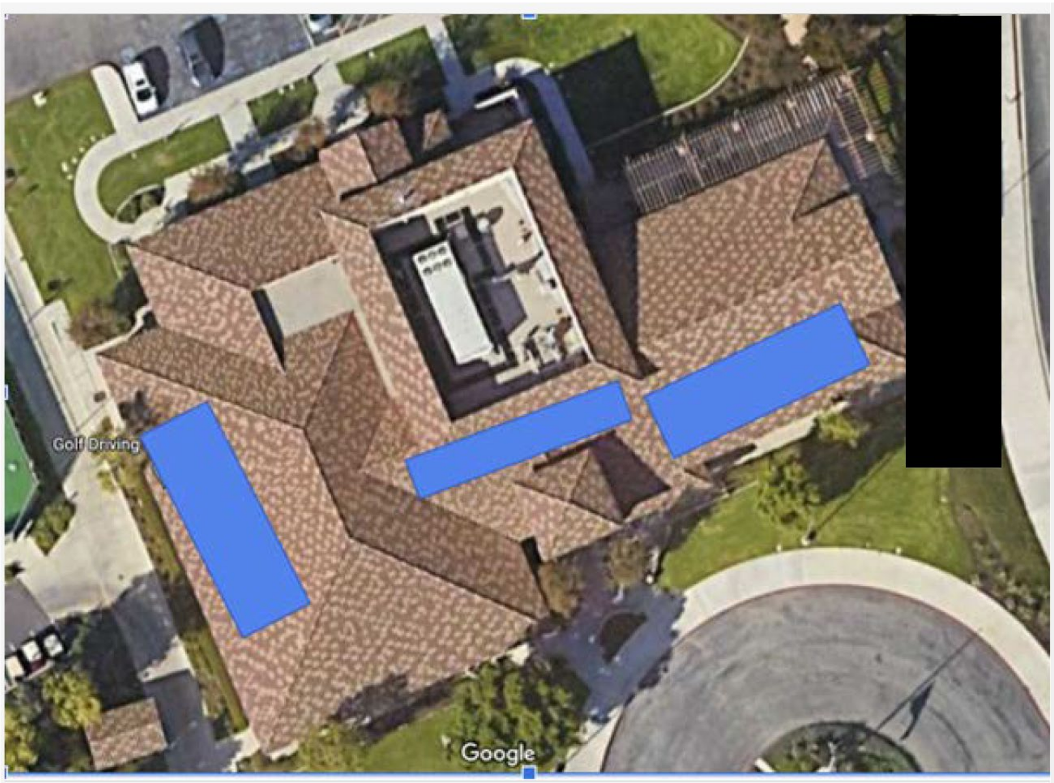


Figure 2 . Proposed system design mounted in the roof

AR #3: Installing Variable Speed Drive to Existing HVAC Equipment
(ARC: 2.7226)

TOTAL ENERGY SAVINGS

ARC: 2.7226	**Estimated Annual Savings**			**Simple Payback**
	Electric Energy Savings	Total Electric Cost Savings	Estimated Implementation Cost	
Total	112,105 kWh/yr (382.5 MMBtu/yr)	$27,340 /yr	$27,100	0.99 years

CLUBHOUSE 3

<u>Recommended Action</u>

It is recommended to install a variable speed drive and upgraded controls for both of the air handling units located by the control room of the auditorium. Currently there are two units that were manufactured in 1992 and a hydronic cooling and heating. Both of these units have a Seasonal Energy Efficiency Ratio (SEER) calculated at 19.3 which is on a scale of 8-21. Adding another VFD to the 30 ton rooftop Trane RAUJ unit will also help savings considering it is the biggest unit, with a SEER rating of 14.4, and has the highest annual cost. 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.

ARC: 2.7226	**Estimated Annual Savings**			**Simple Payback**
	Electric Energy Savings	Total Electric Cost Savings	Estimated Implementation Cost	
Total	33,791 kWh/yr (115.30 MMBtu/yr)	$8,262 /yr	$13,500	1.63 years

<u>Background</u>

<u>Current System</u>

Currently Clubhouse Three has a total of nine HVAC units servicing the entire facility. This facility primes their HVAC systems 30 minutes before opening and totals around 2,210 hours a year. All

7 rooftop units are new (2019-2021) with good SEER ratings from 14-15. These 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. However, the The two Trane 21 ton air handlers currently do not have a variable speed controller. It seems both units were connected to some form of controller but were eventually disconnected. 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.

Proposed System

The proposed system includes installing the three VFD to both air handlers and the air-cooling condensing unit (Trane RAUJ) by the same manufacturer Trane. Recommending adding only VFD and not replacing the air handlers considering how high of an efficiency both already have. As well as installing a VFD to the 30 ton condensing unit will assist in a better performance efficiency since it produces the highest annual cost of $16,575.29. Results will allow for an annual energy consumption savings of up to 30%.

Anticipated Saving

The amount of savings is based on the utility bill summary from 10/21-9/22 provided by Southern California Edison. The average Cents/kWh is used to calculate the next 12 month billing summary. The estimated implementation cost does include labor The upgrade in HVAC will reduce the energy consumption and operation for the facility.

Current System Units:

3-Trane YHC, 2-Trane MCCA, 1-Trane 4YCC, 1-Trane 4TWR, 1-Essick 75, 1-Trane RAUJ

Calculation Sample (One Trane MCCA)

The energy usage of current unit, CE, and the energy cost of current unit, CC, are calculated by the following relations:

$$CE = CD \times OH$$

and

$$CC = CE \times EEC$$

where

CD = demand of the current unit, 13 kW

OH = operating hour, 2,210 hr/yr

EEC = effective energy cost, $0.24361/kWh

Thus, the energy usage of this current unit, CE, and the energy cost of this current unit, CC, are estimated to be:

CE = 13 kW x 2,210 hr/yr

= 28,730 kWh/yr

and

CC = 28,730 kWh/yr x $0.24361/kWh

= $6,999/yr

Current Selected System Annual Costs		
Model	Annual Usage [kWh/yr]	Annual Cost [$/yr]
2-Trane MCCA	57,460	$13,998
3-Trane YHC	53,040	$12,921
Essick 75	170	$41
Trane RAUJ	55,250	$13,459
Trane 4YCC	3,883	$946
Trane 4TWR	9,471	$2,307
Total	179,275	$43,673

<u>Proposed System Units:</u>

3- Trane TR200TM (two Trane MCCA and one Trane RAUJ)

Calculation Sample (One Trane MCCA)

The energy usage of proposed unit, PE, and the energy cost of proposed unit, PC, are calculated by the following relations:

PE = PD x OH x RC

and

PC = PE x EEC

where

PD	=	demand of the proposed unit, 13 kW
OH	=	operating hour, 2,210 hr/yr
RC	=	estimated rate of energy saving from the old unit, 30%
EEC	=	effective energy cost, $0.24361/kWh

Thus, the energy usage of this proposed unit, PE, and the energy cost of this proposed unit, PC, are estimated to be:

PE = 13 kW x 2,210 hr/yr x 30%

= 20,111 kWh/yr

and

PC = 20,111 kWh/yr x $0.24361/kWh

= $4,899/yr

Proposed System Annual Costs			
Quantity	Model	Annual Usage [kWh/yr]	Annual Cost [$/yr]
2	Trane MCCA	40,222	$9,798
1	Trane RAUJ	38,675	$9,422
6	Newer Units Not to be replaced	66,586.98	$16,221
Total		145,483.98	$35,441

The annual electrical energy saving, ES, and the annual cost saving, CS, are calculated by the following relations:

ES = CE - PE

CS = CC - PC

where

CE	=	annual usage of current system
PE	=	annual usage of proposed system
CC	=	annual cost of current system
PC	=	annual cost of proposed system

Thus, the annual electrical energy saving, ES, and the annual cost saving, CS, are estimated to be:

ES	=	179,274.88 kWh/yr - 145,483.98 kWh/yrs
	=	33,791 kWh/yr

CS	=	$43,673/yr - $35,441/yr
	=	$8,262/yr

Implementation Cost

The implementation cost of purchase for the proposed three VFD to service both air handers and condensing unit including labor is estimated at $13,500. Local market value for one Trane TR200TM unit is estimated at $3,500. With the proposed installed equipment the total savings per year is estimated at $8,262 in utilities and will result in a payback period of 1.63 years.

CLUBHOUSE 5

Recommended Action

It is recommended to upgrade one HVAC unit by installing a variable speed drive to enhance efficiency. Currently there are eight units that were manufactured between 2016-2017 and still use freon R410a. These units have an estimated Seasonal Energy Efficiency Ratio (SEER) of 10 on a scale of 8-21. A higher SEER rating means the piece of equipment uses less input power to operate normally. Upgrading the biggest unit to operate more efficiently will reduce the energy consumption as well as increase savings cost.

ARC: 2.7226	Estimated Annual Savings			Simple Payback
	Electric Energy Savings	Total Electric Cost Savings	Estimated Implementation Cost	
Total	47,502 kWh/yr (162.08 MMBtu/yr)	$11,572 /yr	$6,800	0.59 years

Background

Current System

Currently Clubhouse Five has a total of eight rooftop HVAC units servicing the entire facility. This facility primes their HVAC systems 30 minutes before opening and totals around 5,278 hours a year. All units are relatively new and use R410a ($8/lb) and the largest unit is the 25 ton, Trane YHH, labeled "RTU-1", located on the roof of the Ballroom. 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.

Anticipated Saving

The amount of savings is based on the utility bill summary from 10/21-9/22 provided by Southern California Edison. The average Cents/kWh is used to calculate the next 12 month billing summary. The estimated implementation cost does include labor The upgrade in HVAC will reduce the energy consumption and operation for the facility.
Current System Units:

6-Trane YH & 2-Trane 4YC

Calculation Sample (One Trane YH)

The energy usage of current unit, CE, and the energy cost of current unit, CC, are calculated by the following relations:

$$CE = CD \times OH$$

and

$$CC = CE \times EEC$$

where

CD	=	demand of the current unit, 30 kW
OH	=	operating hour, 5,278 hr/yr
EEC	=	effective energy cost, $0.24361/kWh

Thus, the energy usage of this current unit, CE, and the energy cost of this current unit, CC, are estimated to be:

CE	=	30 kW x 5,278 hr/yr
	=	158,340 kWh/yr

and

CC	=	158,340 kWh/yr x $0.24361/kWh
	=	$38,573/yr

Current Selected System Annual Costs			
Quantity	Model	Annual Usage [kWh/yr]	Annual Cost [$]
6	Trane YH	336,644.36	$82,010
2	Trane 4YC	33726.42	$8,216
Total		370370.78	$90,226

Proposed System

The proposed system includes installing one variable speed drive to the biggest rooftop ac unit at 25 tons provided by the same manufacturer, Trane. This excludes the other seven Trane 3-13 ton units because there is not much energy consumption worth the upgrade considering the low number of tonnage and relatively new age of the units. By installing a Trane TR200 VFD, annual energy consumption will lower by 30%.

Proposed System Units:

1-Trane YH with Trane TR200 VFD

Calculation Sample (One Trane YH)

The energy usage of proposed unit, PE, and the energy cost of proposed unit, PC, are calculated by the following relations:

PE = PD x OH

and

PC = PE x EEC

where

PD = demand of the proposed unit, 21 kW

OH = operating hour, 5,278 hr/yr

EEC = effective energy cost, $0.24361/kWh

Thus, the energy usage of this proposed unit, PE, and the energy cost of this proposed unit, PC, are estimated to be:

PE = 21 kW x 5,278 hr/yr

= 110,838 kWh/yr

and

PC = 110,838 kWh/yr x $0.24361/kWh

= $27,238.65/yr

Proposed System Annual Costs			
Quantity	Model	Annual Usage [kWh/yr]	Annual Cost [$]
6	Trane YH	289,142.36	$70,438
2	Trane 4YC	33726.42	$8,216
Total		322,868	$78,654

The annual electrical energy saving, ES, and the annual cost saving, CS, are calculated by the following relations:

ES = CE - PE

CS = CC - PC

where

CE = annual usage of current system

PE = annual usage of proposed system

CC = annual cost of current system

PC = annual cost of proposed system

Thus, the annual electrical energy saving, ES, and the annual cost saving, CS, are estimated to be:

ES = 158,340 kWh/yr - 110,838 kWh/yrs

= 47,502 kWh/yr

CS = $38,573/yr - $27,001/yr

= $11,572/yr

Implementation Cost

The implementation cost of purchase and installation labor for the VFD to service the 25 ton rooftop unit is estimated at $6,800 total. Local market value for one Trane TR200 VFD is $3,500 and with the new proposed system the total savings per year is estimated at $11,572 in utilities and will result in a payback period of 0.59 years.

CLUBHOUSE 7

Recommended Action

It is recommended to upgrade one HVAC unit by installing a variable speed drive to enhance efficiency. Currently there is only one commercial 30 ton ac unit that is brand new and uses R22 ($21/lb). These units have an estimated Seasonal Energy Efficiency Ratio (SEER) of 18.5 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.

ARC: 2.7226	Estimated Annual Savings			Simple Payback
	Electric Energy Savings	Total Electric Cost Savings	Estimated Implementation Cost	
Total	30,812 kWh/yr (105 MMBtu/yr)	$7,506 /yr	$6,800	0.91 years

Background

Current System

Currently Clubhouse Seven has one commercial rooftop AC unit servicing the entire facility. This facility primes their HVAC systems 30 minutes before opening and totals around 5,278 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.

Proposed System

The proposed system includes installing one variable speed drive to the biggest rooftop ac unit at 30 tons provided by the same manufacturer, Trane. By installing a Trane TR200TM VFD, annual energy consumption will lower by 30%.

Anticipated Saving

The amount of savings is based on the utility bill summary from 10/21-9/22 provided by Southern California Edison. The average Cents/kWh is used to calculate the next 12 month billing summary. The estimated implementation cost does include labor The upgrade in HVAC will reduce the energy consumption and operation for the facility.

Current System Units:

One Trane SXH

The energy usage of current unit, CE, and the energy cost of current unit, CC, are calculated by the following relations:

$$CE = CD \times OH$$

and

CC = CE x EEC

where

CD = demand of the current unit, 19.5 kW

OH = operating hour, 2,210 hr/yr

EEC = effective energy cost, $0.24361/kWh

Thus, the energy usage of this current unit, CE, and the energy cost of this current unit, CC, are estimated to be:

CE = 13 kW x 5,278 hr/yr

= 102,707 kWh/yr

and

CC = 102,707 kWh/yr x $0.24361/kWh

= $25,020/yr

Current Selected System Annual Costs	
Model	Annual Cost [$]
Trane SXH	25,020
Total	25,020

Proposed System Units:

1-Trane YH with Trane TR200 VFD

The energy usage of proposed unit, PE, and the energy cost of proposed unit, PC, are calculated by the following relations:

PE = PD x OH

and

PC = PE x EEC

where

PD = demand of the proposed unit, 13.6 kW

OH = operating hour, 5,278 hr/yr

EEC = effective energy cost, $0.24361/kWh

Thus, the energy usage of this proposed unit, PE, and the energy cost of this proposed unit, PC, are estimated to be:

PE = 13.6 kW x 5,278 hr/yr

= 71,894 kWh/yr

and

PC = 71,894 kWh/yr x $0.24361/kWh

= $17,514/yr

Proposed System Annual Costs	
Model	Annual Cost [$]
Trane YH	17,514
Total	17,514

The annual electrical energy saving, ES, and the annual cost saving, CS, are calculated by the following relations:

ES = CE - PE

CS = CC - PC

where

CE = annual usage of current system

PE = annual usage of proposed system

CC = annual cost of current system

PC = annual cost of proposed system

Thus, the annual electrical energy saving, ES, and the annual cost saving, CS, are estimated to be:

ES = 102,707 kWh/yr - 71,894 kWh/yrs

= 30,812 kWh/yr

CS = $25,020/yr - $17,514/yr

= $7,506/yr

Implementation Cost

The implementation cost of purchase and installation labor for the VFD to service the 30 ton rooftop unit is estimated at $6,800 total. Local market value for one Trane TR200 VFD is $3,500 and with the new proposed system the total savings per year is estimated at $7,900 in utilities and will result in a payback period of 0.91 years.

AR #4: Upgrading Existing HVAC Equipment

CLUBHOUSE 1

Recommended Action

It is recommended to upgrade most of the HVAC rooftop units. Currently there are six units that were manufactured in 2000 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). All of these units have a Seasonal Energy Efficiency Ratio (SEER) of 10 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.

ARC: 2.7232	**Estimated Annual Savings**			**Simple Payback**
	Electric Energy Savings	Total Electric Cost Savings	Estimated Implementation Cost	
Total	110,838 kWh/yr (378.2 MBtu/yr)	$27,002 /yr	$37,785	1.40 years

Background

Current System

Currently Clubhouse One has a total of ten 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 four of these units are relatively new ranging from 2017-2021 and use R410a ($8/lb). 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.

Proposed System

The proposed system includes replacing all six of the old units with newer model units by the same manufacturer. This includes five Trane XV18 5 ton units and one Trane TWA 240 20 ton split system heat pump unit . These units are a variable speed AC compatibility, a better SEER rating at 18 and uses Trane’s communication technology (ComfortLink II COM) which has the capability of allowing the occupants to connect to other pieces of equipment. Furthermore, this new system will allow for automatically charges, configure and calibrate itself to achieve optimal performance to ensure the unit's lifetime. Buying these units from Trane also includes a savings of $600 for each unit, possibly more if bought from another local dealer.

<u>Anticipated Saving</u>

The amount of savings is based on the utility bill summary from 10/21-9/22 provided by Southern California Edison. The average Cents/kWh is used to calculate the next 12 month billing summary. The estimated implementation cost does not include labor The upgrade in HVAC will reduce the energy consumption and operation for the facility.

<u>Current System Units:</u>

1-Trane XE, 2-Trane XR, 2-Weathertron TWA, & 1-TWE all manufactured in 2000.

Calculation Sample (One Trane XE)

The energy usage of current unit, CE, and the energy cost of current unit, CC, are calculated by the following relations:

CE = CD x OH

and

CC = CE x EEC

where

CD = demand of the current unit, 3 kW

OH = operating hour, 5,278 hr/yr

EEC = effective energy cost, $0.24361/kWh

Thus, the energy usage of this current unit, CE, and the energy cost of this current unit, CC, are estimated to be:

CE = 3 kW x 5,278 hr/yr

= 15,834 kWh/yr

and

CC = 15,834 kWh/yr x $0.24361/kWh

= $3,857/yr

Current Selected System Annual Costs		
Model	Annual Usage [kWh/yr]	Annual Cost [$]
Trane XE1000	15,834	3,857
Trane XR1000	23,751	5,786
Trane XR1000	27,709.5	6,750
Weathertron TWA	15,834	3,857
Weathertron TWA	59,377.5	14,465
Trane TWE	158,340	38,573
Newer Units Not to be replaced	70,122	17,082
Total	370,968	90,372

Proposed System Units: 5-Trane XV18, 1-Trane TWA

Calculation Sample (One Trane XV18)

The energy usage of proposed unit, PE, and the energy cost of proposed unit, PC, are calculated by the following relations:

PE = PD x OH

and

PC = PE x EEC

where

PD = demand of the proposed unit, 1.34kW

OH = operating hour, 5,278 hr/yr

EEC = effective energy cost, $0.24361/kWh

Thus, the energy usage of this proposed unit, PE, and the energy cost of this proposed unit, PC, are estimated to be:

PE = 1.34 kW x 5,278 hr/yr

= 7072.52 kWh/yr

and

PC = 7072.52 kWh/yr x $0.24361/kWh

= $1542.52/yr

Proposed System Annual Costs			
Quantity	Model	Annual Usage [kWh/yr]	Annual Cost [$]
5	Trane XV18	63,336	15,429
1	Trane TWA	126,672	30,859
3	Newer Units Not to be replaced	70,122	17,082
Total		260,130	63,370

The annual electrical energy saving, ES, and the annual cost saving, CS, are calculated by the following relations:

ES = CE - PE

CS = CC - PC

where

CE = annual usage of current system

PE = annual usage of proposed system

CC = annual cost of current system

PC = annual cost of proposed system

Thus, the annual electrical energy saving, ES, and the annual cost saving, CS, are estimated to be:

ES = 370,968 kWh/yr - 260,130 kWh/yrs

	=	110,838 kWh/yr
CS	=	\$90,372/yr - \$63,370/yr
	=	\$27,002/yr

Implementation Cost

The implementation cost of purchase for the proposed variable speed air conditioning units and split system heat pump is estimated at \$37,785. With the Trane XV18 units costing \$3,557 and the Trane TWA24 model at \$20,000. These units will replace the current units located on the rooftop of the Main Lounge as well as the attic. With the proposed replacement system the total savings per year is estimated at \$27,002 in utilities and will result in a payback period of 1.40 years.

AR #5: 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	85,298 kWh/yr (291.0 MMBtu/yr)	$20,780 /yr	$10,000	0.48 years

CLUBHOUSE 1

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	32,668 kWh/yr (111.47 MMBtu/yr)	$7,958 /yr	$2,500	0.31 years

Background

Lighting can be eliminated during unoccupied periods by installing occupancy sensors into the lighting circuits in the lounge, gym, and other activity 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:

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

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, 666
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, 20
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 x W1 + L2 x W2 + L3 x W3
= 666 x 18.5 + 0 x 40 + 20 x 25
= 12,821 kW

ES = 12,821 x (1 + 0) x (1/1,000) x (5,096 – 2,548)
ES = 32,668 kWh/yr

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

CS = ES × (effective energy cost)
CS = 32,668 kWh/yr × ($0.24361/kWh)
CS = $7,958/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 $7,958/yr and will pay for the implementation cost of $2,500 in approximately 0.31 years.

CLUBHOUSE 3

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	4,329 kWh/yr (14.77 MMBtu/yr)	$1,055 /yr	$2,500	2.37 year

Background

Lighting can be eliminated during unoccupied periods by installing occupancy sensors into the lighting circuits of the dining rooms, kitchens, music room, and billiard room. Energy savings and demand reduction will result from the reduced electrical usage for lighting. Currently, the lighting is turned on approximately 2,080 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, 175
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, 37
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, 2,080 hrs/yr
PH_i	=	proposed operating hours of lamps in area 1,040 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
	=	175 x 18.5 + 0 x 40 + 37 x 25
	=	4,162.5 kW
ES	=	4,162.5 x (1 + 0) x (1/1,000) x (2,080 – 1,040)
ES	=	4,329 kWh/yr

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

CS	=	ES × (effective energy cost)
CS	=	4,329 kWh/yr × ($0.24361/kWh)
CS	=	$1,055/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 $1,055/yr and will pay for the implementation cost of $2,500 in approximately 2.37 years.

CLUBHOUSE 5

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	20,347 kWh/yr (69.43 MMBtu/yr)	$4,957 /yr	$2,500	0.50 years

Background

Lighting can be eliminated during unoccupied periods by installing occupancy sensors into the lighting circuits in the ballroom, gym, dining rooms, kitchen, bathrooms, and offices. 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:

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

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, 303
W1	=	rating of lamps in area, 18.5 Watts
L2	=	number of lamps in area, 17
W2	=	rating of lamps in area, 40 Watts
L3	=	number of lamps in area, 68
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 x W1 + L2 x W2 + L3 x W3
	=	303 x 18.5 + 17 x 40 + 68 x 25
	=	7,985.5 kW

ES	=	7,985.5 x (1 + 0) x (1/1,000) x (5,096 – 2,548)
ES	=	20,347 kWh/yr

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

CS	=	ES × (effective energy cost)
CS	=	20,347 kWh/yr × ($0.24361/kWh)
CS	=	$4,957/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 $4,957/yr and will pay for the implementation cost of $2,500 in approximately 0.50 years.

CLUBHOUSE 7

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	27,954 kWh/yr (95.38 MMBtu/yr)	$6,810 /yr	$2,500	0.67 years

Background

Lighting can be eliminated during unoccupied periods by installing occupancy sensors into the lighting circuits of the Main room, kitchen, office, and bathrooms. 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 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, 516
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, 57
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 x W1 + L2 x W2 + L3 x W3
	=	516 x 18.5 + 0 x 40 + 57 x 25
	=	10,971 kW
ES	=	10,971 x (1 + 0) x (1/1,000) x (5,096 – 2,548)
ES	=	27,954 kWh/yr

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

CS	=	ES × (effective energy cost)
CS	=	27,954 kWh/yr × ($0.24361/kWh)
CS	=	$6,810/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 $6,810/yr will pay for the implementation cost of $2,500 in about 0.37 years.

AR #6: 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	74,839 kWh/yr (255.4 MMBtu/yr)	$18,232/yr	$8,000	0.44 years

CLUBHOUSE 1

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	27,470 kWh/yr (93.7 MMBtu/yr)	$6,692/yr	$2,000	0.30 years

Background

Currently at this facility, approximately 10 HVAC units are used for heating and cooling which serves 32,800 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 6-1 below. The retail space considered is 32,800 sq.ft, therefore 32,800 cfm is required, and 3,936 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, CA 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 6-1 Minimum Ventilation Rates in Breathing Zone (Continued)

	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Default Values Occupant Density		
Occupancy Category	cfm/ person	L/s· person	cfm/ft^2	L/s·m^2	#/1000 ft^2 or #/100 m^2	Air Class	OS (6.2.6.1.4)
Public Assembly Spaces							
Auditorium seating area	5	2.5	0.06	0.3	150	1	✓
Courtrooms	5	2.5	0.06	0.3	70	1	✓
Legislative chambers	5	2.5	0.06	0.3	50	1	✓
Libraries	5	2.5	0.12	0.6	10	1	
Lobbies	5	2.5	0.06	0.3	150	1	✓
Museums (children's)	7.5	3.8	0.12	0.6	40	1	
Museums/galleries	7.5	3.8	0.06	0.3	40	1	✓
Places of religious worship	5	2.5	0.06	0.3	120	1	✓
Retail							
Sales (except as below)	7.5	3.8	0.12	0.6	15	2	
Barbershop	7.5	3.8	0.06	0.3	25	2	✓
Beauty and nail salons	20	10	0.12	0.6	25	2	
Coin-operated laundries	7.5	3.8	0.12	0.6	20	2	
Mall common areas	7.5	3.8	0.06	0.3	40	1	✓
Pet shops (animal areas)	7.5	3.8	0.18	0.9	10	2	
Supermarket	7.5	3.8	0.06	0.3	8	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, 3,936 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	=	3,936 x 1.08 x (90 – 55) x 7 x 90
ES	=	93,731,904 Btu/yr
ES	=	27,470 kWh/yr

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

CS	=	ES x (effective energy cost)
CS	=	27,470 kWh/yr x ($0.24361 /kWh)
CS	=	$6,692 /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 $6,692 will pay for the new CO2 sensors in 0.30 years.

CLUBHOUSE 3

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	14,573 kWh/yr (49.7 MMBtu/yr)	$3,550/yr	$2,000	0.56 years

Background

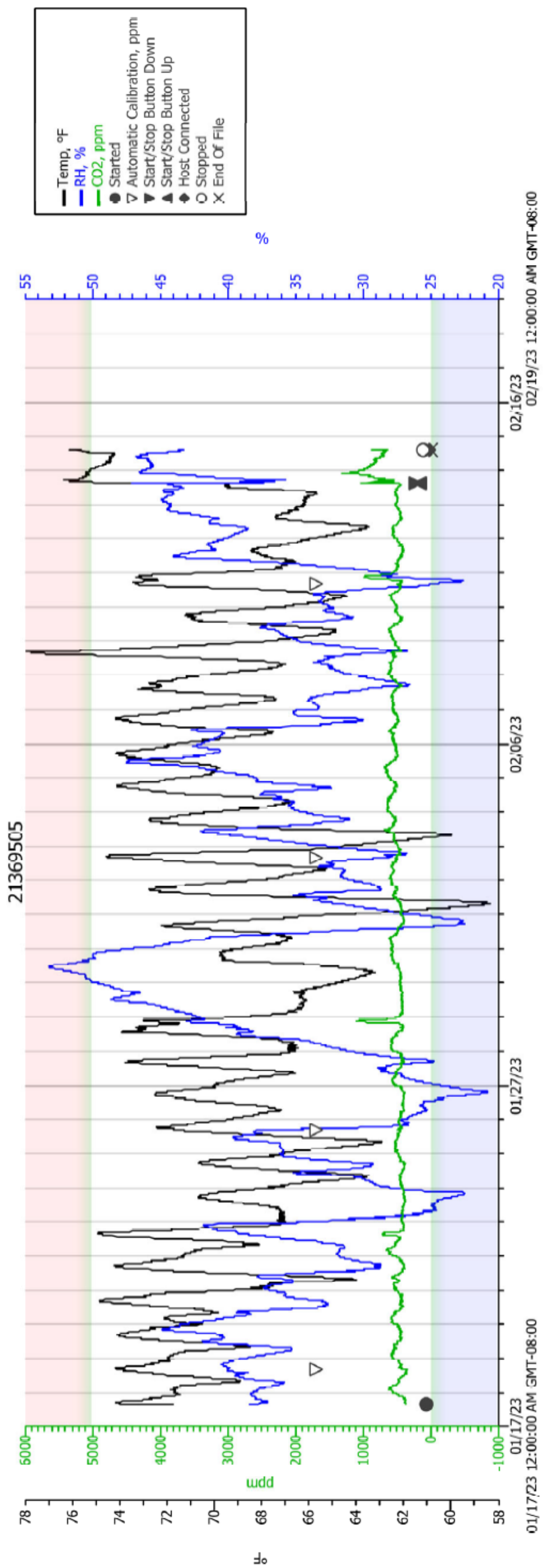
Currently at this facility, approximately 10 HVAC units are used for heating and cooling which serves 17,400 sq.ft total. Retail space requires 0.12 cfm of outside air per sq.ft and industry standard of 1 cfm per sq.ft of total cfm including outside air[1]. Please see table 6-1 below. The retail space considered is 17,400 sq.ft, therefore 17,400 cfm is required, and 2,088 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, CA 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 6-1 Minimum Ventilation Rates in Breathing Zone (Continued)

	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Default Values Occupant Density		
Occupancy Category	cfm/ person	L/s· person	cfm/ft²	L/s·m²	#/1000 ft² or #/100 m²	Air Class	OS (6.2.6.1.4)
Public Assembly Spaces							
Auditorium seating area	5	2.5	0.06	0.3	150	1	✓
Courtrooms	5	2.5	0.06	0.3	70	1	✓
Legislative chambers	5	2.5	0.06	0.3	50	1	✓
Libraries	5	2.5	0.12	0.6	10	1	
Lobbies	5	2.5	0.06	0.3	150	1	✓
Museums (children's)	7.5	3.8	0.12	0.6	40	1	
Museums/galleries	7.5	3.8	0.06	0.3	40	1	✓
Places of religious worship	5	2.5	0.06	0.3	120	1	✓
Retail							
Sales (except as below)	7.5	3.8	0.12	0.6	15	2	
Barbershop	7.5	3.8	0.06	0.3	25	2	✓
Beauty and nail salons	20	10	0.12	0.6	25	2	
Coin-operated laundries	7.5	3.8	0.12	0.6	20	2	
Mall common areas	7.5	3.8	0.06	0.3	40	1	✓
Pet shops (animal areas)	7.5	3.8	0.18	0.9	10	2	
Supermarket	7.5	3.8	0.06	0.3	8	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 CO_2 levels over a two week period for Clubhouse 3



Anticipated Savings

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

ES	=	CFM x CC x (OSA – SA) x H x D

where

CFM	=	Outside air required, 2,088 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	=	2,088 x 1.08 x (90 – 55) x 7 x 90
ES	=	49,723,632.00 Btu/yr
ES	=	14,573 kWh/yr

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

CS	=	ES x (effective energy cost)
CS	=	14,573 kWh/yr x ($0.24361 /kWh)
CS	=	$3,550/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 $3,550 will pay for the new CO_2 sensors in 0.56 years.

CLUBHOUSE 5

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	10,680 kWh/yr (36.4 MMBtu/yr)	$2,602/yr	$2,000	0.77 years

<u>Background</u>

Currently at this facility, approximately 10 HVAC units are used for heating and cooling which serves 12,752 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 6-1 below. The retail space considered is 12,752 sq.ft, therefore 12,752 cfm is required, and 1,530.24 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 Rancho Cucamonga 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 6-1 Minimum Ventilation Rates in Breathing Zone (Continued)

Occupancy Category	People Outdoor Air Rate R_p cfm/person	People Outdoor Air Rate R_p L/s·person	Area Outdoor Air Rate R_a cfm/ft²	Area Outdoor Air Rate R_a L/s·m²	Default Values Occupant Density #/1000 ft² or #/100 m²	Air Class	OS (6.2.6.1.4)
Public Assembly Spaces							
Auditorium seating area	5	2.5	0.06	0.3	150	1	✓
Courtrooms	5	2.5	0.06	0.3	70	1	✓
Legislative chambers	5	2.5	0.06	0.3	50	1	✓
Libraries	5	2.5	0.12	0.6	10	1	
Lobbies	5	2.5	0.06	0.3	150	1	✓
Museums (children's)	7.5	3.8	0.12	0.6	40	1	
Museums/galleries	7.5	3.8	0.06	0.3	40	1	✓
Places of religious worship	5	2.5	0.06	0.3	120	1	✓
Retail							
Sales (except as below)	7.5	3.8	0.12	0.6	15	2	
Barbershop	7.5	3.8	0.06	0.3	25	2	✓
Beauty and nail salons	20	10	0.12	0.6	25	2	
Coin-operated laundries	7.5	3.8	0.12	0.6	20	2	
Mall common areas	7.5	3.8	0.06	0.3	40	1	✓
Pet shops (animal areas)	7.5	3.8	0.18	0.9	10	2	
Supermarket	7.5	3.8	0.06	0.3	8	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, 1,530.24 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	=	1,530.24 x 1.08 x (90 – 55) x 7 x 90
ES	=	36,441,135.36 Btu/yr
ES	=	10,679.85 kWh/yr

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

CS	=	ES x (effective energy cost)
CS	=	10,679.85 kWh/yr x ($0.24361/kWh)
CS	=	$2,602/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 $2,602 will pay for the new CO2 sensors in 0.77 years.

CLUBHOUSE 7

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	22,116 kWh/yr (75.5 MMBtu/yr)	$5,388/yr	$2,000	0.37 years

Background

Currently at this facility, approximately 10 HVAC units are used for heating and cooling which serves 26,407 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 6-1 below. The retail space considered is 26,407 sq.ft, therefore 26,407 cfm is required, and 3,168.84 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, CA 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 6-1 Minimum Ventilation Rates in Breathing Zone (Continued)

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Default Values Occupant Density	Air Class	OS (6.2.6.1.4)
	cfm/person	L/s·person	cfm/ft^2	L/s·m^2	#/1000 ft^2 or #/100 m^2		
Public Assembly Spaces							
Auditorium seating area	5	2.5	0.06	0.3	150	1	✓
Courtrooms	5	2.5	0.06	0.3	70	1	✓
Legislative chambers	5	2.5	0.06	0.3	50	1	✓
Libraries	5	2.5	0.12	0.6	10	1	
Lobbies	5	2.5	0.06	0.3	150	1	✓
Museums (children's)	7.5	3.8	0.12	0.6	40	1	
Museums/galleries	7.5	3.8	0.06	0.3	40	1	✓
Places of religious worship	5	2.5	0.06	0.3	120	1	✓
Retail							
Sales (except as below)	7.5	3.8	0.12	0.6	15	2	
Barbershop	7.5	3.8	0.06	0.3	25	2	✓
Beauty and nail salons	20	10	0.12	0.6	25	2	
Coin-operated laundries	7.5	3.8	0.12	0.6	20	2	
Mall common areas	7.5	3.8	0.06	0.3	40	1	✓
Pet shops (animal areas)	7.5	3.8	0.18	0.9	10	2	
Supermarket	7.5	3.8	0.06	0.3	8	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, 3,168.84 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	=	3,168.84 x 1.08 x (90 – 55) x 7 x 90
ES	=	75,462,755.76 Btu/yr
ES	=	22,115.96 kWh/yr

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

CS	=	ES x (effective energy cost)
CS	=	22,115.96 kWh/yr x ($0.24361/kWh)
CS	=	$5,388/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 $5,388 will pay for the new CO2 sensors in 0.37 years.

AR #7: Use Triple Glazed Windows to Maintain Higher Relative Humidity and to Reduce Heat Losses

(ARC 2.7493)

Recommended Action

Replace all windows in the facility with high-efficiency, triple glazed windows. Energy efficient windows are an important consideration in heating and cooling costs. Using more energy efficient and triple glazed windows can reduce heat gain and heat loss through windows. Replacing the windows will result in savings from less heating and cooling loss, therefore less heating and cooling energy is needed.

ARC: 2.7493	**Annual Savings**			**Simple Payback**
	Electric Energy Savings	Total Cost Savings	Implementation Cost	
Total	33,432 kWh/yr (114.1 MMBtu/yr)	$8,144/yr	$15,610	1.92 years

Background

Energy efficiency windows can have a big impact on heating and cooling costs. Heat gain and heat loss through windows are responsible for 25-30% of heating and cooling energy use. If existing windows are in good condition, steps can be taken to reduce the energy loss through windows. Since the climate in Southern California is warmer, it is suggested to select windows with both coatings and a low solar heat gain factor to reduce heat gain. By using the Plant Energy Profiler, we estimate the current HVAC electricity usage to be 222,881 kWh/yr. It is estimated that heat loss through windows is responsible for 25-30% of heating and cooling costs. We will conservatively estimate savings of 15%.

Anticipated Savings

The estimated energy savings, ES, by replacing the current windows with triple glazed windows could be determined from the following relation:

$$ES = C \times M$$

where

C = estimated current net energy consumption, 222,881 kWh / yr

M = modified net energy consumption reduction, 15%

Thus, the energy savings, ES, for replacing all windows is estimated to be:

ES = 222881 x 0.15

ES = 33,432 kWh/yr

The annual cost savings, CS, for this recommendation are estimated to be:

CS = ES x (effective electricity energy cost)

CS = 33,432 kWhr/yr x ($0.24361/kWh)

CS = $8,144/yr

Implementation Cost

The implementation cost for this measure is estimated to the cost and installation of new triple glazed windows. There are a total of 77 windows of varying sizes throughout the building. The implementation cost is estimated to be $30 per square foot of window with an installation cost of $100 to $400 per window depending on the size, for a total of $15,610. Thus, the cost savings of $8,144/yr will have a payback of 1.92 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.

- 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.

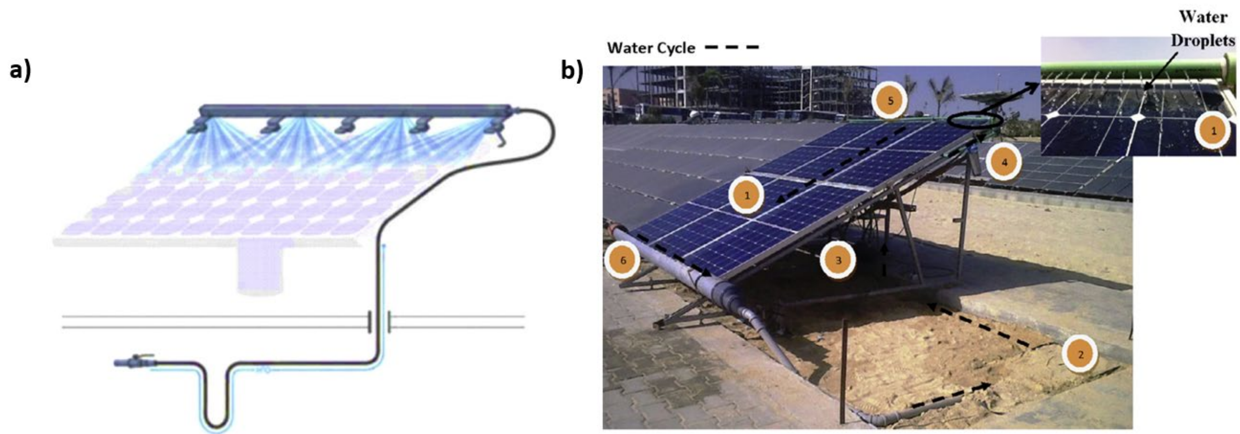


Figure 1. Water spraying system a) diagram taken from Dwivedi et al. [4] and b) experimental setup taken from Moharram et al. [5].

  - 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°C. 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.

- Replace Natural Gas Boilers with Electric Boilers
  - Replacing natural gas-powered equipment, such as boilers, with electric equipment can reduce greenhouse gas emissions and lower carbon footprint. Electric boilers have a higher efficiency associated with them than natural gas boilers. The current system is estimated to be around 80% efficient, while a new electric boiler can be between 95 and 100% efficient.

- Replace Water Heaters with Heat Pump Water Heaters
  - Heat pump water heaters are found to be at least 300% more energy efficient than natural gas water heaters. Heat pump water heater energy usage is calculated by one unit of electricity in and 3 units of energy out. Additionally, these modern heat pump water heaters can be programmed to heat water during off-peak night hours, that would provide additional savings.

- High Efficiency Pool Pumps
  - It is recommended to install high efficiency variable speed pool pumps. Variable speed high performance pool pumps offer energy savings up to 90% compared to traditional

pumps. Many have multiple programmable speed settings and built-in timers to ensure optimal efficiency.

- Other Additional Items
  - Installing and using a smart building energy management system that ties in both HVAC and lighting
  - Photosensors in gym/dining rooms and other areas with great natural light
  - Replacing diesel generator with fuel cell or natural gas/hydrogen blend
  - Carports with solar/EV charging
  - Turn pilot lights off on stove when not in use
  - Switches to turn off gym equipment when not in use

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 Process: High Risk Technology: Low Risk		Overall Risk: Medium	

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 Tool