CONSULTANT REPORT

BERKELEY UNIFIED SCHOOL DISTRICT

Berkeley High School* and Cragmont Elementary School:

Energy Efficiency Measures and Solar Photovoltaic Generation

*G and H buildings, Donahue Gym, and Jackets Pool only

Prepared for: California Energy Commission
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PREFACE

This study was prepared as a result of the Berkeley Unified School District's request for assistance under the Bright Schools Program. This California Energy Commission (Energy Commission or Commission) program assists K-12 schools in identifying projects that can cut energy use and cost in existing and planned facilities. Once the projects are identified, the program can provide assistance with implementing the recommendations. Financial assistance for the implementation of recommendations may also be available through the Energy Commission's Energy Efficiency Financing Program, which requires a separate application. The Commission's zero or low interest loans provide competitive financing and are structured so that the estimated project savings are the basis for the loan repayments.

This study was conducted for the Commission by Digital Energy, Inc., under the direction of Jairam Agaram, P.E. The contract assignment was directed and managed with the assistance of Brian Samuelson of the Commission. Digital Energy, Inc. and the Energy Commission appreciate the assistance offered by Timothy White and all other District personnel during the study efforts.

ABSTRACT

This report presents the evaluation of energy efficiency measures that was conducted in April 2015 for the Berkeley Unified School District (District) under the Bright Schools Program. The focus of the effort was on evaluating the following measures:

1. Solar photovoltaic project at Berkeley High School Donahue Gym
2. Solar photovoltaic project at Cragmont Elementary School
3. Motorized pool covers for the Jackets Pool at Berkeley High School
4. Variable speed fans for the air handlers on the G and H buildings at Berkeley High School
5. Other energy efficiency projects that can help with funding under Proposition 39

This report discusses the results of the energy audit and provides information on the next steps for project implementation.

Projects recommended include:

- LED lighting for Jackets Pool
- Energy management system expansion to Jackets Pool HVAC
- Variable speed drive for pool pump
- Variable frequency drives for the air handlers for G and H buildings
- Solar photovoltaic generation for Cragmont Elementary School and Berkeley High School

The Saving to Investment Ration (SIR) for these bundled recommended projects is 1.29 and simple payback is 11.6 years with incentives.

Other projects were analyzed but not recommended due to their low SIR. These projects include daylighting controls to interior lighting fixtures and new variable air volume handlers.

TABLE OF CONTENTS

Sections

Executive Summary 1

1 Facility Description 7

2 Existing Energy Use 12

3 Energy Using Systems 19

4 Energy Project Summaries 25

5 Grants, Incentives, and Rebates 57

Appendices

A. Baseline Energy Use, Sample Energy Bills, and Current Rate Schedules

B. Energy Balance

C. EEM Measure Calculations

D. Weather Data

E. Cut Sheets and Vendor Cost Quote Requirements

F. Time of Use Electricity Rate and Natural Gas Rate Simulation

G. Photographs from Site Visits

LIST OF TABLES

Table E.1 Recommended Energy Efficiency Measures (EEMs) 3
Table E.2 EEMs Recommended During Future Modernization (Long Payback Periods) 4
Table E.3 Recommended EEMs – Berkeley High School 5
Table E.4 Recommended EEMs – Cragmont Elementary School 6
Table 1.1 Typical Bell Schedules per School 11
Table 2.1 Electricity Use Summary: Entire Schools 12
Table 2.2 Natural gas Use Summary: Entire Schools 12
Table 2.3 Electricity Energy Balance Summary: All Audited Facilities 16
Table 2.4 Natural Gas Energy Balance Summary: All Audited Facilities 17
Table 4.1 Comparison of baseline, relamped, and reballasted 4-foot linear fixtures 30
Table 4.2 IES Lighting Illumination Guidelines 31
Table 4.3 Analysis summary of proposed Lighting Project L-1 32
Table 4.4 Analysis summary of proposed Lighting Project L-1alt 34
Table 4.5 Summary of Proposed LED Fixtures to Replace Metal Halide Fixtures 35
Table 4.6 Analysis summary of proposed Lighting Project L-2 36
Table 4.7 Analysis summary of proposed Lighting Project L-3 38
Table 4.8 Analysis summary of proposed Mechanical Project M-1 43
Table 4.9 Analysis summary of proposed Mechanical Project M-2 46
Table 4.10 Analysis summary of proposed Mechanical Project M-3 50
Table 4.11 Analysis summary of proposed Mechanical Project M-3alt 53
Table 4.12 Analysis summary of proposed Solar PV Project PV-1 56
Table 5.1 Customized retrofit program rebates by category 58

LIST OF FIGURES

Figure 1.1 - General vicinity map of subject District facilities 7
Figure 2.1A – Cragmont Elementary School Electricity Use 13
Figure 2.1B --Berkeley High School Electricity Use 14
Figure 2.2A – Cragmont Elementary School Natural Gas Fuel Use 15
Figure 2.2B – Berkeley High School Natural Gas Fuel Use 15
Figure 2.3 - Electricity Usage Breakdown - All Audited Facilities 17
Figure 2.4 – Natural Gas Usage Breakdown - All Audited Facilities 18

Executive Summary

A. Focus and Scope of the Evaluation

During April 2015, energy efficiency opportunities were evaluated for the Berkeley Unified School District (District) under the Bright Schools Program. The focus of the evaluation was on the following:

1. Solar photovoltaic project at Berkeley High School Donahue Gym
2. Solar photovoltaic project at Cragmont Elementary School
3. Motorized pool covers for the Jackets Pool at Berkeley High School
4. Variable speed fans for the air handlers on the G and H buildings at Berkeley High School
5. Other energy efficiency projects that may help the District qualify for funding under Proposition 39

This report discusses the results of the evaluation and provides information on project implementation.

B. Annual Energy Use and Cost

During a recent 12 month period, Berkeley High School (all of the school) and Cragmont Elementary School together used 2,243,213 kilowatt-hours (kWh) (3.74 kWh per square foot) of electricity and 133,276 Therms (0.22 Therms per square foot) of natural gas. During this period, the District spent $325,556 for electricity and $116,095 for natural gas. The cost of electricity and natural gas during this period averaged $0.145 per kWh and $0.871 per Therm, respectively. Based on a combined area of 600,000 square feet and combined energy cost of $441,651 the average energy cost at the two schools combined was $0.74 per square foot per year.

C. Project Recommendations

The report identifies several projects that can reduce the District's overall energy use and cost. If implemented, these projects could cut overall energy cost by 28 percent or an estimated $122,703 per year. These measures would require an investment of about $1,492,778 and could qualify for utility incentives of $69,176, resulting in net simple payback of 11.6 years which is a SIR of 1.29. Table E.1 lists the recommendations and Section 4 provides detailed information on all projects. Section 5 provides information on possible funding with grants and incentives from Proposition 39 funds through the Energy Commission and incentives from PG&E.

D. Greenhouse Gas Reduction

Greenhouse gas emissions are those greenhouse gases that allow sunlight to enter the atmosphere freely and contribute to the greenhouse effect, which many believe contributes to global warming. One of the primary greenhouse gases is carbon dioxide emissions (CO2). Approximately 0.69 lbs. of CO2 (greenhouse gas) are released in the production of 1 kilowatt-hour (kWh) of electricity.[1] Also, about 11.7 pounds of CO2 are released for each Therm of natural gas consumed. Based on these indices, 798,574 pounds of CO2 greenhouse gas emissions can be saved annually if all recommended measures are implemented. This is equivalent to removing 76 passenger cars from the road for one year.

2. Source: http://www.epa.gov/cleanenergy/energy-resources/calculator.html.

Project Summary Table

Table E.1 Recommended Energy Efficiency Measures (EEMs)

Project #	Project Description	Peak Demand Savings (kW)	Annual Electricity Savings (kWh)	Annual Gas Savings (Therms)	Annual CO2 Savings / Mitigation (Pounds)	Project Cost Estimate ($)	Annual Cost Savings ($)	Payback Period without Incentive (years)	Estimated Incentive ($)	Project Costs w/ Incentive ($)	Payback Period with Incentive (years)	Saving to Investment Ratio (SIR)
L-1	Replace 32-watt T8 lamps with 28-watt T8 lamps	34.2	61,486	0	42,425	$90,454	$10,394	8.7	$10,043	$80,411	7.7	2.11
L-2	New LED floodlights for Jackets Pool at Berkeley High School	16.1	60,950	0	42,056	$133,028	$10,042	13.2	$7,295	$125,733	12.5	1.39
M-1	EMS upgrade--Jackets Pool covers and HVAC	0	190,374	20,787	374,567	$340,784	$32,307	10.5	$36,017	$304,767	9.4	1.78
M-2	EMS upgrade--Jackets Pool poolwater pump	0	47,562	0	32,818	$31,832	$4,518	7.0	$3,805	$28,027	6.2	2.57
M-3	EMS upgrade--VFD's for air handlers for G and H buildings at Berkeley High School	0	150,205	0	103,641	$140,956	$14,269	9.9	$12,016	$128,939	9.0	1.84
PV-1	Solar PV at Cragmont Elementary School	78.6	124,400	0	85,836	$305,990	$23,138	13.2	$0	$305,990	13.2	0.99
PV-1	Solar PV on Donahue Gym at Berkeley High School	115.5	169,900	0	117,231	$449,735	$28,034	16.0	$0	$449,735	16.0	0.76
Total (All Recommended Measures):		**244.3**	**804,877**	**20,787**	**798,574**	**$1,492,778**	**$122,703**	**12.2**	**$69,176**	**$1,423,602**	**11.6**	**1.29**

Table E.2 EEMs Recommended During Future Modernization (Long Payback Periods)

Project #	Project Description	Peak Demand Savings (kW)	Annual Electricity Savings (kWh)	Annual Gas Savings (Therms)	Annual CO2 Savings / Mitigation (Pounds)	Project Cost Estimate ($)	Annual Cost Savings ($)	Payback Period without Incentive (years)	Estimated Incentive ($)	Project Costs w/ Incentive ($)	Payback Period with Incentive (years)	Saving to Investment Ratio (SIR)
L-1Alt	Replace 32-watt T8 lamps with LED tubes	86.456	155,621	0	107,378	$266,751	26407.8	10.1	$25,418	$241,333	9.1	1.82
L-3	Add daylight controls to interior lighting fixtures serving most classrooms in G and H buildings at Berkeley High School	0.0	12,891	0	8,895	$75,887	$1,218	62.3	$1,031	$74,856	61.4	0.27
M-3Alt	New Variable Air Volume air handlers	91.8	228,552	0	157,701	$985,995	$37,654	26.2	$32,060	$953,935	25.3	0.29
Total:		**178.3**	**397,063**	**0**	**273,974**	**$1,328,634**	**$65,281**	**20.4**	**$58,510**	**$1,270,124**	**19.5**	**0.58**

Table E.3 Recommended EEMs – Berkeley High School

Project #	Project Description	Peak Demand Savings (kW)	Annual Electricity Savings (kWh)	Annual Gas Savings (Therms)	Annual CO2 Savings / Mitigation (Pounds)	Project Cost Estimate ($)	Annual Cost Savings ($)	Payback Period without Incentive (years)	Estimated Incentive ($)	Project Costs w/ Incentive ($)	Payback Period with Incentive (years)	Saving to Investment Ratio (SIR)
L-1	Replace 32-watt T8 lamps with 28-watt T8 lamps	27.2	48,953	0	33,777	$69,895	$8,065	8.7	$7,996	$61,899	7.7	2.13
L-2	New LED floodlights for Jackets Pool at Berkeley High School	16.1	60,950	0	42,056	$133,028	$10,042	13.2	$7,295	$125,733	12.5	1.39
M-1	EMS upgrade--Jackets Pool covers and HVAC	--	190,374	20,787	374,567	$340,784	$32,307	10.5	$36,017	$304,767	9.4	1.78
M-2	EMS upgrade--Jackets Pool poolwater pump	--	47,562	0	32,818	$31,832	$4,518	7.0	$3,805	$28,027	6.2	2.57
M-3	EMS upgrade--VFD's for air handlers for G and H buildings at Berkeley High School	--	150,205	0	103,641	$140,956	$14,269	9.9	$12,016	$128,939	9.0	1.84
PV-1	Solar PV on Donahue Gym at Berkeley High School	115.5	169,900	0	117,231	$449,735	$28,034	16.0	$0	$449,735	16.0	0.76
Total (All Recommended Measures):		**158.8**	**667,943**	**20,787**	**704,090**	**$1,166,229**	**$97,236**	**12.0**	**$67,129**	**$1,099,100**	**11.3**	**1.36**

Table E.4 Recommended EEMs – Cragmont Elementary School

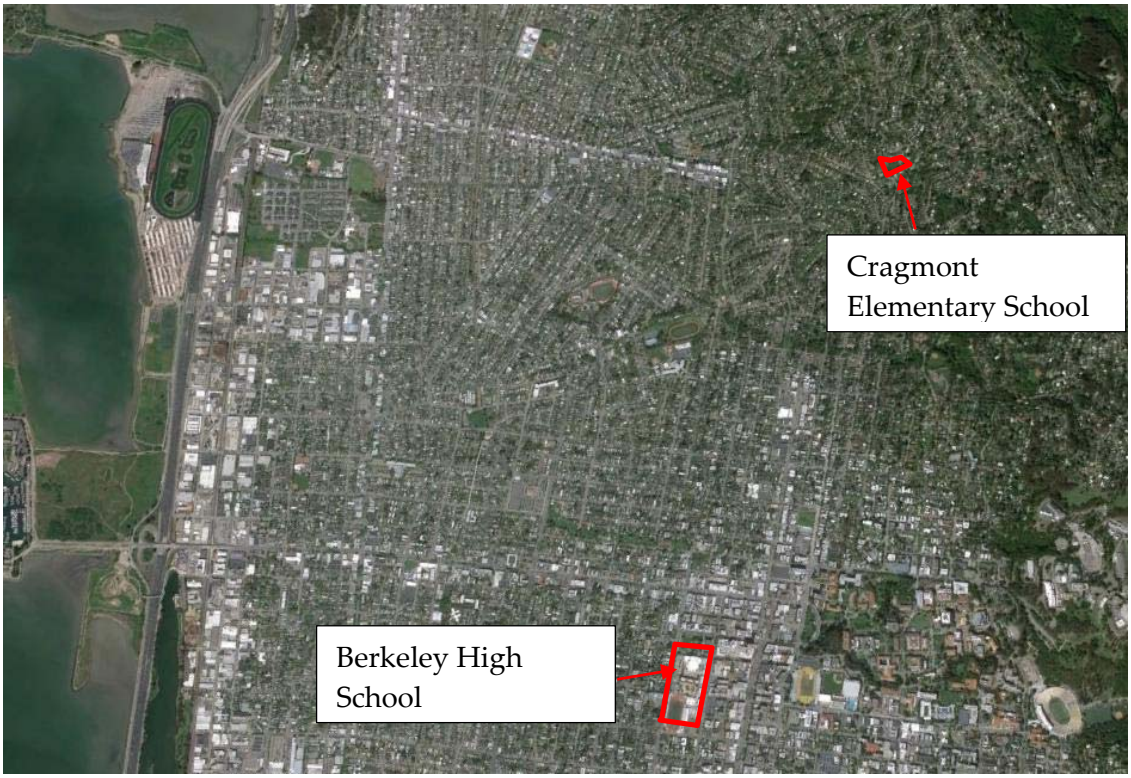
Project #	Project Description	Peak Demand Savings (kW)	Annual Electricity Savings (kWh)	Annual Gas Savings (Therms)	Annual CO2 Savings / Mitigation (Pounds)	Project Cost Estimate ($)	Annual Cost Savings ($)	Payback Period without Incentive (years)	Estimated Incentive ($)	Project Costs w/ Incentive ($)	Payback Period with Incentive (years)	Saving to Investment Ratio (SIR)
L-1	Replace 32-watt T8 lamps with 28-watt T8 lamps	7.0	12,533	0	8,648	$20,559	$2,329	8.8	$2,047	$18,512	7.9	2.06
PV-1	Solar PV at Cragmont Elementary School	78.6	124,400	0	85,836	$305,990	$23,138	13.2	0	$305,990	13.2	0.99
Total (All Recommended Measures):		**85.5**	**136,933**	**0**	**94,484**	**$326,549**	**$25,468**	**12.8**	**$2,047**	**$324,502**	**12.7**	**1.05**

1 Facility Description

Background

The Berkeley Unified School District is located in Berkeley, Alameda County. The District serves approximately 10,442 students in three preschools, eleven elementary schools, three middle schools, one comprehensive high school, one continuation high school, and one adult school. This study focuses on (a) Cragmont Elementary School and (b) a portion of Berkeley High School. A map of the facilities is below:

Figure 1.1 --General Vicinity Map of Subject District facilities



Site Description

Cragmont Elementary School

With an enrollment of 441 students, Cragmont Elementary School serves students in grades K through 5.

Figure 1.2 –Site map of Cragmont Elementary School

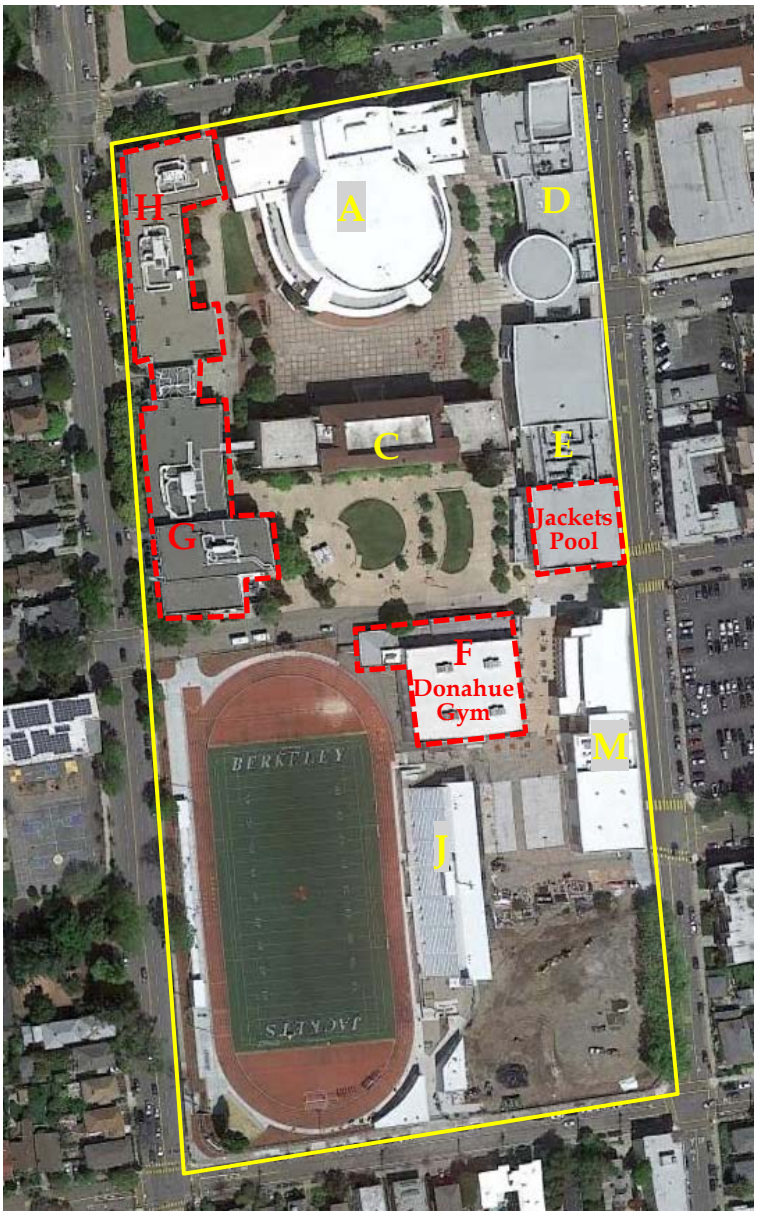
The school's modernization was completed in 1999, replacing buildings that dated back to 1926. The school covers over three acres of hillside and has 20 classrooms on two

stories plus offices, library, and multi-purpose room, all in permanent buildings. It has a total of 50,000 square feet of floor space.

Berkeley High School

With 3,182 students, Berkeley High School serves grades 9 through 12.

Figure 1.3 –Site map of Berkeley High School



The school covers a large block in downtown Berkeley and has a total of 550,000 square feet of floor space. Its buildings (all permanent) include:

- A building (theaters and classrooms) built 1949
- C building (classrooms) built 1949
- D and E buildings built in 2004
- F building (Donahue gym) built in 1979
- G and H classroom buildings built in 1939
- J and M buildings (stadium, PE, gym) built in 2014

This study includes only a portion of Berkeley High. The areas included are:

Donahue Gym (F Building)	18,000 square feet
Jackets Pool (inside E Building)	8,000 square feet
G and H Buildings	122,000 square feet

These areas are outlined in dashed red lines on the site map of the school in Figure 1.3.

Operating Schedules

Both schools operate on a traditional academic calendar (Appendix F) with 180 schooldays a year. The first day of school is typically in the last week of August and the last day is in the middle of June.

- Custodial operations at both Cragmont Elementary School and Berkeley High School typically start at 6 a.m. and end at 10 p.m.
- Athletic events, public performances in the theaters, after-school and summer programs, and academic testing extend operations in some areas.
- Although teachers generally stay one or two hours after the end of the last class period, facilities like administrative offices, corridors, and restrooms operate for longer periods.

Table 1.1 summarizes the bell schedules for each school. Note that building operating hours are not necessarily representative of actual room usage.

Table 1.1 Typical Bell Schedules per School

Facility	Year Built	Area (Sq. Ft.)	Operating Schedule [1]	Working Days per Year[2]
Cragmont E.S.	1999	50,000	9 a.m. – 3:10 p.m.	180
Berkeley H.S.	1920-2014	550,000	8:30 a.m. - 3:30 p.m.	180

Local Weather Statistics

Weather data statistics for Berkeley, California, indicate that the region has 122 annual cooling degree-days and 3012 annual heating degree-days with respect to a base temperature of 65°F. Extremes recorded at the weather station show that temperatures have reached as high as 107°F in the summer and as low of 25°F in the winter. The average maximum temperature in September is 71.8°F, and the average minimum temperature in January is 42.7°F. More weather statistics for the region are shown in Appendix D[3].

1. Representative of bell schedules. Berkeley High has before and after-school periods in its bell schedule that are not included because they are used for a limited number of classes and after-school activities. Cragmont Elementary has early dismissal on Wednesdays. Note that additional hours before and after are probable for teachers and administrative staff.

2. Data gathered from the District's 2014-2015 K-12 Calendars (see Appendix F).

3. Cooling Degree Day units are computed as the difference between the daily average temperature and the base temperature. (Daily Ave. Temp. - Base Temp.) One unit is accumulated for each degree Fahrenheit the average temperature is above the base temperature. Negative numbers are discarded. Example: If the day's high temperature was 95 and the low temperature was 51, the base 60 heating degree day units is ((95 + 51) / 2) - 60 = 13. This is done for each day of the month and summed. Heating Degree Day units are computed as the difference between the base temperature and the daily average temperature. (Base Temp. - Daily Ave. Temp.) One unit is accumulated for each degree Fahrenheit the average temperature is below the base temperature. Negative numbers are discarded. Example: If the day's high temperature was 65 and the low temperature was 31, the base 50 heating degree day units is 50 - ((65 + 31) / 2) = 2. This is done for each day of the month and summed.

2 Existing Energy Use

Site Energy Usage

Energy records for the District show that during a recent 12-month period (May 2013 through April 2014), Berkeley High School (entire school) and Cragmont Elementary School together used 2,243,213 kWh of electricity and 133,276 Therms of natural gas. Cost of electricity and natural gas during this period averaged $0.145 per kWh and $0.871 per Therm, respectively. The combined energy cost of $441,651 is equivalent to a unit cost index of $0.74 per square foot. Electricity and natural gas delivery are purchased from PG&E and natural gas (commodity) is purchased from School Project for Utility Rate Reduction (SPURR). Existing rate schedules include A6, A10, and E19 Time-of-Use for electricity and GNR1 for gas. The overall energy costs and usage indices are summarized below in Tables 2.1 and 2. 2. Refer to Appendix A for detailed historical energy use data.

Table 2.1 Electricity Use Summary: Entire Schools

School	GSF	Rate Schedule	Electricity (kWh)	Cost ($)	kWh/ GSF	$/GSF	Site kBtu/GSF	Rate ($/kWh)
Cragmont Elementary	50,000	HA10S	170,682	$32,281	3.41	$0.646	11.6	$0.189
Berkeley High School	550,000	E19SX, A10S, HA6	2,072,531	$293,275	3.77	$0.533	12.9	$0.142
Total	**600,000**	**-**	**2,243,213**	**$325,556**	**3.74**	**$0.543**	**12.8**	**$0.145**

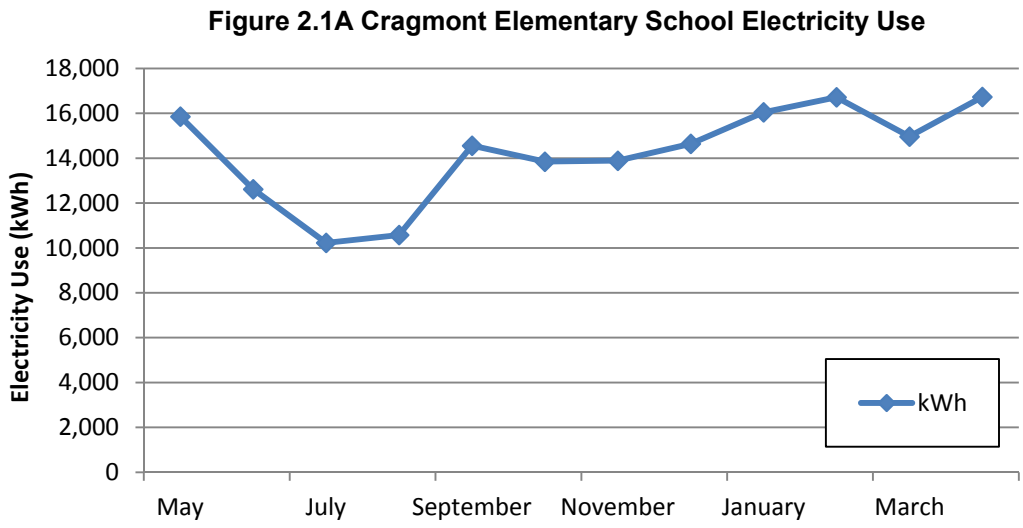
Table 2.2 Natural gas Use Summary: Entire Schools

School	GSF	Rate Schedule	Natural Gas (Therms)	Cost ($)	Therm/ GSF	$/GSF	Site kBtu/GSF	Rate ($/Therm)
Cragmont Elementary	50,000	GNR1	5,870	$7,359	0.12	$0.147	1.2	$1.254
Berkeley High School	550,000	GNR1	133,276	$108,736	0.24	$0.198	2.4	$0.816
Total	600,000	-	133,276	$116,095	0.22	$0.193	20.5	$0.871

Energy Use Patterns

Figures 2.1A and 2.1B illustrate the seasonal variation in the use of electricity for Cragmont Elementary and Berkeley High School. Figures 2.2A and 2.2B illustrate the

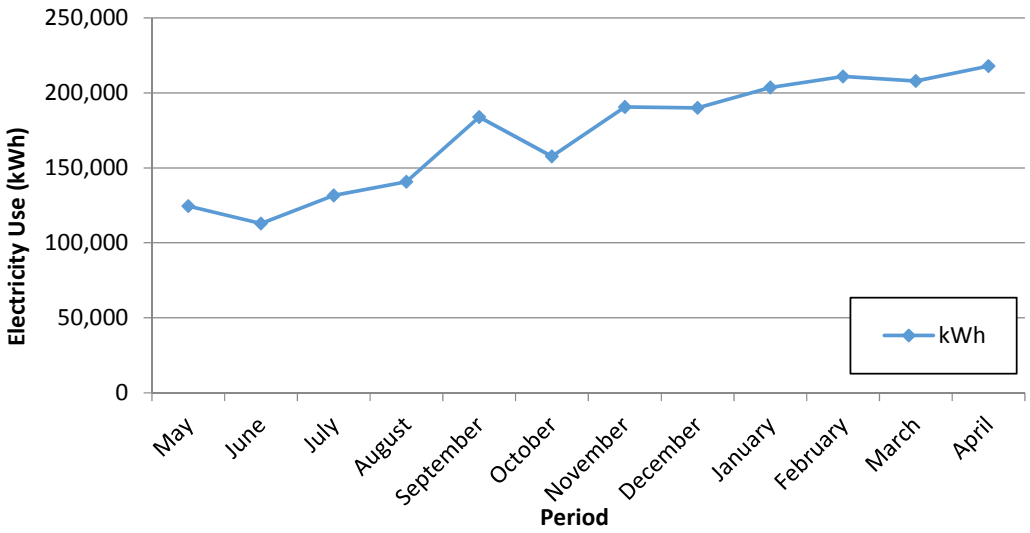
seasonal variation in the use of natural gas at the two schools. Notes are provided below the figures with respect to observations made.



Trends and Observations

- Usage is characteristically lower during summer months while school is not in session, and also dips due to the winter break.
- Highest usage months are January, February, April, and May, due to extra operation of heating unit fan and pump motors.

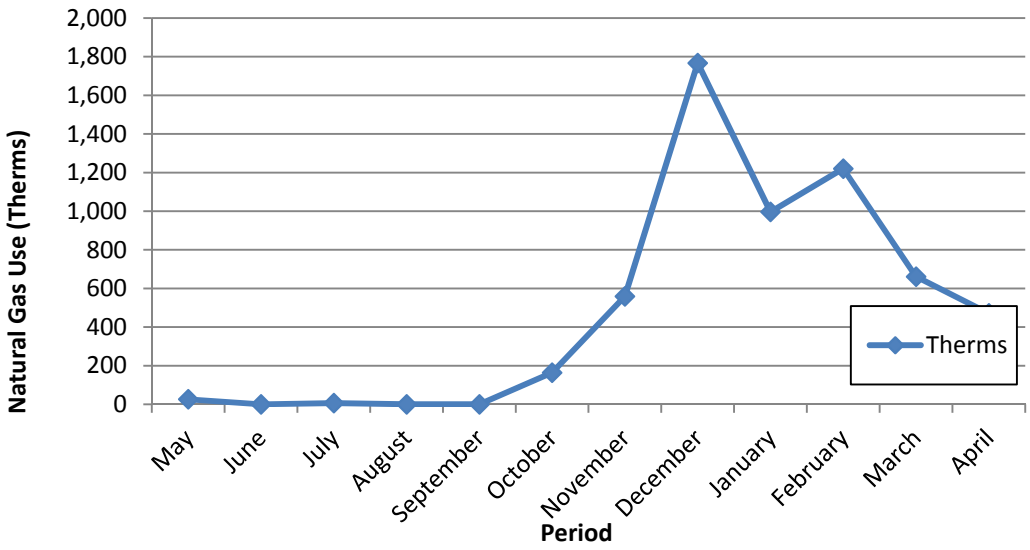
Figure 2.1B Berkeley High School Electricity Use



Trends and Observations

- Usage is lower in summer when school is not in session.
- Highest usage is January – April due to extra operation of electric heaters and heating unit fans.
- September usage shows spike, which may be due to operation of air conditioning units serving the administration building (D building).
- Usage is growing during this period, due to completion of J and M buildings.

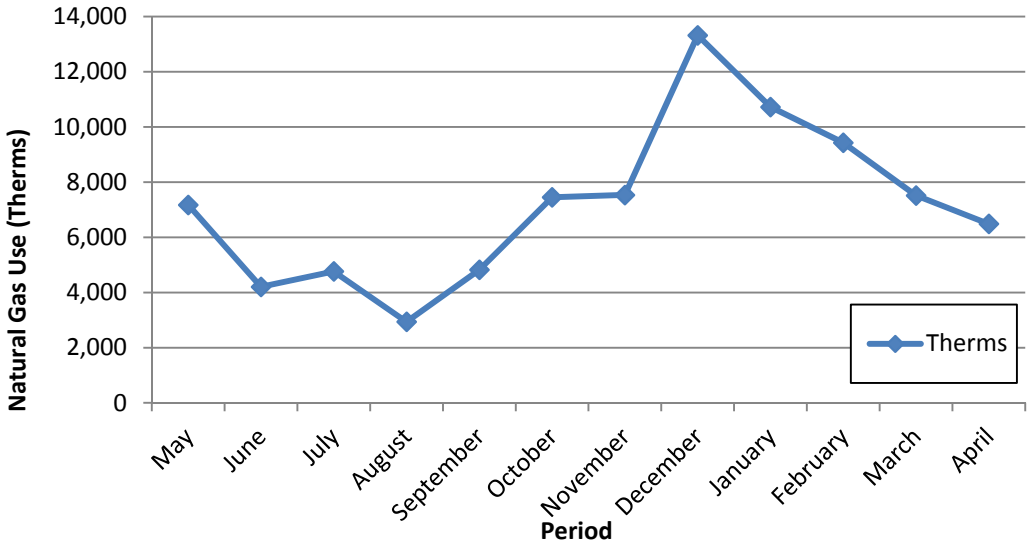
Figure 2.2A Cragmont Elementary School - Natural Gas Fuel Use



Trends and Observations

- Natural gas use peaks in January when heating demand is the highest.
- Almost no natural gas is used May to September due to summer break (June – August), mild weather, and absence of natural gas uses other than space heating.

Figure 2.2B Berkeley High School: Natural Gas Fuel Use



Trends and Observations

- Natural gas use peaks in December when demand for space heating is at a maximum.
- Usage is lowest in August when there is little demand for heating.
- Usage during summer break (June – August) is predominantly for swimming pool heating, plus summer athletic programs (domestic hot water for showers).

Energy Balance

Based on the analysis of lighting and HVAC equipment, and the best estimate of operating hours and efficiency ratings of the various systems, a breakdown of energy use was calculated and is presented in Appendix B. The energy balance was prepared for all of Cragmont Elementary School and for G and H buildings, Donahue Gym, and the Jackets Pool at Berkeley High School. A summary of the electricity and natural gas balances are shown in Tables 2.3 and 2.4, respectively. Graphical representations of the same are shown in Figures 2.3 and 2.4.

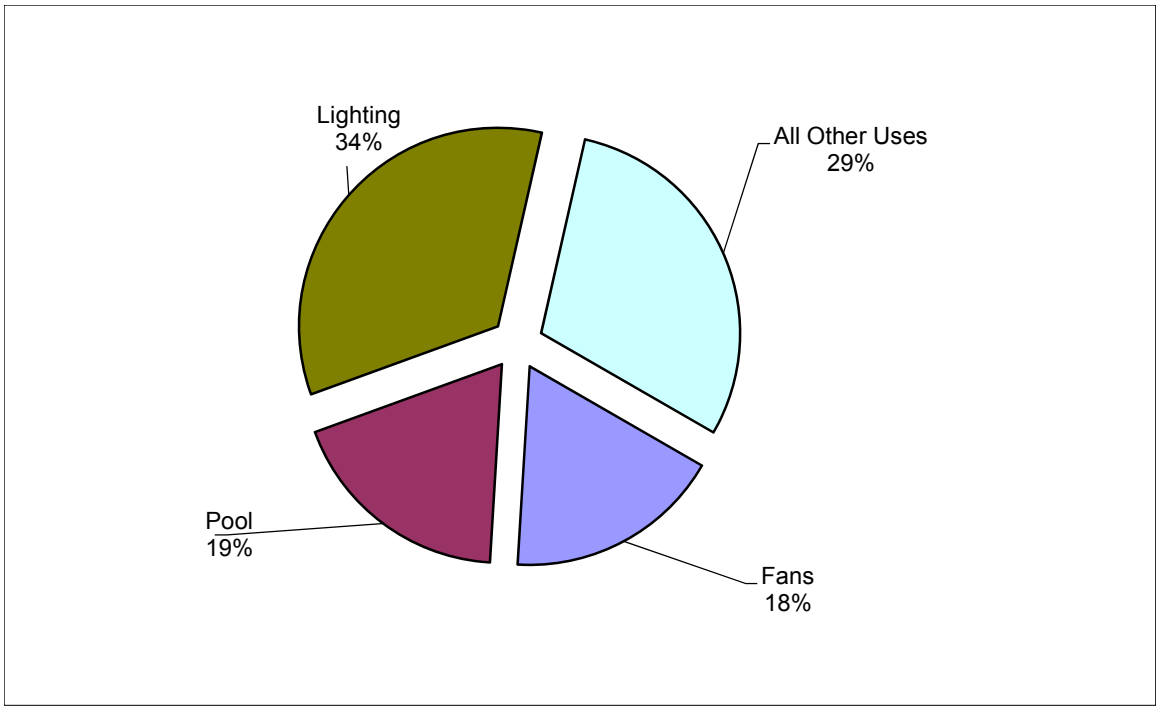
Electricity

Table 2.3 Electricity Energy Balance Summary: All Audited Facilities

End Use	Fans	Pool	Lighting	All Other Uses	TOTAL kWh
Cragmont Elementary School	23,464		91,400	55,818	**170,682**
% of Total	*14%*	*0%*	*53%*	*33%*	***100%***
Berkeley High School	372,065	414,545	673,475	612,447	**2,072,531**
% of Total	*18%*	*20%*	*32%*	*30%*	***100%***
TOTAL	**395,529**	**414,545**	**764,875**	**668,265**	**2,243,213**
% of Total	*18%*	*19%*	*34%*	*29%*	***100%***

Notes
"Pool" use includes dehumidifier and circulating pump; pool room lighting is included under "Lighting".
"All Others" includes office equipment (e.g., computers, printers, copiers), domestic water heaters, kitchen appliances, plug loads, and miscellaneous equipment not accounted for.

Figure 2.3 Electricity Usage Breakdown: All Audited Facilities



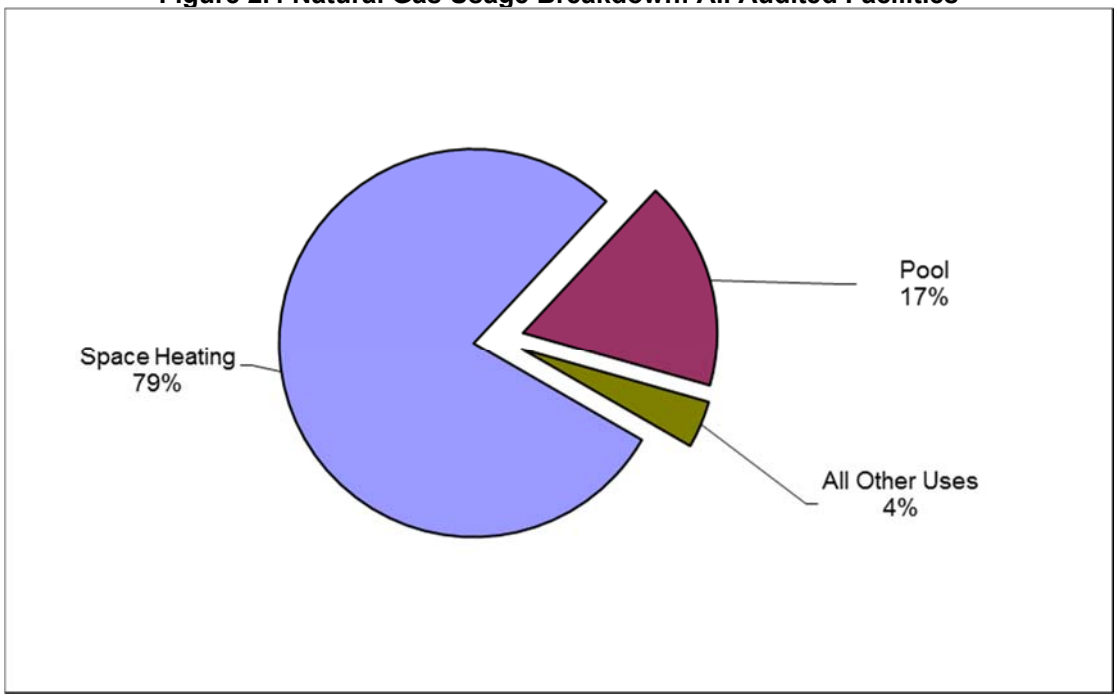
Natural gas

Table 2.4 Natural Gas Energy Balance Summary: All Audited Facilities

End Use	Space Heating	Pool	All Other Uses	TOTAL Therms
Cragmont Elementary School	5,870			**5,870**
% of Total	*100%*	*0%*	*0%*	***100%***
Berkeley High School	103,524	24,303	5,449	**133,276**
% of Total	*78%*	*18%*	*4%*	***100%***
TOTAL	**109,394**	**24,303**	**5,449**	**139,146**
% of Total	*79%*	*17%*	*4%*	***100%***

Notes
"Pool" use includes use in dehumidifier and pool heater.
"All Others" includes domestic hot water & kitchen equipment

Figure 2.4 Natural Gas Usage Breakdown: All Audited Facilities



3 Energy Using Systems

Lighting Systems

District facility lighting includes T8 linear fluorescent fixtures and compact fluorescents powered by electronic ballasts as well as high intensity discharge (HID) fixtures. Lighting controls are by wall switches, occupancy sensors, and lighting control panels with photocell sensors and programmable time clocks. The District recently retrofitted its lighting with high efficiency lamps, ballasts, and lighting controls.

The following are additional notes and observations with respect to lighting-systems at each facility:

Cragmont Elementary School

Lighting includes linear fluorescent fixtures with four foot T8 lamps and electronic ballasts in the classrooms, as well as pendant T5HO fluorescent fixtures in the multipurpose room and compact fluorescents powered by electronic ballasts in hallways and pendant fixtures in the library. Exterior lighting includes recessed downlights with compact fluorescent lamps on electronic ballasts and low-wattage metal halide floodlights and downlights.

The lighting is controlled by programmable lighting control panels plus occupancy sensors and wall switches.

All of the rooms have large windows that can provide light.

Berkeley High School—Donahue Gym

Donahue Gym is lit by 42 pendant T5HO fluorescent fixtures that are controlled by circuit breakers. The lockers, lobby, and restroom are lit with linear fluorescent fixtures with four foot T8 lamps and electronic ballasts. The lighting in the locker rooms and restrooms is slated for replacement with new LED fixtures as part of the gym modernization project. Exterior lighting includes wall-mounted jar type fixtures with screw-in compact fluorescent converters and recessed fixtures with compact fluorescent lamps.

Lighting in the main room of the gym is controlled by circuit breakers only. Lighting in the restrooms and locker rooms is controlled by single-circuit keyswitches that will be replaced with occupancy sensors and bi-level keyswitches.

The only windows are in the lobby and some restrooms.

Berkeley High School—Jackets Pool

The pool room has 32 floodlights with 1,000-watt metal halide lamps, as well as 12 downlights with 42-watt compact fluorescents powered by electronic ballasts. The floodlights are pointed upwards at the ceiling to provide indirect light. The swimming pool has underwater light fixtures, but they are not functional.

The floodlights and downlights are controlled by a programmable lighting control panel with manual override switches.

The pool room has extensive windows on the east, south, and west sides that provide large amounts of daylight.

Berkeley High School—G and H Buildings

These classroom buildings are predominantly lit by fluorescent fixtures with T8 lamps powered by electronic ballasts. Most of the fixtures in the classrooms are row-mounted pendant indirect/direct fixtures with four-foot tubes. There are also some recessed troffers in the areas of the classrooms with lower ceilings (under the heating and ventilating ducts and coils), most of which have four-foot tubes, but also some U-lamps in 2x2 fixtures. Hallways and restrooms have surface mounted vandal-resistant vapor tight style wraparound fixtures with four-foot T8 lamps.

Lighting in the classrooms is controlled by wall-switches and occupancy sensors. Restroom lighting is controlled by keyswitches and occupancy sensors. Hallway lights are controlled only by keyswitches, and there is only one keyswitch per floor in each building, plus one keyswitch for each stairway.

Most classrooms have large windows along one wall that provide large amounts of daylight.

Heating, Ventilation, and Air Conditioning (HVAC)

Cragmont Elementary School

This school was built in 1999 and heating and ventilation are typically provided by heating and ventilation units in the classrooms, a large air handler in the multi-purpose room, and a smaller fan-coil unit in the library. Air-conditioning is provided to only one IT area which has a small split system air conditioner.

All of the classrooms have operable sections in their windows to provide additional fresh air.

A rooftop heating boiler provides heating hot water to the space heating units. The boiler is fueled with natural gas, has atmospheric burners, and is 80 percent percent efficient. Heating hot water is circulated by a pump with a 3 horsepower (hp) motor.

The HVAC systems are controlled by an Alerton energy management system (EMS).

Berkeley High School—Jackets Pool

The pool room is dehumidified and heated by a dehumidifier mounted on the roof of the E building above the dance studio. The dehumidifier is rated to remove 182 pounds of water an hour from the pool room air. It operates continuously and its supply fan runs at constant speed, powered by a 40 hp motor. Two exhaust fans, each with a 1 hp motor, mounted on the roof of the Jackets pool room run continuously at constant speed to exhaust air from the pool room.

The dehumidifier has a 50-ton air-conditioning system to cool off a portion of the return air from the pool room to condense moisture from the air. Part of the heat rejected by the air-conditioning system's compressor is used to reheat all of the return air as well as outside air drawn into the dehumidifier. The outside air replaces the air removed from the pool room by the exhaust fans.

The dehumidifier is controlled by an internal microprocessor that is not connected to the building's energy management system. The control senses the temperature and humidity of the return air, and it a) turns on and off the dehumidifier's air-conditioning system to maintain the return air between 50 percent and 60 percent relative humidity and b) modulates the heating hot water valve to maintain the return air temperature above 81F.

Space heating for the Jackets Pool room is supplied by heating hot water from a boiler in the basement of the E building. The boiler also supplies heating hot water to the air handlers for the gym and for the dance studio and locker rooms. This boiler is fueled by natural gas, has atmospheric burners, and is about 80 percent efficient.

The Jackets Pool room has operable windows on one side, and sliding doors that can be opened if desired.

Berkeley High School—G and H Buildings

These classroom buildings are heated and ventilated by four rooftop air handlers with heat recovery and indirect evaporative cooling. The air handlers were installed in 1995 and the indirect evaporative cooling is no longer working. The air handlers were designed to supply 100 percent outside air to the classrooms. In cold weather, the units were supposed to recover about 60 percent of the heat from the return air. In warm

weather, the units were supposed to evaporatively cool the return air, and use the cooled return air in their heat exchangers to cool off the outside air before sending it to the classrooms. The air handlers have no heating coils or mechanical cooling. The supply air is ducted to the classrooms, each of which has a duct-mounted heating coil to supply additional heat as needed to maintain room temperature.

The G and H buildings have large windows with operable sections that can admit additional fresh air.

Each of the four rooftop air handlers has two exhaust fans and two supply fans. Because of the restriction created by the heat exchanger and indirect evaporative cooling pad in each unit, the fans operate against a much higher pressure differential than is typical for typical air handlers without heat recovery or indirect evaporative cooling. The four air handlers have a total of 245 hp of motors driving their supply and exhaust fans. The fan horsepower per square foot of floor space is much higher than in buildings that have air handlers with heating hot water and chilled water or direct expansion coils.

The heat exchangers in the air handlers only recover about 60 percent of the heat from the air exhausted from the building. This requires more heat from the boilers than a typical air handler that recirculates about 75 percent of the return air. When the return air is recirculated, all of the heat in the recirculated air is returned to the space. Use of 100 percent outside air is not necessary in the G and H buildings, since they contain normal classrooms without any special need for 100 percent outside air for odor control or chemical or biological hazards.

The heating hot water for the G and H buildings is supplied by boilers in the basement of the adjacent C building. These were recently installed to replace condensing boilers that failed. The boilers in the C building are fueled with natural gas and are about 85 percent efficient.

The air handlers are controlled by an energy management system that starts and stops the air handlers and controls the valves on the heating coils in the classrooms. Typical operation of the air handlers is from 6 a.m. to 4 p.m. on schooldays. The smallest of the four air handlers runs from 5 a.m. to 5 p.m. on schooldays. There is additional operation for academic testing and other events taking place after regular hours in the classrooms. The air handlers have internal controllers to provide an economizer function by bypassing exhaust air around the heat exchanger when the classrooms need cool air and the outside air is cooler than the return air. On one unit, the damper actuator for this function has failed, and the controller is erratic on all of the units.

Other District Energy Using Systems

Jackets Pool Heating

The Jackets Pool requires heating primarily to replace heat lost from evaporation. This heat is supplied by a natural gas fired pool heater in the basement of the E Building. The pool heater is an atmospheric type and is about 80 percent efficient. It is controlled by an external thermostat.

Jackets Pool Filtration and UV treatment

In addition to heating, the Jackets pool needs considerable amounts of electricity for filtration and ultraviolet (UV) treatment of the pool water. The pool's water is continuously circulated by a pump driven by a 25 hp electric motor. The pump forces water through filters in the basement and back to the pool. Along the way, chemicals are injected into the water, part of the water is diverted to the pool heater, and all of the water passes over a UV lamp for disinfection and removal of chloramines (compounds of chlorine and ammonia, responsible for most of the smell and irritation in indoor pools). The UV lamps draw about 5 kilowatts continuously.

Office Equipment

Other types of equipment that use electricity include computers, printers, and copiers. Almost every classroom has at least one computer, as do all offices. All of the offices in the audited areas have printers and copiers. Computers appear to have automatic shutdown software; very few were seen idle with the monitor on during the audit. Printers and copiers appeared to be new and Energy Star compliant.

Domestic Water Heaters

Domestic hot water (DHW) in both schools is provided by electric or natural gas fired tank-type water heaters. Cragmont Elementary has electric water heaters, including a 40 gallon tank unit in the kitchen and a 10 gallon tank unit under-sink unit. The G and H buildings and the Jackets Pool do not have water heaters, they are supplied with hot water from a water heater located in another building. The Donahue Gym has a natural gas water heater.

Kitchen

The kitchen at Cragmont Elementary School is used for heating and serving only. It has a hot food storage cart, two cabinet refrigerators, a residential refrigerator, a cabinet freezer, a beverage storage refrigerator, a milk dispenser refrigerator, an electric serving line, and an electric water heater. It has no automatic dishwasher and there is no spray valve.

The only kitchen facilities in the audited area at Berkeley High School consist of the Good Morning Café in the H building, which has three refrigerators, a gas range, an exhaust hood, a dough mixer, a washer, and a dryer. The refrigerators, gas range, washer, and dryer are all used residential appliances. There is no automatic dishwasher, and the sink has a garbage disposal but no spray valve.

4 Energy Project Summaries

Lighting

Berkeley Unified School District has converted its fluorescent light fixtures to energy-efficient T8 lamps powered by electronic ballasts, and installed occupancy sensor based controls to shut off lights when areas are vacant. There are opportunities to further increase the energy efficiency of the lighting in the areas that were audited. These opportunities have been evaluated in light of the new regulations that govern projects to modify existing lighting systems and their controls.

2013 Title 24 Non-Residential Indoor Lighting Equipment and Controls Requirement

The 2013 Building Energy Efficiency Standards are having a big impact on the way lighting and controls are used in California buildings. The most important change to the 2013 Standards (specifically Title 24, Part 6, effective July 2014), in terms of energy savings, is that many more (compared to 2008 Standards) retrofit projects (where the number of fixtures retrofitted exceeds the compliance threshold) will be required to meet the new-construction standards for lighting. Spaces in which less than 10 percent of the lighting is being changed out, or buildings in which fewer than 40 luminaries are being altered (lamps and ballasts replaced or rewiring) are exempt, but otherwise all new lighting must meet not only the lighting power density (LPD) requirements, but also most of the controls requirements (including dimming). The following discussion elaborates on which projects can be treated as "Alteration."

Lighting system alterations include alterations where an existing lighting system is modified, luminaires are replaced, or luminaires are disconnected from the circuit, removed, and reinstalled, whether in the same location or installed elsewhere.

Luminaire modification in place is not considered lighting system alteration provided the following conditions are met:

1. Replacing lamps and ballasts with like type or quantity in a manner that preserves the original luminaire listing.

2. Changing the number or type of light source in a luminaire including: socket renewal, removal or relocation of sockets or lamp holders, and/or related wiring internal to the luminaire including the addition of safety disconnection devices.

3. Changing the optical system of a luminaire in part or in whole.

4. Replacement of whole luminaires one for one in which the only electrical modification involves disconnecting the existing luminaire and reconnecting the replacement luminaire.

5. Luminaire modifications in place shall not be part of or the result of any general remodeling or renovation of the enclosed space in which they are located.

6. Luminaire modifications in place shall not cause, be the result of, or involve any changes to the panel board or branch circuit wiring, including line voltage switches, relays, contactors, dimmers, and other control devices providing power to the lighting system. ***Exception: Circuit modifications strictly limited to the addition of occupancy or vacancy sensors and class two lighting controls are permitted for luminaire modifications in place.***

Note: The following indoor lighting alterations are not required to comply with the lighting requirements in Title 24, Part 6:

1. Replacement in kind of parts of an existing luminaire that include new lamps, lamp holders, or lenses.

2. Lighting alterations directly caused by the disturbance of asbestos.

The salient features of the 2013 Standards applicable to this study (specifically, general zones with areas greater than 100 square feet and any size classrooms) are discussed below:

1. **Area Lighting Controls**: Each area enclosed by ceiling-height partitions must have an independent, manual switching or control device that is readily accessible to occupants and is located in the space. The switching or control device must provide ON and OFF functionality. ***Applicable to all interior lighting retrofits.***

2. **Multilevel Switching Controls:** This is applicable to all enclosed spaces with areas 100 square feet or larger with a connected load lighting power density exceeding 0.5 watt per square foot. The multi-level lighting control requirements allow a room to be occupied with all of the lights turned on, part of the lights

turned on, and none of the lights turned on, whether the room is occupied or not. The number of required lighting control steps varies, depending on the type of lighting technology in each installed luminaire, in accordance with Table 130.1-A of the Title 24, Part 6. For example, the linear fluorescent fixtures must have at least four steps* of control (one in each range) in the range of 100 percent, 80-85 percent, 50-70 percent, and 20-40 percent. The step switching can be done by one of the following methods: manual dimming; continuous dimming; and switching alternate lamps in each luminaire, having a minimum of four lamps per luminaire, illuminating the same area and in the same manner. ***Exceptions: Only one step switching (30 percent -70 percent) is allowed for the zones less than 100 square feet and with lighting power density equal or lower than 0.5 watt per square foot; for the classrooms with lighting power density equal to or lower than 0.7 watt per square foot; and enclosed spaces with lighting power density equal to or lower than 85 percent of the allowed lighting power density (per Area Category Method).***

3. **Automatic Shut-off Controls:** All interior lighting zones shall be able to turn OFF lighting either completely or partially depending upon the space type when space typically unoccupied. ***Complete shut off is applicable for all offices 250 square feet or less, multipurpose rooms of less than 1,000 square feet, and classrooms or conference rooms of any size. Lighting shall be controlled with occupancy sensing controls to automatically shut of all of the lighting when the room is unoccupied. Partial shut off (reduce lighting power by at least 50 percent off) is applicable to library book stack aisles, warehouse aisles, corridors, and stairwells. Exception: In corridors, stairwells, and warehouse aisles where the calculated lighting power density is 80 percent or less of the value allowed under the area category method, occupant sensing controls shall reduce the lighting power by at least 40 percent.***

4. **Automatic Daylight Controls:** This is applicable for the spaces exceeding allowed lighting power density (per Area Category Method) by 85 percent. Luminaires providing general lighting that are in or are partially in the skylit/daylit zones or primary sidelit/daylit zones shall be controlled by fully functional automatic day lighting controls. The lighting must be continuously dimmable or meet the required number of controls steps from Table 130.1-A of the Title 24, Part 6. The combined luminance from controlled lighting and daylight shall not be less than controlled lighting with no daylight. In the daylight controlled areas, when the illuminance received from the daylight is

greater than 150 of the designed illuminance received from the general lighting system at full power, the general lighting power in that daylight zone shall be reduced by a minimum of 65 percent. ***Exceptions: Not applicable for spaces using less than 0.3 watts per square foot; rooms where the total lighting power in the daylight zones is less than 120 watt; and rooms with a total glazing area less than 24 square feet***

5. **Demand Response Controls:** Lighting power in buildings larger than 10,000 square feet shall be capable of being automatically reduced in response to demand response signal; so that the building's lighting power can be lowered by a minimum of 15 percent below the total lighting power installed. ***Exception: Spaces that are non-habitable and spaces with a lighting power density of less than 0.5 watts per square foot shall not be counted toward the building's total power density. Also, not applicable for building retrofits that do not increase lighting power in the enclosed space above the pre-retrofit levels.***

Lighting Project L-1: Retrofit all existing 32-watt T8 fluorescent lamps with 28-watt T8 lamps

Project Description

Most existing fluorescent fixtures at the audited District facilities make use of standard linear T8 lamps (32-watts) and standard instant-start electronic ballasts.
This project proposes to replace lamps only (i.e., replacing 32-watt T8 linear fluorescent lamps with 28-watt T8 lamps.). In addition, it involves general cleaning of each fixture for improved lighting performance as well as replacement in kind of any broken or defective components.

Use of 28-watt T8 lamps will reduce the illumination level by up to three percent. Based on observations made during the audit, the resulting light levels should still be within the IES acceptable range (Table 4.2). In addition, the new lamps have better color rendering index (CRI) than the existing lamps. This should be an improvement in lighting quality. It is strongly emphasized that prior to a full-scale retrofit, pilot projects be done in representative areas to determine if light levels are adequate.

An alternative to this project would be to retrofit all the fixtures with new ballasts that are designed to produce about 15 percent less light than the existing fixtures. However, this would have an unacceptably long payback time because of a) the cost of the new ballasts and b) the cost of additional work to meet Title 24 guidelines. Table 4.1 below compares the efficiency and light output characteristics of 32-watt lamps on the existing type of ballasts (baseline), 28-watt lamps on the existing type of ballast, and 28-watt ballasts on reduced light output ballasts.

Table 4.1 Comparison of baseline, relamped, and reballasted 4-foot linear fixtures

	Baseline	Case A Short-Term Payback Option	Case B Long-Term Payback Option
	4-lamp fixture with 32-watt T8 lamps and normal ballast factor electronic ballast	4-lamp fixture with 28-watt T8 lamps and normal ballast factor electronic ballast	4-lamp fixture with 28-watt T8 lamps and low ballast factor electronic ballast
LAMP DATA [1]			
Lamp Watts	32	28	28
Initial Lamp Output (Lumens)	2,800	2,750	2,750
Design Lamp Output (Lumens) [2]	2,660	2,590	2,590
Lamp Lumen Maintenance (%)	95%	94%	94%
Lamp Life (Hours)	20,000	20,000	20,000
CRI	70	85	85
SYSTEM DATA			
Lamps per Fixture	4	4	4
Ballast Factor	0.88	0.88	0.77
Fixture Efficiency [3]	90%	90%	90%
Initial System Lumens	8,870	8,712	7,623
Mean System Lumens	8,427	8,205	7,179
Lumen Reduction / Increase	**-**	**3%**	**15%**
Fixture Input Power (Watts)	108	95	84
Watt Savings	-	**12%**	**22%**
Design Lamp Efficacy (Lumens/Watt)	99	109	123

[1] Data gathered from lamp and ballast manufacturers including Sylvania and General Electric

[2] At 40% Rated Life

[3] Fixture efficiency is an estimate based on typical values. Efficiency varies by fixture design, condition, etc.

Table 4.2 IES Lighting Illumination Guidelines

Space Category	Foot-Candles	Illuminance on Vert. or Horiz. Plane
General		
Restrooms	5	H
Stairways, Corridors	5	H
Conference Rooms	30	H
Offices		
Filing	50	H
Private Office	50	H
General Office with Handwritten Tasks	30	H
Lobbies, Lounges, Reception Areas	10	H
Mail Sorting	50	H
Copy Rooms	10	H
Libraries		
Reading Stacks	30	H
Book-stacks (Active)	30	V
Book-stacks (Inactive)	5	V
Circulation Desk	30	H
Audiovisual Areas	30	H
Educational Facilities		
General Classroom (Reading)	30-50	H
White Board	5	V
Chalk Board	50	V
CAD Stations Only	10	H
Mixed CAD and Paper Tasks	30-50	H
Science Laboratories	50	H
Gymnasiums (Basketball)	100	H
Gymnasiums (Social Events)	5	H
Cafeterias (Dining)	10	H
Kitchen	50	H
Industrial		
Inactive Storage	5	On Plane
Active Storage	10	On Plane
Maintenance	50	On Plane

Implementation Scope of Work

1. Remove existing lamps. Follow local, state, federal, and industry recommended guidelines associated with storage, transport, and waste disposal of lamps and ballasts.

2. Clean the existing fixtures, including all reflective surfaces inside the fixture and lens. Use an approved cleansing agent that is non-toxic. Repair or replace any damaged components including lampholders and broken, yellowed, or opaque lenses. Any damaged or clouded old lenses shall be replaced with new lenses that are a direct replacement for size, material, and thickness. Many lenses are in poor

shape, especially the hallway and restroom fixtures in the G and H buildings at Berkeley High School.

3. Install new T8 florescent lamps (28-watts).

4. Prior to a full-scale retrofit project, a pilot project should be performed to ascertain the performance of the new T8 system. The desired results are low glare, high-efficiency, and uniform distribution with foot-candle levels as recommended by IES. See Table 4.2.

Analysis Summary

The analysis shows a payback time that is close to the lamps' expected life at three hours usage per start (most of the affected light fixtures are controlled by occupancy sensors, so three hours per start is realistic). A major portion of the cost is for replacement of lenses and repairs to fixture components. The high SIR of this retrofit makes it a good option and it is recommended.

Table 4.3 Analysis summary of proposed Lighting Project L-1

Facility	# fix	kW Saved	kWh Saved	Rate ($/kWh)	Project Cost ($)	Cost Savings ($)	Payback Period without Incentive (Years)	Approx. Incentive ($)	Project Costs w/ Incentive ($)	Payback Period with Incentive (Years)
Cragmont Elementary	633	7.0	12,533	$0.186	$20,559	$2,329	8.8	$2,047	$18,512	7.9
Berkeley High	2,697	27.2	48,953	$0.165	$69,895	$8,065	8.7	$7,996	$61,899	7.7
Total	**3,330**	**34.2**	**61,486**	**$0.167**	**$90,454**	**$10,394**	**8.7**	**$10,043**	**$80,411**	**7.7**

Lighting Project L-1alt: Retrofit existing standard T8 fluorescent fixtures with LED tubes

Project Description

This project is an alternative to Lighting Project L-1, which would change out the standard T8 lamps (32-watts) to new 28-watt lamps. Instead, this measure would change out the T8 lamps to LED tubes that are designed to work with the existing ballasts inside the existing fixtures.

The advantages of the LED tubes over the 28-watt fluorescent lamps include:

1. Longer life. The T8 tubes can last about 20,000 hours, depending on how many times they are switched on and off, while the LED tubes may last about 50,000 hours (with some loss of light output, based on testing that attempts to duplicate aging effects within a shorter period than the estimated lifetime).
2. Potentially less light absorbed inside the fixture and in the ceiling. While fluorescent lamps emit light evenly in all directions—up, down, and sideways—the LED lamps are designed to emit light downward only.
3. Less electricity used. The LED tubes are typically 16-watts. They're about as efficient as a 28-watt fluorescent lamp, and they draw less electricity (so they produce less light).
4. Higher quality light. The LED's can provide better color rendition than 28-watt lamps.

The disadvantages of the LED tubes are as follows:

1. Higher, but declining costs. 28-watt fluorescent lamps typically cost about $2.00 in quantities of around 1,000, while LED tubes are being offered at $10.00 apiece in similar quantities. Prices are falling as worldwide production increases.
2. Incompatibility with some fixtures. "Parabolic reflector" fixtures often have one or more lamps placed above an opaque plastic bar which will block most of the light from an LED tube.
3. Internal electronics. LED tubes are compatible with existing ballasts because the LED tube has an electronic circuit to convert the ballast's high voltage, high frequency alternating current (AC) output to the low voltage, direct current (DC) required by LED's. The electronic circuit represents an additional point of failure, and must be disposed of properly at the end of the LED tube's life.

Implementation Scope of Work

1. Remove existing lamps. Follow local, state, federal, and industry recommended guidelines associated with storage, transport, and waste disposal of lamps.

2. Clean the existing fixtures, including all reflective surfaces inside the fixture and lens. Use an approved cleansing agent that is non-toxic. Replace any broken or defective fixture hardware such as broken lampholders and any yellowed or damaged lenses. Any damaged or clouded old lenses shall be replaced with new lenses that are a direct replacement for size, material, and thickness. Many of the lenses are in poor shape, especially in the hallways and restrooms of the G and H buildings at Berkeley High School.

3. Install new LED tubes that are compatible with existing ballasts and fixtures.

4. Prior to a full-scale retrofit project, a pilot project should be performed in a selected area to ascertain the performance of the new T8 system. The desired results are low glare, high-efficiency, and uniform distribution with foot-candle levels as recommended by IES.

Analysis Summary

The analysis shows a simple payback time that does not exceed the lifetime of the LED tubes. It does exceed the length of the warranty offered by most manufacturers. Some manufacturers offer an extended warranty of ten years. However, the warranty is only for replacement of the tubes and excludes the cost of labor to remove and replace the tubes. This project is not recommended for initial implementation but should be considered in the future due to the energy efficiency and high quality color rendition of LED lighting.

Table 4.4 Analysis summary of proposed Lighting Project L-1alt

Facility	# fix	kW Saved	kWh Saved	Rate ($/kWh)	Project Cost ($)	Cost Savings ($)	Payback Period without Incentive (Years)	Approx. Incentive ($)	Project Costs w/ Incentive ($)	Payback Period with Incentive (Years)
Cragmont Elementary	633	20.3	36,461	$0.186	$75,643	$6,776	11.2	$5,955	$69,688	10.3
Berkeley High	2,697	66.2	119,160	$0.165	$191,108	$19,632	9.7	$19,463	$171,645	8.7
Total	**3,330**	**86.5**	**155,621**	**$0.167**	**$266,751**	**$26,408**	**10.1**	**$25,418**	**$241,333**	**9.1**

Lighting Project L-2: Replace existing metal halide floodlight lighting fixtures in Jackets Pool with LED fixtures and install photocell and vacancy controls.

Project Description

The Jackets Pool room is lit by 32 1000-watt floodlights that illuminate the ceiling of the room, as shown below.

These light fixtures operate for extended hours, often while the area is vacant. During the audit, these lights were observed to be lit on an early Sunday morning as well as a Saturday afternoon. The lights are controlled by a lighting control panel with manual override switches. The lights may be left on continuously (in manual override) because the pool has after-hours activities, the controls are hard to use, and the fixtures take a long time to warm up and to restart after being shut off.

Light emitting diode (LED) fixtures offer instantaneous startup as well as efficiency and light quality that are better than metal halide. LED fixtures can be controlled with photocell and vacancy sensor based controls to restrict operation to when the spaces are occupied and light is needed.

Table 4.5 summarizes the existing fixture and the proposed LED fixture option. Also shown are the estimated savings per fixture.

Table 4.5 Summary of Proposed LED Fixtures to Replace Metal Halide Fixtures

Baseline Fixture	Baseline Watts	Proposed Fixture	Proposed Watts	Watts Saved (per Fixtures)
MH-1000W	1080	LED-567W	567	513

Because only 32 fixtures are being replaced, this project will not necessarily trigger the Title 24 requirements for a lighting system alteration. The photocell and occupancy sensor controls should nevertheless be installed to provide energy savings. If the District chooses to repair the underwater swimming pool lighting system, and convert the lights to LED, there could be Title 24 implications.

Implementation Scope of Work

1. Prior to initiating service, follow all safety precautions associated with working on metal halide (MH) fixtures.

2. Remove old MH fixtures. Follow local, state, federal, and industry recommended guidelines associated with storage, transport, and waste disposal of lamps, ballasts, and other fixture components.

3. Install new LED fixtures, occupancy sensors, photocells, powerpacks, and low-voltage wiring. Installation and wiring shall be conducted by a certified electrician. Installation shall be based on the manufacturer's recommendations.

4. The photocell control probe shall be positioned correctly and not exposed to bright light sources.

5. Installation shall be in compliance with the latest NEC and all applicable regulations.

6. Take lighting measurements before and after to confirm that the new lighting system meets or exceeds original lighting levels.

Analysis Summary

The project shows a payback time that is within the expected lifetime of the light fixtures and a high SIR. It also has non-energy benefits in the form of reduced cost for re-lamping and avoiding the eventual cost of replacing the existing ballasts and fixtures when they fail. Therefore, this project is recommended for immediate implementation.

Table 4.6 Analysis summary of proposed Lighting Project L-2

Facility	# fixtures	kW Saved	kWh Saved	Rate ($/kWh)	Project Cost ($)	Cost Savings ($)	Payback Period without Incentive (Years)	Approx. Incentive ($)	Project Costs w/ Incentive ($)	Payback Period with Incentive (Years)
Berkeley High-Jackets Pool	32	16.1	60,950	$0.165	$133,028	$10,042	13.2	$7,295	$125,733	12.5

Lighting Project L-3: Add daylight controls to interior lighting fixtures serving most classrooms in G and H buildings at Berkeley High School.

Project Description

Most of the classrooms in the G and H buildings at Berkeley High School have large windows on one wall which allow abundant daylight into the space. There is usually a row of pendant fluorescent lighting parallel to the window.

When daylight is present, an opportunity exists to shut off the lights in the row adjacent to the windows. Observations indicate that lighting fixtures generally remain on regardless of daylight presence. This project would install a photocell controller on the lighting circuit that controls the subject light fixtures.

Logic shall be that when daylight is available, the photocell sensor will switch off all fluorescent fixtures serving the area. Although it is ideal to dim the fixtures in the primary daylight area, dimming will entail retrofitting the existing ballast with the dimming ballast; which will trigger Title 24's mandated control and LPD requirements. Pictures of representative site conditions are presented below.

Usage hour savings for this project are based on assumed hour savings with implementation of daylight controls. See Appendix C for details.

Note: Per Title 24, Part 6, circuit modifications are strictly limited to the addition of occupancy or vacancy sensors and class two lighting controls to treat the project as luminaire modifications in place. Any other modification with respect to wiring or control will be treated as alteration and will trigger the mandated Title 24 controls and LPD requirements.

Implementation Scope of Work

1. Retain a lighting contractor to design and specify the lighting controller.

2. Locate the circuit or the switch-leg that energizes the lights in the subject zone.

3. The proposed controller is a stand-alone "On/Off" photocell sensor with internal logic to do all the specified tasks noted above.

4. Install the photo sensor in a suitable spot for the area that needs to be controlled.

5. One power-pack (i.e., relay) is required per photocell controlled circuit. This relay will be connected to the photocell sensor.

6. On/Off switching shall be based on pre-programmed light-level set-points. Calibrate the sensor to confirm adequacy of lighting levels that would trigger opening of the

circuit. The lights shall turn "on" when the space's light level drops below a programmable threshold (or set-point). The lights shall turn "off" when the light is above a set-point plus a 10-20 percent dead-band. This dead-band (or safety factor) will prevent the system from cycling. The controller shall also contain an adaptive delay (5 to 25 minutes) to prevent the system from cycling during a cloudy day.

7. When using a photocell in conjunction with an occupancy sensor, logic shall be that when the space is unoccupied, the lights will stay off regardless of daylight levels. When the space is occupied, the photocell will control the lights according to daylight level and set-point.

8. Installation shall be in compliance with the latest NEC and all applicable regulations.

Analysis Summary

This project shows a payback time in excess of the expected lifetime of the new equipment, and therefore it is not recommended for immediate implementation. The District may wish to consider it in planning upgrades to existing controls such as occupancy sensors that have built-in photocells or provision for attaching an external photocell.

Table 4.7 Analysis summary of proposed Lighting Project L-3

Facility	# fix	kW Saved	kWh Saved	Rate ($/kWh)	Project Cost ($)	Cost Savings ($)	Payback Period without Incentive (Years)	Approx. Incentive ($)	Project Costs w/ Incentive ($)	Payback Period with Incentive (Years)
Berkeley High	576	0.0	12,891	$0.095	$75,887	$1,218	62.3	$1,031	$74,856	61.4

Mechanical

Mechanical Project M-1: Expand and upgrade existing energy management system to automate pool covers and provide variable speed operation of the dehumidifier with heat recovery on the Jackets Pool at Berkeley High School

Project Description and Objectives

This project would consist of installing, programming and commissioning a system to ensure that:

1. The Jackets Pool can be automatically covered and uncovered, with minimum manual effort.
2. The HVAC system for the pool room, consisting of the pool room dehumidifier with its internal supply fan and two rooftop exhaust fans, will operate at minimum airflow and no outside air when:
    a. the pool room is vacant; and
    b. the pool is covered; and
    c. there is no danger of condensation on walls and windows due to high humidity.
3. The HVAC system will operate at 100 percent of its design airflow and outside air whenever needed to control humidity and to provide fresh air for pool users.
4. Any waste heat from the dehumidifier that is not needed for reheating air can be applied to pool heating.

Existing System and Background

The Jackets Pool is an indoor, 25 yard by 25 meter swimming pool that is used for swim meets and PE classes. Currently, due to budgetary problems, there are no PE classes.

Although the pool has manual pool covers, due to the budgetary problems, there is no staff available to supervise use of the manual covers. The manual covers require at least 15 minutes of time from several persons to apply to the pool and to remove from the pool, due to the obstacles (handrails) in the way, the limited deck space, and the large size of the pool. As a result of no staffing and the difficulty of use, the manual pool covers have not been used for at least two years.

Pool covers prevent almost all evaporation of water from the pool surface. Evaporation of water is the main reason why pools need to be heated. Evaporation of water from an

indoor pool raises the humidity of the air in the room. If the humidity isn't controlled, condensation on the walls and windows will lead to corrosion and mold.

The Jackets Pool has a dehumidifier and exhaust air system to control humidity in the room. The dehumidifier is basically an air handler with a 50 ton direct expansion air conditioner, a heating coil, and a supply air fan. The air handler draws air from the room, then cools it with the direct expansion[4] air conditioner to condense moisture from the air. This produces cold air, which is then reheated with waste heat from the direct expansion air conditioner. The heating coil supplies any additional heat needed to maintain the pool room at 81° °F. The heating coil receives heating hot water from the space heating hot water boiler in the basement. The supply fan, driven by a 40hp motor, pushes air into the room. The exhaust fans (two fans, each with 1 hp motor, on the roof above the pool) remove part of the air from the room, so it can be replaced with fresh air drawn into the dehumidifier. There are two exhaust fans on the roof and there is an exhaust port on the dehumidifier as well. An air-cooled condenser next to the dehumidifier rejects any waste heat not needed for reheating the air after dehumidification. The dehumidifier also has heat exchangers designed to use waste heat to heat pool water, but no pipes were run from the basement to the roof for these heat exchangers, so there is no heat recovery to the pool water. Instead, all the heat needed in the pool is supplied by a pool heater in the basement.

The dehumidifier runs continuously since the pool is uncovered all the time. The dehumidifier has internal controls that sense humidity in the return air and activate the compressor of the direct expansion air conditioner to maintain the humidity between 50 percent and 60 percent. The exhaust fans also run continuously. The current operation wastes both energy and water.

Proposed New Equipment

The proposed automation equipment for the existing pool covers would consist of motorized reels for the covers plus a system of cables suspended from the ceiling and winches. The covers would be applied to the pool by winching them off the reels, and they would be removed by winding back onto the reels. When the pool is in use, the cables would be pulled up above the pool out of the way of pool users. The cover system would be controlled by an operator station, allowing the pool to be covered and uncovered with a password-protected key entry. The pool covers would be monitored with occupancy sensors to provide an alarm if any prolonged activity (someone under the covers, for example) is detected in the pool room while the covers are on the pool.

[4] Direct expansion air conditioners have coils with refrigerant in them rather than chilled water from a chiller.

The controls would include humidity and carbon dioxide (CO2) sensors as well as occupancy sensors in the pool room. The new sensors would connect to the building's energy management system. If spare input and output points are not available in the pool room on an existing field controller, a new field controller would be installed. The building's energy management system would control the dehumidifier through a new microprocessor and electrical panel on the dehumidifier. When the pool is covered, the humidity sensors would control the dehumidifier, running it only until there is no danger of condensation. They would also control the exhaust fans and shut off all exhaust air when the pool is vacant and covered. When the pool is in use, the CO2 sensor would cycle the exhaust fans and the outside air damper on the dehumidifier to control the amount of fresh air brought into the pool room.

The dehumidifier's supply fan would be retrofitted with a variable speed drive, mounted on the dehumidifier, and a new inverter duty motor (compatible with variable speed drive) to replace the existing motor on the supply fan. When the pool is covered and the pool room air is dry enough to avoid condensation, the fan would be slowed down to provide just enough circulation to keep the room air mixed.

The heat exchangers inside the dehumidifier would be repaired and new pool water lines would be run from the basement to the roof to recover waste heat from the dehumidifier and use it to heat pool water. The heat exchangers were never connected, and the refrigerant connections were crimped off and will need to be restored. There is an existing chase from the basement to the dehumidifier for the heating hot water lines, but it may not have space for new pool water piping.

Implementation Scope

The new system should be designed by an architect experienced in indoor swimming pool design, with civil, mechanical, and electrical engineering consultants.

The basic scope for construction of the project is as follows:

1. Based on structural analysis, provide attachment points on the walls for the motorized reels and winches on the ceiling for the cable supports.
2. Install new pool covers, motorized reels, winches, cables, and controls including occupancy sensors, relative humidity sensors, and carbon dioxide sensor.
3. Based on electrical design, provide electrical conduits for power to the reel motors, winches, and control power supplies, and provide low voltage cabling for the sensors, controller, and control outputs to the dehumidifier and exhaust fan motor starters.
4. Based on mechanical design, provide swimming pool water piping from the basement pool equipment room to the rooftop dehumidifier; core-sawing and new chase may be required.

5. Remove existing supply fan motor from dehumidifier and replace with new inverter duty motor unless existing motor is compatible with variable speed drive.
6. Remove existing electrical panel from dehumidifier and replace with new panel including new microprocessor and new variable speed drive
7. Based on mechanical design, provide new controller if required, connect existing building EMS to new sensors, program EMS to control exhaust fan start/stop, supply fan speed, and dehumidifier outside air damper based on:
    a. pool cover controls for covered/uncovered status;
    b. occupancy sensors;
    c. relative humidity inside room; and
    d. carbon dioxide level in room or return air.
8. Commission system and demonstrate proper operation over a period of at least a week, including continuous monitoring of room humidity, fan speed, and heat recovery to the pool water.

Analysis Summary

Savings from this project were analyzed using the Washington State University "Indoor Pool Calc" program to estimate savings for pool heating and dehumidification, plus additional spreadsheet calculations of savings from the variable speed drive on the fan and from the shutoff of the exhaust air during hours when the pool is vacant and covered.

The Indoor Pool Calc model calculates savings in pool water heating and pool room air dehumidification energy and costs due to changes in pool cover use, heat recovery from dehumidification, pool water temperature, and other factors. It is a spreadsheet model based on evaporative heat loss calculations.

The spreadsheet for calculating savings from a variable speed fan is based on fan laws. It assumes that the fan will operate at minimum flow during most of the hours when the pool is covered.

The spreadsheet for calculating savings from the shutoff of the exhaust air during hours when the pool is vacant and covered is a simple thermal model, using the exhaust air flow, the room temperature, and the outdoor air temperature to calculate the amount of heat needed to heat up the make-up air needed to replenish the exhaust air. Outside air temperatures for Berkeley were obtained as a Skycalc weather file from the DOE-2 website.

The hours when the pool would be in use were provided by District staff. The pool use includes PE classes, swim and dive meets, and water polo. It was assumed that PE classes will resume, and that the pool will remain uncovered during the day between morning use, PE classes, and any evening activities.

The cost for the new equipment and its installation was estimated based on vendor quotes and cost estimating factors for both installation materials (such as wiring and piping) and soft costs including overhead, profit, engineering, construction management, and contingency. Vendor costs were obtained for the most expensive components, including:

- Pool cover automation system;
- New microprocessor electrical panel for the dehumidifier; and
- New supply fan motor and variable speed drive.

The dollar value of the energy savings was calculated using the current utility tariffs for electricity and natural gas service to the Jackets Pool. The electricity price that was used includes only energy charges, based on the assumption that the pool will be in use when demand charges are incurred, so that the measure will not affect electrical demand.

Incentives are available from PG&E that could reduce the cost of the project. Incentives were estimated using a value of $0.08 per kilowatt-hour of electricity saved, and $1.00 per Therm of natural gas saved.

In addition to the energy savings, the measure will save 115,045 gallons of water a year by preventing evaporation while the pool is covered. Additional water could be saved by piping the dehumidifier's water drain to the pool's surge tank when the heat recovery piping is installed.

Project Summary

This project shows a payback time that is less than the expected lifetime of the proposed new equipment and a high SIR. It would also have non-energy benefits including reduced water consumption. Therefore this project is recommended.

Table 4.8 Analysis summary of proposed Mechanical Project M-1

Facility	kW Saved	kWh Saved	Rate ($/kWh)	Natural Gas Therms Saved	Rate ($/Therm)	Project Cost ($)	Cost Savings ($)	Payback Period without Incentive (Years)	Approx. Incentive ($)	Project Costs w/ Incentive ($)	Payback Period with Incentive (Years)
Berkeley High-Jackets Pool	--	190,374	$0.095	20,787	$0.684	$340,784	$32,307	10.5	$36,017	$304,767	9.4

Mechanical Project M-2: Expand and upgrade existing energy management system to provide variable speed operation of the pool water circulation pump for the Jackets Pool at Berkeley High School

Project Description and Objectives

This project would consist of installing, programming and commissioning a system to ensure that:

1. The circulation pump on the Jackets Pool will run automatically at reduced speed when the new pool covers (see mechanical project M-1) are in place covering the pool.
2. When the pump is operating at reduced speed, the chemical injection systems and the ultraviolet (UV) lamp system will operate properly.
3. The circulation pump will operate at 100 percent of its design flow whenever the pool is uncovered.

Existing System and Background

The Jackets Pool is an indoor, 25 yard by 25 meter swimming pool that is used for swim meets and PE classes. It has a circulation pump in the basement mechanical room adjacent to the pool. The pump draws about 1,050 gallons per minute (gpm) of water from the pool through a strainer, and discharges the water through filters and back out to the pool. As the water goes back to the pool, chemicals are injected and the water passes around a UV lamp, and part of the water is diverted through the pool heater.

The pump runs continuously at constant speed. Health codes require that the pump circulate the water at 1,050 gpm when the pool is occupied. The pool operating schedule provided by District staff indicates that the pool is only occupied about 2100 hours a year.

Mechanical project M-1 would install motorized pool covers and controls to reduce heat loss by evaporation in the pool, heat loss in air exhausted from the room, and power consumption in the dehumidifier and fans serving the room. The system would interface to the existing energy management system in the building and would control the fans and dehumidifier based on whether the covers are in place on the pool and whether the room is vacant.

Proposed New Equipment

The proposed new equipment consists of:

1. A variable frequency drive;
2. A new inverter duty motor for the pump to replace the existing motor (if not inverter duty);
3. A new field controller for the energy management system (if needed); and
4. Low voltage wiring to interface to existing controls including the chemicals controls (if needed).

The new variable frequency drive would be installed in the electrical room adjacent to the pool equipment room where the pump is located. The new pump motor would be installed on the existing pump to replace the existing motor if it is not designed for inverter duty. The speed input for the variable frequency drive would be interfaced to the existing controls, including the new controls installed for Mechanical Project M-1, to reduce the pump speed when the pool is covered and unoccupied. The controls would include a timed override feature to allow the pump to be run at full speed overnight during swim meets and other periods of heavy pool use, in order to provide maximum filtration of the pool water. The controls would also interface to the chemical injection and UV lamp controls as needed to maintain proper chemical balance when the pool is covered and the pump is running at reduced speed.

Implementation Scope

The new system should be designed by an architect experienced in indoor swimming pool design with mechanical and electrical engineering consultants.

The basic scope for construction of the project is as follows:

1. Provide controls interface as needed to existing chemical injection and UV lamp controls, provide controls interface to pool cover controls, and install low voltage wiring and field controller as needed.
2. Based on electrical design, provide mounting and enclosure for variable frequency drive inside the electrical room, intercepting the existing power wiring to the pump motor.
3. Remove existing pump motor unless existing motor is compatible with variable frequency drive.
4. Install new variable frequency drive, motor, and controls.
5. Commission system and demonstrate proper operation over a period of at least a week, including continuous monitoring of water flow, pump speed, and chemical balance of the pool water.

Analysis Summary

Savings from this project were analyzed using a spreadsheet calculation of savings from the variable frequency drive on the pump motor during hours when the pool is vacant and covered.

The spreadsheet for calculating savings from a variable speed pump is based on pump laws. It assumes that the pump will operate at 50 percent flow during most of the hours when the pool is covered. Erring on the conservative side, the calculation assumes that the pump will run at 100 percent flow 3,504 hours a year, even though the pool is reportedly in use less than 2,100 hours a year.

The hours the pool is in use were provided by District staff. The pool use includes PE classes, swim and dive meets, and water polo. It was assumed that PE classes will resume, and that the pool will remain uncovered during the day between morning use, PE classes, and any evening activities.

The cost for the new equipment and its installation was based on vendor quotes and cost estimating factors for both installation materials (such as wiring and piping) and soft costs including overhead, profit, engineering, construction management, and contingency. Vendor costs were obtained for the new pump motor and variable speed drive.

The dollar value of the energy savings was calculated using the current utility tariffs for electricity service to the Jackets Pool. The electricity price that was used includes only energy charges, based on the assumption that the pool will be in use when demand charges are incurred, so that the measure will not affect electrical demand.

Incentives are available from PG&E that could reduce the cost of the project. Incentives were estimated using a value of $0.08 per kilowatt-hour of electricity saved.

Project Summary

This project has a payback time that is within the expected lifetime of the new equipment and a high SIR. Therefore this project is recommended.

Table 4.9 Analysis summary of proposed Mechanical Project M-2

Facility	kW Saved	kWh Saved	Rate ($/kWh)	Natural Gas Therms Saved	Rate ($/Therm)	Project Cost ($)	Cost Savings ($)	Payback Period without Incentive (Years)	Approx. Incentive ($)	Project Costs w/ Incentive ($)	Payback Period with Incentive (Years)
Berkeley High-Jackets Pool	--	47,562	$0.095	--	$0.684	$31,832	$4,518	7.0	$3,805	$28,027	6.2

Mechanical Project M-3: Upgrade and expand existing energy management system to provide variable speed operation of the fans in the air handlers serving G and H buildings at Berkeley High School

Project Description and Objectives

This project would consist of installing, programming and commissioning a system to provide efficient, variable speed operation of the fans in the air handlers serving the G and H buildings at Berkeley High School. The fan speed would be reduced when the rooms do not require maximum airflow for heating or ventilation.

Existing System and Background

The G and H buildings are heated and ventilated by four rooftop air handlers with heat recovery and indirect evaporative cooling. The air handlers were installed in 1995 and the indirect evaporative cooling is no longer working. The air handlers were designed to supply 100 percent outside air to the classrooms. In cold weather, the units were supposed to recover about 60 percent of the heat from the return air. In warm weather, the units were supposed to evaporatively cool the return air, and use the cooled return air in their heat exchangers to cool off the outside air before sending it to the classrooms. The air handlers have no heating coils or mechanical cooling. The supply air is ducted to the classrooms, each of which has a duct-mounted heating coil to supply additional heat as needed to maintain room temperature.

The G and H buildings also have large windows with operable sections. The windows provide a second source of fresh air in addition to the air handlers.

Each of the four rooftop air handlers has two exhaust fans and two supply fans. Each of the fans is driven by a separate motor. The motors are all standard efficiency and many appear to be original units from 1995. The smallest motors are 7-1/2 hp and the largest are 25 hp. The fans all run at constant speed whenever they are on.

The air handlers are controlled by an energy management system that starts and stops the air handlers and controls the valves on the heating coils in the classrooms. Typical operation of the air handlers is from 6 a.m. to 4 p.m. on schooldays. The smallest of the four air handlers runs from 5 a.m. to 5 p.m. on schooldays. The air handlers have internal controllers to provide an economizer function by bypassing exhaust air around the heat exchanger when the classrooms need cool air and the outside air is cooler than the return air. On one unit, the damper actuator for this function has failed, and the controller is erratic on all of the units.

Proposed New Equipment

The proposed new equipment consists of:

1. Eight new variable frequency drives, installed in four panels designed for mounting on the air handlers;
2. Sixteen new inverter duty motor for the fans; and
3. Four new outside air temperature sensors, four new return air temperature sensors, and four new damper actuators plus four new field controller expansion boards (if needed) to interface to the energy management system, along with low voltage wiring.

The new panels containing the variable frequency drives would be installed on the outside of the air handlers next to the existing motor switchgear. The new fan motors would be installed inside the air handlers to replace the existing motors. The speed inputs for the variable frequency drives would be interfaced to the existing energy management system which would be programmed to reduce the fan speed when the outside air temperature is not extremely cold (e.g., below 45° °F) or warm (e.g., above 75 ° °F). The programming would include a morning purge that would run the fans at full speed for a short period (e.g., an hour) after startup. It would also include control of the exhaust bypass damper to bypass the exhaust air around the heat exchanger when the weather is warm and the outside air is cooler than the return air.

Implementation Scope

The new system should be designed by a mechanical engineer with an electrical engineering consultant.

The basic scope for construction of the project is as follows:

1. Provide new temperature sensors, damper actuators, and low voltage wiring to connect to existing energy management system, along with new field controller expansion boards as needed.
2. Install new outdoor electrical panels each with two variable speed drives, one drive for the exhaust fans and the other for the supply fans, and connect variable speed to existing motor wiring and to output points on existing energy management system.
3. Remove existing fan motors and replace with new inverter duty motors. Follow local, state, federal, and industry recommended guidelines associated with storage, transport, and recycling of motors.
4. Program energy management system to provide variable speed operation of fans, including tracking of return air and supply air to maintain proper balance inside building. Also program energy management system to provide economizer operation by opening exhaust bypass damper when outside air is between 65 and 72 ° °F.

5. Commission system and demonstrate proper operation over a period of at least a week, including continuous monitoring of outside air temperature, return air temperature, exhaust damper position, and fan speed.

Analysis Summary

Savings from this project were analyzed using a spreadsheet calculation of savings during normal school hours. The spreadsheet for calculating savings from a variable speed fan is based on fan laws. It assumes that the fan will operate at 100 percent speed when the outside air temperature is below 45˚ F or above 75˚ F, and the fan speed will be reduced to 50 percent when the outside air temperature is 60˚ F.

The spreadsheet for calculating savings uses outdoor air temperatures to estimate fan speeds. Outside air temperatures for Berkeley were obtained as a Skycalc weather file from the DOE-2 website. The estimate is made only for school days between 6 a.m. and 4 p.m., when the air handlers are normally on. The estimates were made for every hour that the air handlers would normally be on, and the motors' electricity consumption was then estimated from the fan speed based on fan laws, taking into account the efficiency loss in the motors at part load. Savings from the higher efficiency of the new inverter duty motors was also included in the savings calculation spreadsheet. The details of the savings calculation are presented in Appendix C.

The cost for the new equipment and its installation was estimated based on vendor quotes and cost estimating factors for both installation materials (such as wiring and electrical panels) and soft costs including overhead, profit, engineering, construction management, and contingency. Vendor costs were obtained for the new fan motors and variable speed drives.

The dollar value of the energy savings was calculated using the current utility tariffs for electricity service to the G and H buildings. The electricity price that was used includes only energy charges, based on the assumption that the fans will be at 100 percent speed when demand charges are incurred, so that the measure will not significantly affect electrical demand.

Incentives are available from PG&E that could reduce the cost of the project. Incentives were estimated using a value of $0.08 per kilowatt-hour of electricity saved.

Project Summary

This project has a payback time that is within the expected lifetime of the new equipment (variable speed drives and other equipment to expand the existing energy management system) and a high SIR. The existing air handlers are twenty years old, but may be expected to last another five years. Therefore the project is recommended. If the District intends to replace the air handlers in kind (with new units with heat recovery

and indirect evaporative cooling, for 100 percent outside air operation), this measure should be implemented to upgrade the new replacement units for variable speed operation.

Table 4.10 Analysis summary of proposed Mechanical Project M-3

Facility	kW Saved	kWh Saved	Rate ($/kWh)	Natural Gas Therms Saved	Rate ($/Therm)	Project Cost ($)	Cost Savings ($)	Payback Period without Incentive (Years)	Approx. Incentive ($)	Project Costs w/ Incentive ($)	Payback Period with Incentive (Years)
Berkeley High-G&H Building Air Handlers	--	150,205	$0.095	--	$0.684	$140,956	$14,269	9.9	$12,016	$128,939	9.0

Mechanical Project M-3alt: Replace the existing air handlers serving G and H buildings at Berkeley High School with new variable air volume units

Project Description and Objectives

This project is an alternative to Measure M-3. It would consist of replacing the existing air handlers serving the G and H buildings at Berkeley High School with new variable air volume units. The new units would recirculate return air except when in economizer mode (where 100 percent outside air would be used), and their fan speed would be reduced when the rooms do not require maximum airflow for heating or ventilation.

The existing air handlers are twenty years old and replacement may be warranted based on their age. The new air handlers would use less energy than the existing air handlers because they would use return air rather than a heat exchanger, thus avoiding the heat loss and air flow restriction in the existing design.

Existing System and Background

The G and H buildings are heated and ventilated by four rooftop air handlers with heat recovery and indirect evaporative cooling. The air handlers were installed in 1995 and the indirect evaporative cooling is no longer working. The air handlers were designed to supply 100 percent outside air to the classrooms. In cold weather, the units were supposed to recover about 60 percent of the heat from the return air. In warm weather, the units were supposed to evaporatively cool the return air, and use the cooled return air in their heat exchangers to cool off the outside air before sending it to the classrooms. The air handlers have no heating coils or mechanical cooling. The supply air is ducted to the classrooms, each of which has a duct-mounted heating coil to supply additional heat as needed to maintain room temperature.

The G and H buildings also have large windows with operable sections. The windows provide a second source of fresh air in addition to the air handlers.

Each of the four rooftop air handlers has two exhaust fans and two supply fans. Each of the fans is driven by a separate motor. The motors are all standard efficiency and many appear to be original units from 1995. The smallest motors are 7-1/2 hp and the largest are 25 hp. The fans all run at constant speed whenever they are on.

The air handlers are controlled by an energy management system that starts and stops the air handlers and controls the valves on the heating coils in the classrooms. Typical operation of the air handlers is from 6 a.m. to 4 p.m. on schooldays. The smallest of the four air handlers runs from 5 a.m. to 5 p.m. on schooldays. The air handlers have internal controllers to provide an economizer function by bypassing exhaust air around the heat exchanger when the classrooms need cool air and the outside air is cooler than

the return air. On one unit, the damper actuator for this function has failed, and the controller is erratic on all of the units.

Proposed New Equipment

The proposed new equipment consists of:

1. Four new variable air volume air handlers, each with high efficiency fans, premium efficiency inverter motors, and variable frequency drives, with economizer dampers; and
2. Controls interface to existing EMS to provide control of air handler start/stop, fan speed, and economizer damper position.

Implementation Scope

The new system should be designed by a mechanical engineer with an electrical engineering consultant.

The basic scope for construction of the project is as follows:

1. Follow all safety procedures for working on rooftops and with electrical motors and wiring.
2. Remove existing air handlers. Follow local, state, federal, and industry recommended guidelines associated with storage, transport, and waste disposal of air handler components.
3. Install new air handlers on rooftop and connect to existing return and supply air ducting, electrical wiring, and low-voltage wiring for energy management system.
4. Install new control interface and connect to existing energy management system and to new air handlers' start/stop, fan speed, and economizer inputs.
5. Program existing energy management system to provide all controls and monitoring functions including starting, stopping, adjusting fan speed based on outside air temperature, and modulating exhaust damper position based on outside air and return air temperatures.
6. Commission system and demonstrate proper operation over a period of at least a week, including continuous monitoring of outside air temperature, return air temperature, exhaust damper position, and fan speed.

Analysis Summary

Savings from this project were analyzed using a spreadsheet calculation of savings during normal school hours. The spreadsheet for calculating savings from a variable speed fan is based on fan laws. The proposed new air handlers are assumed to have fans sized for the typical static pressures found in an air handler without heat exchanger or evaporative cooling, serving a two-story building. The spreadsheet assumes that the

fans in the new air handlers will operate at 100 percent speed when the outside air temperature is below 45° F or above 75° F, and the fan speed will be reduced to 50 percent when the outside air temperature is 60° F.

The spreadsheet for calculating savings uses outdoor air temperatures to estimate fan speeds. Outside air temperatures for Berkeley were obtained as a Skycalc weather file from the DOE-2 website. The estimate is made only for school days between 6 a.m. and 4 p.m., when the air handlers are normally on. The estimates were made for every hour that the air handlers would normally be on, and the motors' electricity consumption was then estimated from the fan speed based on fan laws, taking into account the efficiency loss in the motors at part load. Savings from the higher efficiency of the new inverter duty motors was also included in the savings calculation spreadsheet. The details of the savings calculation are presented in Appendix C.

The cost for the new equipment and its installation was estimated based on RS Means cost data and cost estimating factors for the new air handlers and installation materials (such as wiring and electrical panels). The RS Means cost data was supported by a budgetary cost estimate provided by the vendor who originally supplied the existing units. The project cost includes soft costs including overhead, profit, engineering, construction management, and contingency.

The dollar value of the energy savings was calculated using the current utility tariffs for electricity service to the G and H buildings. The electricity price that was used includes demand charges, since the reduced fan horsepower provides savings when demand charges are incurred and thus the project will reduce electrical demand.

Incentives are available from PG&E that could reduce the cost of the project. Incentives were estimated using a value of $0.08 per kilowatt-hour of electricity saved and $150 per kilowatt of demand saved.

Project Summary

This project has a payback time that exceeds the expected lifetime of the new air handlers. It is therefore not recommended, but should be considered if the District plans to replace the air handlers with units that do not use 100 percent outside air, and thus do not have heat exchangers or indirect evaporative cooling.

Table 4.11 Analysis summary of proposed Mechanical Project M-3alt

Facility	kW Saved	kWh Saved	Rate ($/kWh)	Natural Gas Therms Saved	Rate ($/Therm)	Project Cost ($)	Cost Savings ($)	Payback Period without Incentive (Years)	Approx. Incentive ($)	Project Costs w/ Incentive ($)	Payback Period with Incentive (Years)
Berkeley High-G&H Building Air Handlers	91.8	228,552	$0.165	--	$0.684	$985,995	$37,654	26.2	$32,060	$953,935	25.3

Solar Project PV-1: Install grid-tied rooftop solar PV systems at Cragmont Elementary School and Berkeley High School

Project Description and Objectives

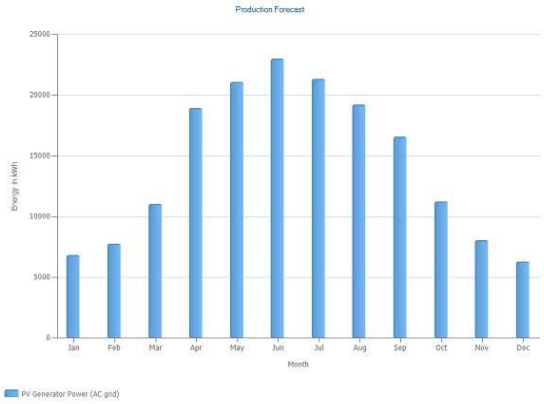
This project would consist of installing grid-tied solar PV systems on the roofs of Cragmont Elementary School and the Donahue Gym at Berkeley High School. Installing these solar PV systems will allow the District to generate electricity on-site, thereby offsetting electricity that is currently purchased from the utility.

Implementation Scope

The project will be implemented as part of two larger capital projects. The District has completed competitive bidding processes for a) re-roofing at Cragmont Elementary School and b) modernization of the Donahue Gym at Berkeley High School. Each of these two capital projects includes installation of grid-tied solar PV systems on the rooftops. The California Department of General Services, Division of the State Architect, has approved the designs, and District staff have indicated they intend to move forward with this project.

Analysis Summary

The performance for the solar PV systems was analyzed based on the drawings from the bid packages for the capital projects. The design for Cragmont Elementary School called for a total of 82.7 kilowatts DC power (including additive alternate), while the design for Donahue Gym called for 121.6 kW DC power. Both designs include flat mounting of the PV modules (panels) on the roofs, DC wiring and combiner boxes, inverters, AC wiring, generation metering, and interface with the existing electric services. The inverter capacity (maximum AC power output) is 74 kW AC at Cragmont Elementary School. The inverter capacity is estimated at 100 kW AC for Berkeley High School.



The annual production of power from the system was estimated using PV*SOL software. The figure at right shows the estimated monthly solar output from the Berkeley High School system. In estimating power output, weather data from Oakland Airport was used in the software. Each system was modeled based on the PV modules specified in the bid packages, which were Sunpower 327 Watt modules for Cragmont Elementary and SolarWorld 275 Watt modules for Donahue Gym.

The power output from the systems was estimated based on the rate simulation (see Appendix F), using the total energy price including demand charges. The systems will produce more power than the schools require at some times. This is especially likely at Cragmont Elementary School, where the estimated annual production is 73 percent of the school's annual electricity use. Surplus electricity can be exported under Net Energy Metering, but this may require a rate change that can result in higher costs for the supplementary power that the school will still need. Also, there is no demand credit for the exported power. The District may wish to sign up for a state-wide program that PG&E is offering, the Renewable Energy Self-Generation Bill Credit Transfer (RES-BCT) program. This program allows local governments (including school districts) to generate renewable electricity at one account and transfer any bill credits to one or more separate accounts owned by the same local government. Bill credits are calculated on a TOU basis as the energy component of the generating account's TOU rate, multiplied by the amount of electricity exported to the grid during that period. The customer (local government) retains ownership of renewable energy credits (REC's).

The estimated installed unit cost (labor and materials included) for the roof-mounted PV systems is $3,700 per kW[5]. This estimate is the average total project cost of 152 government-owned systems that submitted California Solar Initiative (CSI) rebate applications between January 2014 and April 2015. The range of project costs reported to CSI during this same period was between $1,900/kW to $5,100/kW. The overall size of the system does have an impact on cost, though there are many systems of all sizes that are under $3,500/kW, before applying incentives.

Financial incentives were not included in the cost analysis presented in this report; the CSI program will conclude by summer 2015 and there is no replacement program under development and the state and federal tax credits are not applicable for government-owned facilities.

[5] The capital projects that include the solar PV also include re-roofing and other non-solar components.

Project Summary

This project is recommended because it has a payback time that is less than the expected lifetime of the new equipment and an acceptable SIR.

Table 4.12 Analysis summary of proposed Solar PV Project PV-1

Location	kWAC	kWh Saved	Rate ($/kWh)	Project Cost ($)	Cost Savings ($)	Payback Period without Incentive (Years)	Approx. Incentive ($)	Project Costs w/ Incentive ($)	Payback Period with Incentive (Years)
Cragmont	78.6	124,400	$0.186	$305,990	$23,138	13.2	$0	$305,990	13.2
Berkeley High	115.5	169,900	$0.165	$449,735	$28,034	16.0	$0	$449,735	16.0
Totals	194.0	294,300		$755,725	$51,172	14.8	$0	$755,725	14.8

5 Grants, Incentives, and Rebates

The California Clean Energy Jobs Act (Proposition 39)

Under Proposition 39, the California Clean Energy Jobs Act, local educational agencies (LEAs) can request money from the California Department of Education to fund identified energy efficiency projects. Eligible recipients include county offices of education, school districts, charter schools, and state special schools. Applications are submitted to the Energy Commission and, in conjunction with the Department of Education, funds are allocated upon application approval. These funds are allocated over a five-year implementation cycle and are based on identified energy conservation measures submitted via an Energy Expenditure Plan to the Energy Commission. For more information on Proposition 39, please refer to the following website:

http://www.energy.ca.gov/efficiency/proposition39/ and
http://www.cde.ca.gov/ls/fa/ce/.

PG&E's Customized Retrofit – Demand Response Program

PG&E's Customized Retrofit – Demand Response Program provides customers cash incentive payments for energy efficiency projects involving the installation of new, high-efficiency equipment or systems. The program entails an itemized approach whereby the incentive is based on a list of eligible equipment as well as a calculated approach whereby the incentive is based on the amount of energy savings produced annually. The District is encouraged to investigate itemized rebates as they may result in higher incentives.

Customized retrofit incentives are categorized as being either basic or targeted and lighting or non-lighting. Targeted lighting includes LED lighting retrofits, EMS lighting control systems, and any comprehensive lighting control solution (involving three or more of the following: occupancy sensing, scheduling, task-tuning, day-lighting control, demand response). Basic lighting includes non-LED lighting systems and basic control systems. Targeted non-lighting measures involve wholesale HVAC or refrigeration system change-outs that result in improved overall efficiency. Basic non-lighting entails non-HVAC or refrigeration measures, or HVAC/refrigeration measures that involve add-ons that result in reduced load but are not full replacements.

The customized incentive payment amount is based on a flat incentive rate (per kW, per kWh or per Therms) applied to one year of energy savings. As is indicated in the following table, incentive rates vary with the type of measure implemented:

Table 5.1 Customized retrofit program rebates by category

Measure Category	Incentive Rate
Lighting (Fluorescent, Other Lighting, or Controls)	Basic- $0.03 per kWh saved Targeted - $0.08 per kWh saved Peak Demand - $150 per kW Saved
Non Lighting	Basic - $0.08 per kWh saved Targeted - $0.15 per kWh saved Peak Demand - $150 per kW Saved

Measures must exceed applicable government and/or industry minimum efficiency standards to qualify. Incentives are paid for direct energy savings only; energy savings due to interactive effects such as the reduced cooling load due to installing more efficient lamps are not eligible.

Customers may apply as "self-sponsors" or elect to have a third party apply on their behalf for retrofit projects. A Project Sponsor follows a multi-step application process using forms supplied specifically for the customized retrofit option. The forms are submitted to PG&E for evaluation and payment. Depending on the nature of the project, the application process may involve one or more site inspections by PG&E prior to payment. In all cases, PG&E will work closely with the Project Sponsor to facilitate the review and payment process.

It is important to note that if any of the project measures are included in applications to any other California end user energy efficiency rebate program, the project may be ineligible for participation. Other California end user energy efficiency programs include, but are not limited to, any end user program offered by or through Southern California Gas Company, Southern California Edison, PG&E, San Diego Gas and Electric, the Energy Commission, and the CPUC, including local programs funded by the Public Goods Charge. For additional details including project applicability, funding availability, and important dates and deadlines, the District is strongly encouraged to speak with a utility representative.

PG&E Rebates

PG&E offers standard rebates for specific measures as well as the customized retrofit incentives based on estimated savings. The rebates are for specific types of equipment that must retrofit, replace, or upgrade old equipment with new technologies with energy efficiencies that exceed applicable government and/or industry minimum efficiency

standards. The types of equipment for which K-12 schools often can receive standard rebates include:

- Domestic Water Heaters
- Space Heating Boilers
- Pool and Spa Heaters
- Network Desktop Computer Power Management Software
- Plug Load Occupancy Sensors
- Central Natural Gas Furnaces
- Variable Frequency Drives (VFD's) for HVAC Fans
- Advanced Digital Economizer Controls
- HVAC Units Demand Controlled Ventilation (DCV) for Packaged HVAC Units
- Notched V-Belts Replacing Solid V-Belts for HVAC fans
- 7-Day Programmable Thermostats
- LED High-Bay and Low-Bay Lighting
- LED Exterior Area Lighting
- Interior High-Bay Linear Fluorescent Fixtures
- Low- or Reduced-Wattage T8 Lamps
- LED Accent, Surface, Pendant, Track and Recessed Downlight Fixtures
- Anti-Sweat Heater (ASH) Controls for Display Case Refrigerators
- Auto-Closers for Walk-in Cooler or Freezer Doors
- Efficient Evaporator Fan Motors
- Vending Machine Controllers
- Commercial Demand Control Kitchen Ventilation
- Commercial Convection Ovens and Steam Cookers
- Insulated Holding Cabinets
- Commercial Solid Door Refrigerators and Freezers

The standard rebates apply only to specific applications. The rebate for economizer controls, for example, applies only to packaged HVAC units, not to units that provide only heating and ventilation. The customized retrofit incentives are an alternative to the standard rebate program, and can provide a larger dollar amount in some instances.

In this study, incentive amounts for energy efficiency measures were calculated by selecting the larger of the applicable standard rebate or customized retrofit incentive.

Appendix A

Baseline Energy Use

Electricity Use Summary

School	GSF	Rate Schedule	Electricity (kWh)	Cost ($)	kWh/ GSF	$/GSF	Site kBtu/ GSF	Rate ($/kWh)
Cragmont Elementary	50,000	HA10S	170,682	$32,281	3.41	$0.646	11.6	$0.189
Berkeley High School	550,000	E19SX, A10S, HA6	2,072,531	$293,275	3.77	$0.533	12.9	$0.142
Total	**600,000**	**-**	**2,243,213**	**$325,556**	**3.74**	**$0.543**	**12.8**	**$0.145**

Natural Gas Use Summary

School	GSF	Rate Schedule	Natural Gas (Therms)	Cost ($)	Therm/ GSF	$/GSF	Site kBtu/ GSF	Rate ($/Therm)
Cragmont Elementary	50,000	GNR1	5,870	$7,359	0.12	$0.147	1.2	$1.254
Berkeley High School	550,000	GNR1	133,276	$108,736	0.24	$0.198	2.4	$0.816
Total	600,000	-	133,276	$116,095	0.22	$0.193	20.5	$0.871

Total Energy Use Summary

School	GSF	Total Energy (MMBTU)	Total Energy Cost	Total Energy Cost per GSF	kBTU/ GSF
Cragmont Elementary	50,000	582	$39,640	$0.79	11.65
Berkeley High School	550,000	19,400	$402,011	$0.73	35.27
Total	600,000	19,982	$441,651	$0.74	33.30

Site Name: Berkeley High School
Service Address: 2246 Milvia St, Berkeley, CA 94704
Buildings: C, D, E, F, G, H
Service Type: **Electricity**
Service Provider: PG&E
Rate Schedule: E19SX
Service Agreement ID: 3220496521
Account ID: 3220496972
Meter #: 1004779090

					Summer Energy			*Winter Energy*		*Max Demand*	*Summer Demand*		*Winter Dem*	*Total Charges*	
No.	Month	Date Read	Days Billed	Total Usage	On Peak	Partial Peak	Off Peak	Partial Peak	Off Peak		On Peak	Part Peak	Part Peak	Electric Charges	Ave. Rate
				kWh	*kWh*	*kWh*	*kWh*	*kWh*	*kWh*	*kW*	*kW*	*kW*	*kW*	*$*	*$/kWh*
1		6/2/13	32	108,553	25,296	27,299	55,958			266	245	266		$ 18,804	$ 0.173
2		7/1/13	29	100,136	24,524	25,865	49,747			246	244	246		$ 17,752	$ 0.177
3		7/31/13	30	119,346	25,675	28,066	65,605			268	243	260		$ 19,580	$ 0.164
4		8/29/13	29	127,783	26,664	29,793	71,326			294	294	291		$ 21,562	$ 0.169
5		9/30/13	32	165,766	35,088	39,189	91,489			319	319	319		$ 25,989	$ 0.157
6		10/29/13	29	142,070	33,654	37,384	71,032			326	316	326		$ 24,331	$ 0.171
7		12/1/13	33	171,089	3,240	4,254	5,918	65,943	91,734	378	19	378	378	$ 19,753	$ 0.115
8		12/30/13	29	166,256				74,358	91,898	373	0		373	$ 18,814	$ 0.113
9		1/30/14	31	179,388				81,469	97,919	355	0		355	$ 20,093	$ 0.112
10		3/3/14	32	183,045				81,538	101,507	362	0		362	$ 20,517	$ 0.112
11		4/1/14	29	191,739				89,942	101,797	438	0		438	$ 22,592	$ 0.118
12		5/1/14	30	205,151	1,852	3,093	3,684	89,691	106,831	394	11	394	394	$ 23,563	$ 0.115
TOTAL			365	1,860,322	175,993	194,943	414,759	482,941	591,686	-	-	-	-	$ 253,350	$ 0.136

Site Name: Berkeley High School
Service Address: ALLSTON & GROVE STS, BERKELEY, CA 94710
Buildings: A
Service Type: **Electricity**
Service Provider: PG&E
Rate Schedule: A10S
Service Agreement ID: 5158034195
Account ID: 5158034396
Meter #: X01915

					Summer Energy	*Winter Energy*	*Max Demand*	*Summer Demand*	*Winter Demand*	*Total Charges*	
No.	Month	Date Read	Days Billed	Total Usage	all	all	all	Summer Max Demand	Winter Demand	Electric Charges	Ave. Rate
				kWh	*kWh*	*kWh*	*kW*	*kW*	*kW*	*$*	*$/kWh*
1	May	6/2/13	32	14,237	14,237		62	62		$3,296.67	$ 0.232
2	June	7/1/13	29	11,955	11,955		44	44		$2,769.92	$ 0.232
3	July	7/31/13	30	11,249	11,249		35	35		$2,608.16	$ 0.232
4	August	8/29/13	29	11,467	11,467		53	53		$2,657.55	$ 0.232
5	September	9/30/13	32	15,076	15,076		67	67		$3,489.74	$ 0.231
6	October	10/29/13	29	13,215	13,215		54	54		$3,070.98	$ 0.232
7	November	12/1/13	33	14,744	894	13,850	62		62	$2,496.95	$ 0.169
8	December	12/30/13	29	14,923		14,923	70		70	$2,338.12	$ 0.157
9	January	1/30/14	31	13,892		13,892	60		60	$2,206.77	$ 0.159
10	February	3/3/14	32	16,640		16,640	61		61	$2,528.15	$ 0.152
11	March	4/1/14	29	9,914		9,914	29		29	$1,531.11	$ 0.154
12	April	5/1/14	30	9,227		9,227	28		28	$1,471.36	$ 0.159
TOTAL			365	156,539	78,093	78,446	-	-	-	$30,465.48	$ 0.195

Site Name: Berkeley High School
Service Address: MLK Jr Way & Channing Way, Berkeley, CA 94709
Buildings: Lights Ballfield
Service Type: **Electricity**
Service Provider: PG&E
Rate Schedule: HA6
Service Agreement ID: 5158034215
Account ID: 5158034396
Meter #: 5000111711

No.	Month	Date Read	Days Billed	Total Usage	*Total Charges* Electric Charges	Ave. Rate
				kWh	*$*	*$/kWh*
1	May	6/3/13	32	1,680	$393.93	$ 0.234
2	June	7/2/13	29	880	$203.52	$ 0.231
3	July	8/1/13	30	1,040	$254.59	$ 0.245
4	August	8/30/13	29	1,600	$365.11	$ 0.228
5	September	10/1/13	32	3,120	$657.37	$ 0.211
6	October	10/22/13	21	2,320	$501.12	$ 0.216
7	November	11/20/13	29	4,838	$869.07	$ 0.180
8	December	12/22/13	32	8,862	$1,370.80	$ 0.155
9	January	1/22/14	31	10,363	$1,607.05	$ 0.155
10	February	2/23/14	32	11,257	$1,706.46	$ 0.152
11	March	3/24/14	29	6,246	$977.25	$ 0.156
12	April	4/23/14	30	3,465	$553.25	$ 0.160
TOTAL			356	55,670	$ 9,460	$ 0.170

Site Name: Cragmont Elementary School
Service Address: 830 Regal Rd, Berkeley, CA 94708
Building: all
Service Type: **Electricity**
Service Provider: PG&E
Rate Schedule: HA10S
Service Agreement ID: 4316669134
Account ID: 4316669443
Meter #: 1009542415

					Summer Energy	*Winter Energy*	*Max Demand*	*Summer Demand*	*Winter Demand*	*Total Charges*	
No.	Month	Date Read	Days Billed	Total Usage	all	all	*all*	Summer Max Demand	Winter Demand	Electric Charges	Ave. Rate
				kWh	*kWh*	*kWh*	*kW*	*kW*	*kW*	*$*	*$/kWh*
1	May	6/3/13	32	15,857	15,857		65	65		$ 3,558	$ 0.224
2	June	7/2/13	29	12,616	12,616		56	56		$ 2,911	$ 0.231
3	July	8/1/13	30	10,229	10,229		37	37		$ 2,265	$ 0.221
4	August	9/2/13	32	10,575	10,575		56	56		$ 2,600	$ 0.246
5	September	10/1/13	29	14,560	14,560		60	60		$ 3,256	$ 0.224
6	October	10/30/13	29	13,846	13,846		60	60		$ 3,171	$ 0.229
7	November	12/2/13	33	13,890	421	13,469	52		52	$ 2,155	$ 0.155
8	December	1/1/14	30	14,644		14,644	54		54	$ 2,201	$ 0.150
9	January	2/2/14	32	16,048		16,048	55		55	$ 2,444	$ 0.152
10	February	3/4/14	30	16,719		16,719	63		63	$ 2,564	$ 0.153
11	March	4/2/14	29	14,967		14,967	61		61	$ 2,363	$ 0.158
12	April	5/4/14	32	16,730	2,091	14,639	67		67	$ 2,793	$ 0.167
TOTAL			367	170,682	80,195	90,487	-	-	-	$ 32,281	$ 0.189

Site Name: Berkeley High School
Service Address: 2246 Milvia St, Berkeley, CA 94704
Buildings: Pool
Service Type: **Natural Gas**
Service Provider: PG&E
Rate Schedule: GNR1
Service Agreement ID: 6482456308
Account ID: 6482456669
Meter #: 30523031

					Delivery Charges		*Estimated Procurement Charge [1]*		*Estimated Total Charges*	
No.	Month	Date Read	Days Billed	Total Usage	Natural Gas Charges	Ave. Rate	Ave. Rate	Procurement Charge	Total Charges	Ave. Rate
				Therms	*$*	*$/Therm*	*$/Therm*	*$*	*$*	*$/Therm*
1	May	6/3/13	32	6,948	$2,040.79	$ 0.294	$0.53	$3,680.29	$5,721.08	$ 0.823
2	June	7/2/13	29	4,017	$1,485.79	$ 0.370	$0.48	$1,910.77	$3,396.56	$ 0.846
3	July	8/1/03	30	4,464	$1,571.60	$ 0.352	$0.45	$1,989.25	$3,560.85	$ 0.798
4	August	8/30/13	29	2,725	$1,029.89	$ 0.378	$0.43	$1,179.22	$2,209.11	$ 0.811
5	September	10/1/13	32	4,677	$1,615.75	$ 0.345	$0.40	$1,879.69	$3,495.44	$ 0.747
6	Oct-Nov	12/2/13	61	14,377	$4,058.36	$ 0.282	$0.46	$6,613.42	$10,671.78	$ 0.742
7	December	12/31/13	29	25,929	$6,625.16	$ 0.256	$0.47	$12,254.90	$18,880.06	$ 0.728
8	January	1/31/14	31	21,231	$6,121.94	$ 0.288	$0.52	$11,031.84	$17,153.78	$ 0.808
9	February	3/4/14	32	18,770	$5,517.80	$ 0.294	$0.59	$11,099.08	$16,616.88	$ 0.885
10	March	4/2/14	29	14,983	$4,527.83	$ 0.302	$0.64	$9,660.29	$14,188.12	$ 0.947
11	April	5/2/14	30	12,907	$3,410.66	$ 0.264	$0.55	$7,065.94	$10,476.60	$ 0.812
TOTAL			364	131,028	$ 38,006	$ 0.290		$ 68,365	$ 106,370	$ 0.812

[1] based on historical GNR1 procurement rates given on http://www.pge.com/nots/rates/tariffs/GRF.SHTML#GNR1

Site Name: Berkeley High School
Service Address: 2246 Milvia St, Berkeley, CA 94704
Buildings: Donahue Gym
Service Type: **Natural Gas**
Service Provider: PG&E
Rate Schedule: GNR1
Service Agreement ID: 3149182005
Account ID: 3149182775
Meter #: 60900503

No.	Month	Date Read	Days Billed	Total Usage	*Delivery Charges* Natural Gas Charges	Ave. Rate
				Therms	*$*	*$/Therm*
1	May	6/3/13	32	0	$8.65	
2	June	7/2/13	29	0	$7.84	
3	July	8/1/03	30	0	$8.11	
4	August	8/30/13	29	0	$7.84	
5	September	10/1/13	32	0	$8.65	
6	Oct-Nov	12/2/13	61	0	$8.90	
7	December	12/31/13	29	0	$7.84	
8	January	1/31/14	31	0	$8.38	
9	February	3/4/14	32	0	$8.38	
10	March	4/2/14	29	0	$8.11	
11	April	5/2/14	30	0	$8.11	
TOTAL			364	0	$ 91	

Site Name: Berkeley High School
Service Address: 2246 Milvia St, Berkeley, CA 94704
Buildings:
Service Type: **Natural Gas**
Service Provider: PG&E
Rate Schedule: GNR1
Service Agreement ID: 9099587885
Account ID: 9099587917
Meter #: 61203113

No.	Month	Date Read	Days Billed	Total Usage	Total Charges Natural Gas Charges	Ave. Rate
				Therms	*$*	*$/Therm*
1	May	6/3/13	32	225	$230.04	$ 1.022
2	June	7/2/13	29	189	$184.06	$ 0.974
3	July	8/1/03	30	300	$274.00	$ 0.913
4	August	8/30/13	29	213	$196.01	$ 0.920
5	September	10/1/13	32	145	$135.63	$ 0.935
6	October	10/30/13	29	261	$229.02	$ 0.877
7	November	12/2/13	33	346	$364.63	$ 1.054
8	December	12/31/13	29	357	$360.75	$ 1.011
9	January	1/31/14	31	109	$130.91	$ 1.201
10	February	3/4/14	32	45	$75.58	$ 1.680
11	March	4/2/14	29	25	$45.31	$ 1.812
12	April	5/2/14	30	33	$49.22	$ 1.492
TOTAL			365	2,248	$ 2,275	$ 1.012

Site Name: Cragmont Elementary School
Service Address: 830 Regal Rd, Berkeley, CA 94708
Building: all
Service Type: **Natural Gas**
Service Provider: PG&E
Rate Schedule: GNR1
Service Agreement ID: 4358336634
Account ID: 4358336107
Meter #: 48919486

					Total Charges		*Estimated Procurement Charge*		*Estimated Total Charges*	
No.	Month	Date Read	Days Billed	Total Usage	Natural Gas Charges	Ave. Rate	Ave. Rate	Procurement Charge	Total Charges	Ave. Rate
				Therms	*$*	*$/Therm*	*$/Therm*	*$*	*$*	*$/Therm*
1	May	6/4/13	32	26	$67.13	$ 2.58	$0.53	$13.77	$80.90	$ 3.112
2	June	7/3/13	29	0	$51.90		$0.48	$0.00	$51.90	
3	July	8/2/13	30	6	$55.96	$ 9.33	$0.45	$2.67	$58.63	$ 9.772
4	August	9/3/13	32	0	$57.26		$0.43	$0.00	$57.26	
5	September	10/2/13	29	0	$51.90		$0.40	$0.00	$51.90	
6	October	10/31/13	29	164	$114.02	$ 0.70	$0.41	$66.58	$180.60	$ 1.101
7	November	12/3/13	33	559	$314.48	$ 0.56	$0.51	$287.09	$601.57	$ 1.076
8	December	1/2/14	30	1,767	$864.19	$ 0.49	$0.47	$835.14	$1,699.33	$ 0.962
9	January	2/3/14	32	996	$538.47	$ 0.54	$0.52	$517.53	$1,056.00	$ 1.060
10	February	3/5/14	30	1,220	$643.08	$ 0.53	$0.59	$721.41	$1,364.49	$ 1.118
11	March	4/3/14	29	661	$364.99	$ 0.55	$0.64	$786.60	$1,429.68	$ 2.163
12	April	5/5/14	32	471	$241.61	$ 0.51	$0.55	$361.86	$726.85	$ 1.543
TOTAL			367	5,870	$3,365	$ 0.57	$ 0.61	$ 3,593	$7,359.12	$ 1.25

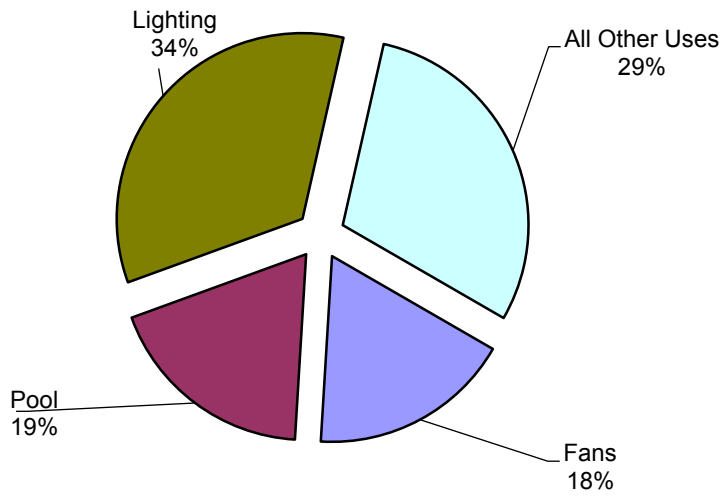
Appendix B

Energy Balance

Electricity Energy Balance Summary - *kWh*

End Use	Fans	Pool	Lighting	All Other Uses	TOTAL kWh
Cragmont Elementary School	23,464		91,400	55,818	**170,682**
% of Total	*14%*	*0%*	*53%*	*33%*	***100%***
Berkeley High School	372,065	414,545	673,475	612,447	**2,072,531**
% of Total	*18%*	*20%*	*32%*	*30%*	***100%***
TOTAL	**395,529**	**414,545**	**764,875**	**668,265**	**2,243,213**
% of Total	*18%*	*19%*	*34%*	*29%*	***100%***

"Pool" use includes dehumidifier and circulating pump; pool room lighting is included under "Lighting"
“All Others” includes office equipment (e.g., computers, printers, copiers), domestic water heaters, kitchen appliances, plug loads, and other miscellaneous equipment not accounted for

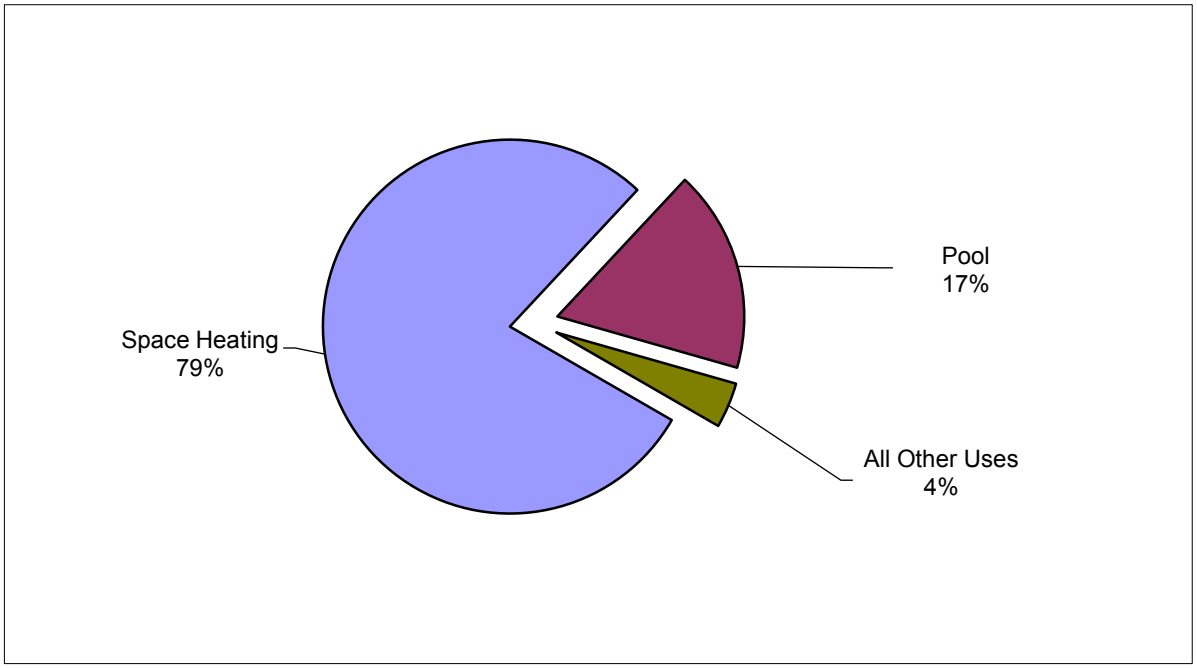


Natural Gas Energy Balance Summary - *Therms*

End Use	Space Heating	Pool	All Other Uses	TOTAL Therms
Cragmont Elementary School	5,870			**5,870**
% of Total	*100%*	*0%*	*0%*	***100%***
Berkeley High School	103,524	24,303	5,449	**133,276**
% of Total	*78%*	*18%*	*4%*	***100%***
TOTAL	**109,394**	**24,303**	**5,449**	**139,146**
% of Total	*79%*	*17%*	*4%*	***100%***

"Pool" use includes use in dehumidifier and pool heater

"All Others" includes domestic hot water & kitchen equipment



List of HVAC Systems - Berkeley High School

Exhaust Fans

Fan Type	Facility	Area (Sq. Ft.)	Fan HP / 1000 Sq. Ft.	Total Fan HP	Motor Eff.	Ave. Load Factor	Ave. Use Hours	kWh/ Year [1]
Exhaust Fan	Jackets Pool	8,000	0.25	2.00	85%	84%	8,760	12,916
Exhaust Fan	Donahue Gym	18,000	0.10	1.80	85%	84%	8,760	11,625
Exhaust Fan	G and H buildings	122,000	0.10	12.20	81%	80%	1,800	16,180
TOTAL		148,000	0.11	16.00				40,721

Heating and Ventilating Systems

			Fan/Pump Energy Use					*Natural Gas Heat Energy Use*				
Unit ID	Area Served	# of Units	Motor HP	Motor Eff.	Ave. Load Factor	Annual Use Hours	kWh/ Year [1]	Max Input (MBH)	AFUE / Eff.	Ave. Load Factor	Annual Use Hours	Therms/ Year
AH - 1 to AH - 4 Supply Fans	Donahue Gym	4	5	85%	80%	1,800	25,276	1080	82%	44%	1,800	10,530
AH - 1 to AH - 4 Return Fans	Donahue Gym	4	3	85%	80%	1,800	15,166					
Heating (HHW) Pump	Donahue Gym	1	1 1/2	85%	80%	800	843					
AH1 Supply Fan	G and H Buildings	2	10	90%	80%	1,800	24,005					
AH2 Supply Fan	G and H Buildings	2	15	91%	80%	1,800	35,415					
AH3 Supply Fan	G and H Buildings	2	25	92%	80%	1,800	58,574					
AH4 Supply Fan	G and H Buildings	2	20	91%	80%	1,800	47,219					
AH1 Return Fan	G and H Buildings	2	7 1/2	89%	80%	1,800	18,207					
AH2 Return Fan	G and H Buildings	2	10	90%	80%	1,800	24,005					
AH3 Return Fan	G and H Buildings	2	20	91%	80%	1,800	47,219					
AH4 Return Fan	G and H Buildings	2	15	91%	80%	1,800	35,415					
Heating Coils in Rooms	G and H Buildings		0					7320	85%	46%	1,800	71,368
TOTAL		**25**					**331,344**					**81,898**

[1] Estimated kWh = [HP x 0.746 x LF / Eff] x Usage Hours
[2] Equipment data based on as-built plans and site observations
[3] Heating Coil Max Input estimated based on 0.06 MBH/sq ft floorspace

Pool Dehumidifier

		Fan/Pump Energy Use					*Natural Gas Heat Energy Use*					*Air Conditioning Energy Use*					
Unit ID	Component	Motor HP	Motor Eff.	Ave. Load Factor	Annual Use Hours	kWh/ Year [1]	Max Input (MBH)	AFUE / Eff.	Ave. Load Factor	Annual Use Hours	Therms/ Year	Tons Capacity	COP	Max kW	Ave. Load Factor	Annual Use Hours	kWh/ Year
Jackets Pool Dehumidifier	Supply Fan	40	93%	90%	8,760	252,966											
Jackets Pool Dehumidifier	Heating Coil						480	80%	14%	8,760	7,588						
Jackets Pool Dehumidifier	AC											50	5	35.3	23%	8760	69,727
TOTAL						**252,966**					**7,588**						**69,727**

List of HVAC Systems - Cragmont Elementary School

Fan Type	Facility	Area (Sq. Ft.)	Fan HP / 1000 Sq. Ft.	Total Fan HP	Motor Eff.	Ave. Load Factor	Ave. Use Hours	kWh/ Year [1]
Exhaust Fan	Cragmont Elementary School	50,000	0.10	5.00	78%	80%	1,800	6,886
Heating & Ventilation Unit Fan	Cragmont Elementary School	50,000	0.25	12.50	81%	80%	1,800	16,578
Total	Cragmont Elementary School	50,000						23,464

[1] Estimated kWh = [HP x 0.746 x LF / Eff] x Usage Hours

Summary of Lighting Systems

Facility	Cragmont Elementary School	Berkeley High School
GSF	50,000	550,000
Interior Lighting Estimate		
Basis for kWh Estimate	***Square Footage***	***Square Footage***
Watts/Sq. Ft.	1.5	1.1
Estimated Interior Lighting Load (kW)	75.0	605.0
Diversity Factor	0.65	0.6
Average Interior Lighting Load (kW)	48.8	363.0
Average Hours per Day	10	10
Typical Days per Year	180	180
Lighting Operational Hours per Year	1,800	1,800
Estimated Interior Lighting kWh	87,750	653,400
Exterior Lighting Estimate		
Basis for kWh Estimate	***Square Footage***	***Square Footage***
Estimated Exterior Lighting (W/Sq.Ft.)	0.02	0.01
Total Exterior Lighting Load (kW)	1.0	5.5
Average Hours per Day	10	10
Typical Days per Year	365	365
Average Exterior Lighting Hours	3,650	3,650
Estimated Exterior Lighting kWh	3,650	20,075
TOTAL LIGHTING kWh	**91,400**	**673,475**

Appendix C

Energy Efficiency Measure Calculations

Project L-1 **Replace 32-watt T8 lamps with 28-watt T8 lamps**

Cost Factors

Tax Rate	9.5%
Sub Contractor Overhead & Profit Multiplier	1.20
City Location Price Multiplier	1.168

Cragmont Elementary

Item	Qty.	Units	Unit Material Cost ($)	Unit Labor Hours	Average Labor Rate	Unit Labor Cost ($)	Unit Equipment Cost ($)	Total Unit Cost ($)	Material Cost ($)	Labor Cost ($)	Equipment Cost ($)	Taxes ($)	TOTAL DIRECT COST ($)	CONTRACTOR COST WITH SUB O&P
Fixture Cleaning and Repairs	633	Ea.	$ 0.25	0.15	$ 25	$ 4	$ 2	$ 6	$ 158	$ 2,374	$ 1,266	$ 15	$ 4,454	$ 5,344
New 28-watt T8 fluorescent lamps	1899	Ea.	$ 2.00	0.025	$ 25	$ 1		$ 3	$ 3,798	$ 1,187	$ -	$ 361	$ 6,244	$ 7,493
Disposal of old 32-watt T8 lamps	1899	Ea.	$ 0.25	0.025	$ 25	$ 1		$ 1	$ 475	$ 1,187	$ -	$ 45	$ 1,993	$ 2,392
INSTALLING CONTRACTOR COST														$ 15,229
General Contractor O&P	0%													$ -
Construction Contingency	15%													$ 2,284
Construction Cost with Contingency														$ 17,513
Soft Costs Markup (i.e. design, CM, Cx)	20%													$ 3,046
TOTAL PROJECT BUDGET														**$ 20,559**

Berkeley High School

Item	Qty.	Units	Unit Material Cost ($)	Unit Labor Hours	Average Labor Rate	Unit Labor Cost ($)	Unit Equipment Cost ($)	Total Unit Cost ($)	Material Cost ($)	Labor Cost ($)	Equipment Cost ($)	Taxes ($)	TOTAL DIRECT COST ($)	CONTRACTOR COST WITH SUB O&P
Fixture Cleaning and Repairs	2,697	Ea.	$ 0.25	0.15	$ 25	$ 4	$ 2	$ 6	$ 674	$ 10,114	$ 5,394	$ 64	$ 18,975	$ 22,770
New 28-watt T8 fluorescent lamps	5572	Ea.	$ 2.00	0.025	$ 25	$ 1		$ 3	$ 11,144	$ 3,483	$ -	$ 1,059	$ 18,320	$ 21,984
Disposal of old 32-watt T8 lamps	5572	Ea.	$ 0.25	0.025	$ 25	$ 1		$ 1	$ 1,393	$ 3,483	$ -	$ 132	$ 5,849	$ 7,019
INSTALLING CONTRACTOR COST														$ 51,774
General Contractor O&P	0%													$ -
Construction Contingency	15%													$ 7,766
Construction Cost with Contingency														$ 59,540
Soft Costs Markup (i.e. design, CM, Cx)	20%													$ 10,355
TOTAL PROJECT BUDGET														**$ 69,895**

Project L-1 **Replace 32-watt T8 lamps with 28-watt T8 lamps**

School	Bldg	fixture	# fixtures	lamps/fixtu	W/fix now	kW now	W/fix after	kW after	hr/yr	kWh/yr now	kWh/yr after
Berkeley High	G&H	2-F32T8	2512	2	58	145.7	48	120.6	1800	262,253	217,037
Berkeley High	G&H	3-F32T8	154	3	83	12.8	72	11.1	1800	23,008	19,958
Berkeley High	Donahue	6-F32T8	6	6	166	1.0	144	0.9	1800	1,793	1,555
Berkeley High	Donahue	2-F32T8	25	2	58	1.5	48	1.2	1800	2,610	2,160
Cragmont	all	3-F32T8	633	3	83	52.5	72	45.6	1800	94,570	82,037
Total			3330			213.5		179.3		384,233	322,747

Value of Electricity
Cragmont $0.18584
Berkeley High $0.16475 /kWh

Project Summary

	Cragmont	Berkeley H	Total
Total kW Saved	7.0	27.2	34.2
Total kWh Saved	12,533	48,953	61,486
% Savings from Baseline	13%	17%	16%
Electricity Rate ($/kWh)	$0.18584	$0.16475	$0.167
Total Electricity Savings ($)	$2,329	$8,065	$10,394
Project Cost ($)	$20,559	$69,895	$90,454
Incentive Rate ($/kWh)	$0.08	$0.08	$0.08
Incentive Rate ($/kW)	$150.00	$150.00	$150.00
Estimated Incentive ($)	$2,047	$7,996	$10,043
Project Cost with Incentive ($)	$18,512	$61,899	$80,411
Simple Payback Period w/out Incentive (years)	8.8	8.7	8.7
Simple Payback Period with Incentive (years)	7.9	7.7	7.7

Facility	# fix	kW Saved	kWh Saved	Rate ($/kWh)	Project Cost ($)	Cost Savings ($)	Payback Period without Incentive (Years)	Approx. Incentive ($)	Project Costs w/ Incentive ($)	Payback Period with Incentive (Years)
Cragmont Elementary	633	7.0	12,533	$0.186	$20,559	$2,329	8.8	$2,047	$18,512	7.9
Berkeley High	2,697	27.2	48,953	$0.165	$69,895	$8,065	8.7	$7,996	$61,899	7.7
Total	**3,330**	**34.2**	**61,486**	**$0.167**	**$90,454**	**$10,394**	**8.7**	**$10,043**	**$80,411**	**7.7**

Project L-1alt **Replace 32-watt T8 lamps with LED tubes**

Cost Factors

Tax Rate	9.5%
Sub Contractor Overhead & Profit Multiplier	1.20
City Location Price Multiplier	1.168

Cragmont Elementary

Item	Qty.	Units	Unit Material Cost ($)	Unit Labor Hours	Average Labor Rate	Unit Labor Cost ($)	Unit Equipment Cost ($)	Total Unit Cost ($)	Material Cost ($)	Labor Cost ($)	Equipment Cost ($)	Taxes ($)	TOTAL DIRECT COST ($)	CONTRACTOR COST WITH SUB O&P
Fixture Cleaning and Repairs	633	Ea.	$ 0.25	0.15	$ 25	$ 4	$ 2	$ 6	$ 158	$ 2,374	$ 1,266	$ 15	$ 4,454	$ 5,344
New 16-watt LED tubes	1899	Ea.	$ 16.00	0.025	$ 25	$ 1		$ 17	$ 30,384	$ 1,187	$ -	$ 2,886	$ 40,246	$ 48,295
Disposal of old 32-watt T8 lamps	1899	Ea.	$ 0.25	0.025	$ 25	$ 1		$ 1	$ 475	$ 1,187	$ -	$ 45	$ 1,993	$ 2,392
INSTALLING CONTRACTOR COST														$ 56,032
General Contractor O&P	0%													$ -
Construction Contingency	15%													$ 8,405
Construction Cost with Contingency														$ 64,437
Soft Costs Markup (i.e. design, CM, Cx)	20%													$ 11,206
TOTAL PROJECT BUDGET														**$ 75,643**

Berkeley High School

Item	Qty.	Units	Unit Material Cost ($)	Unit Labor Hours	Average Labor Rate	Unit Labor Cost ($)	Unit Equipment Cost ($)	Total Unit Cost ($)	Material Cost ($)	Labor Cost ($)	Equipment Cost ($)	Taxes ($)	TOTAL DIRECT COST ($)	CONTRACTOR COST WITH SUB O&P
Fixture Cleaning and Repairs	2,697	Ea.	$ 0.25	0.15	$ 25	$ 4	$ 2	$ 6	$ 674	$ 10,114	$ 5,394	$ 64	$ 18,975	$ 22,770
New 16-watt LED tubes	5572	Ea.	$ 16.00	0.025	$ 25	$ 1		$ 17	$ 89,152	$ 3,483	$ -	$ 8,469	$ 118,089	$ 141,707
Disposal of old 32-watt T8 lamps	5572	Ea.	$ 0.25	0.025	$ 25	$ 1		$ 1	$ 1,393	$ 3,483	$ -	$ 132	$ 5,849	$ 7,019
INSTALLING CONTRACTOR COST														$ 171,497
General Contractor O&P	0%													$ -
Construction Contingency	15%													$ 8,405
Construction Cost with Contingency														$ 179,902
Soft Costs Markup (i.e. design, CM, Cx)	20%													$ 11,206
TOTAL PROJECT BUDGET														**$ 191,108**

Project Savings Estimate

Project L-1alt **Replace 32-watt T8 lamps with LED tubes**

School	Bldg	fixture	# fixtures	lamps/fixtu	W/fix now	kW now	W/fix after	kW after	hr/yr
Berkeley High	G&H	2-F32T8	2512	2	58	145.7	34	85.4	1800
Berkeley High	G&H	3-F32T8	154	3	83	12.8	51	7.9	1800
Berkeley High	Donahue	6-F32T8	6	6	166	1.0	102	0.6	1800
Berkeley High	Donahue	2-F32T8	25	2	58	1.5	34	0.9	1800
Cragmont	all	3-F32T8	633	3	83	52.5	51	32.3	1800
Total			3330			213.5		127.0	

Value of Electricity

Cragmont	$0.18584
Berkeley High	$0.16475 /kWh

Project Summary

	Cragmont	Berkeley H	Total
Total kW Saved	20.3	66.2	86.5
Total kWh Saved	36,461	119,160	155,621
% Savings from Baseline	39%	41%	41%
Electricity Rate ($/kWh)	$0.18584	$0.16475	$0.167
Total Electricity Savings ($)	$6,776	$19,632	$26,408
Project Cost ($)	$75,643	$191,108	$266,751
Incentive Rate ($/kWh)	$0.08	$0.08	$0.08
Incentive Rate ($/kW)	$150.00	$150.00	$150.00
Estimated Incentive ($)	$5,955	$19,463	$25,418
Project Cost with Incentive ($)	$69,688	$171,645	$241,333
Simple Payback Period w/out Incentive (years)	11.2	9.7	10.1
Simple Payback Period with Incentive (years)	10.3	8.7	9.1

Facility	# fix	kW Saved	kWh Saved	Rate ($/kWh)	Project Cost ($)	Cost Savings ($)	Payback Period without Incentive (Years)	Approx. Incentive ($)	Project Costs w/ Incentive ($)
Cragmont Elementary	633	20.3	36,461	$0.186	$75,643	$6,776	11.2	$5,955	$69,688
Berkeley High	2,697	66.2	119,160	$0.165	$191,108	$19,632	9.7	$19,463	$171,645
Total	**3,330**	**86.5**	**155,621**	**$0.167**	**$266,751**	**$26,408**	**10.1**	**$25,418**	**$241,333**

Project L-2 **LED floodlights for Jackets Pool at Berkeley High School**

Cost Factors

Tax Rate	9.5%
Sub Contractor Overhead & Profit Multiplier	1.20
City Location Price Multiplier	1.168

Item	Qty.	Units	Unit Material Cost ($)	Unit Labor Hours	Average Labor Rate	Unit Labor Cost ($)	Unit Equipment Cost ($)	Total Unit Cost ($)	Material Cost ($)	Labor Cost ($)	Equipment Cost ($)	Taxes ($)	TOTAL DIRECT COST ($)	CONTRACTOR COST WITH SUB O&P
Demolition & Disposal	32	Ea.	$ -	2	$ 32	$ 64	$ 25	$ 89	$ -	$ 2,048	$ 800	$ -	$ 3,326	$ 3,992
New 576-watt LED floodlights	32	Ea.	$ 1,500	4	$ 55	$ 220	$ 50	$ 1,770	$ 48,000	$ 7,040	$ 1,600	$ 4,560	$ 71,482	$ 85,778
New Occupancy Sensors, Photocells, Powerp	1	Ea.	$ 2,000	18	$ 55	$ 990		$ 2,990	$ 2,000	$ 990	$ -	$ 190	$ 3,714	$ 4,457
Low Voltage Wiring; Communication Wiring; and Conduit (ft)	250	linear feet	$ 2.50	$ 0.15	$ 55	$ 8		$ 11	$ 625	$ 2,063	$ -	$ 59	$ 3,208	$ 3,850
Start-up and Commissioning	1	Ea.	$ -	6	$ 55	$ 330		$ 330	$ -	$ 330	$ -	$ -	$ 385	$ 463
INSTALLING CONTRACTOR COST														$ 98,539
General Contractor O&P	0%													$ -
Construction Contingency	15%													$ 14,781
Construction Cost with Contingency														$ 113,320
Soft Costs Markup (i.e. design, CM, Cx)	20%													$ 19,708
TOTAL PROJECT BUDGET														**$ 133,028**

Notes:
[1] New floodlight material cost based on quotation from vendor

Project L-2 **LED floodlights for Jackets Pool at Berkeley High School**

Existing Fixture Wattag	1080	Watts
Number of Fixtures	32	

Proposed Fixture Watt	576	Watts
Number of Fixtures	32	

Current Operation								
School Yea	180 day/yr, 6a - 5p			36	5	11	1980	
Spring swir	Sat am	Feb	May	17	1	2	34	
Spring swir	Wed eve a	Feb	May	17	1	4	68	
							2082	
Operation with new fixtures and occupancy sensor and photocell controls								
School Yea	180 day/yr, 6a - 5p			36	5	2.75	495	*75% savings*
Spring swir	Sat am	Feb	May	17	1	2	34	
Spring swir	Wed eve a	Feb	May	17	1	4	68	
							597	

Current Electricity Use	71,954	kWh/yr
Estimated Electricity U	11,004	kWh/yr
Estimated Electricity S	60,950	kWh/yr
Estimated Demand Sa	16.1	kW
Value of Electricity	$0.18584	/kWh

Project Summary

Total kW Saved	16.1
Total kWh Saved	60,950
% Savings from Baseline	84.7%
Electricity Rate ($/kWh) [2]	$0.165
Total Electricity Savings ($)	$10,042
Project Cost ($)	$133,028
Incentive Rate ($/kWh)	$0.08
Incentive Rate ($/kW)	$150.00
Estimated Incentive ($)	$7,295
Project Cost with Incentive ($)	$125,733
Simple Payback Period w/out Incentive (years)	13.2
Simple Payback Period with Incentive (years)	12.5

Facility	# fixtures	kW Saved	kWh Saved	Rate ($/kWh)	Project Cost ($)	Cost Savings ($)	Payback Period without Incentive (Years)	Approx. Incentive ($)	Project Costs w/ Incentive ($)	Payback Period with Incentive (Years)
Berkeley High-Jackets Pool	32	16.1	60,950	$0.165	$133,028	$10,042	13.2	$7,295	$125,733	12.5

Project L-3

Add daylight controls to interior lighting fixtures serving most classrooms in G and H buildings at Berkeley High School

Cost Factors

Tax Rate	9.5%
Sub Contractor Overhead & Profit Multiplier	1.20
City Location Price Multiplier	1.168

Item	Qty.	Units	Unit Material Cost ($)	Unit Labor Hours	Average Labor Rate	Unit Labor Cost ($)	Unit Equipment Cost ($)	Total Unit Cost ($)	Material Cost ($)	Labor Cost ($)	Equipment Cost ($)	Taxes ($)	TOTAL DIRECT COST ($)	CONTRACTOR COST WITH SUB O&P
Photocell and Switchpack	72	Ea.	$ 250.00	0.15	$ 55	$ 8		$ 258	$ 18,000	$ 594	$ -	$ 1,710	$ 23,715	$ 28,458
Low Voltage Wiring and Conduit	1440	linear feet	$ 3.00	0.15	$ 55	$ 8	$ 1	$ 12	$ 4,320	$ 11,880	$ 1,440	$ 410	$ 21,083	$ 25,299
Commissioning and Training	1	Ea.		16	$ 55	$ 880		$ 880	$ -	$ 880	$ -	$ -	$ 1,028	$ 1,233
INSTALLING CONTRACTOR COST														$ 54,991
General Contractor O&P	0%													$ -
Construction Contingency	15%													$ 8,249
Construction Cost with Contingency														$ 63,240
Soft Costs Markup (i.e. design, CM, Cx)	20%													$ 12,648
TOTAL PROJECT BUDGET														**$ 75,887**

Project L-3 **Add daylight controls to interior lighting fixtures serving most classrooms in G and H buildings High School**

Berkeley High G&H Buildings

Lighting fixture	# fixtures	# by window	W/fix	kW	hr/yr before photocell	kWh/yr before photocell	hr/yr after photocell	kWh/yr after
2-F32T8	2512	480	58	27.8	1800	50,112	1440	40,090
3-F32T8	154	96	83	8.0	1800	14,342	1440	11,474
Totals	2666			35.8		64,454		51,564

Value of Electricity
Berkeley High $0.16475 /kWh

Project Summary

Facility	# fix	kW Saved	kWh Saved	Rate ($/kWh)	Project Cost ($)	Cost Savings ($)	Payback Period without Incentive (Years)	Approx. Incentive ($)	Project Costs w/ Incentive ($)
Berkeley High	576	0.0	12,891	$0.095	$75,887	$1,218	62.3	$1,031	$74,856

Project Cost Estimate

Project M-1: EMS Expansion to Jackets Pool HVAC

Cost Factors

Tax Rate	9.5%
Sub Contractor Overhead & Profit Multiplier	1.20
City Location Price Multiplier	1.168

Item #	Description	Qty.	Units	Unit Material Cost ($)	Unit Labor Hours	Average Labor Rate	Unit Labor Cost ($)	Unit Equipment Cost ($)	Total Unit Cost ($)	Material Cost ($)	Labor Cost ($)	Equipment Cost ($)	Taxes ($)	TOTAL DIRECT COST ($)	CONTRACTOR COST WITH SUB O&P
1	Covers, winches, cables, pulleys, manual switches [1]	1	Ea.	$ 105,000	480	$ 55	$ 26,400	$ 5,000	$ 136,400	$ 105,000	$ 26,400	$ 5,000	$ 9,975	$ 170,966	$ 205,159
2	New processor and panel for pool dehumidifier [2]	1	Ea.	$ 20,570	32	$ 55	$ 1,760		$ 22,330	$ 20,570	$ 1,760	$ -	$ 1,954	$ 28,364	$ 34,037
3	Occupancy sensors for pool room	4	Ea.	$ 200	2	$ 55	$ 110	$ 50	$ 360	$ 800	$ 440	$ 200	$ 76	$ 1,771	$ 2,125
4	Humidity and CO2 sensors for pool room	3	Ea.	$ 800	4	$ 55	$ 220	$ 50	$ 1,070	$ 2,400	$ 660	$ 150	$ 228	$ 4,016	$ 4,819
5	EMS field controller	1	Ea.	$ 4,000		$ 55	$ -		$ 4,000	$ 4,000	$ -	$ -	$ 380	$ 5,116	$ 6,139
6	Motor Demolition & Disposal	1	Ea.	$ -	2	$ 55	$ 110		$ 110	$ -	$ 110	$ -	$ -	$ 128	$ 154
7	New 40-hp Premium Efficiency	1	Ea.	$ 3,000	6	$ 55	$ 330		$ 3,330	$ 3,000	$ 330	$ -	$ 285	$ 4,222	$ 5,067
8	Variable speed drive for pool dehumidifier supply fan (40 hp 460V) [3]	1	Ea.	$ 4,000	16	$ 55	$ 880		$ 4,880	$ 4,000	$ 880	$ -	$ 380	$ 6,144	$ 7,372
9	Pool Water Piping for Heat Recovery from Dehumidifier (ft)	150	linear feet	$ 31	0.5	$ 55	$ 28		$ 59	$ 4,650	$ 4,125	$ -	$ 442	$ 10,765	$ 12,918
10	Connections, Chases, and Repairs for Heat Recovery from Dehumidifier	1	Ea.	$ 2,500	40	$ 55	$ 2,200	$ 2,500	$ 7,200	$ 2,500	$ 2,200	$ 2,500	$ 238	$ 8,687	$ 10,424
11	Electrical power wiring, cable and conduit	250	linear feet	$ 9	0.25	$ 55	$ 14		$ 23	$ 2,250	$ 3,438	$ -	$ 214	$ 6,893	$ 8,271
12	Low Voltage Wiring; Communication Wiring; and Conduit	250	linear feet	$ 2.50	0.15	$ 55	$ 8		$ 11	$ 625	$ 2,063	$ -	$ 59	$ 3,208	$ 3,850
13	Programming	1	Ea.	$ -	12	$ 55	$ 660		$ 660	$ -	$ 660	$ -	$ -	$ 771	$ 925
14	Start up & Testing	1	Ea.	$ -	16	$ 55	$ 880		$ 880	$ -	$ 880	$ -	$ -	$ 1,028	$ 1,233
	INSTALLING CONTRACTOR COST														$ 252,433
	General Contractor O&P	0%													$ -
	Construction Contingency	15%													$ 37,865
	Construction Cost with Contingency														
	Soft Costs Markup (i.e. design	20%													$ 50,487
	TOTAL PROJECT BUDGET														**$ 340,784**

Notes
[1] Budgetary equipment cost provided by Alta Enterprises
[2] Budgetary equipment cost provided by Norman-Wright
[3] Equipment cost based on prices from Automation Direct website

Project M-1: EMS Expansion to Jackets Pool HVAC

Summary of Savings

Equipment	Current Consumption	With Covers and Variable Speed Drive	With Heat Recovery from Dehumidifier	Energy Savings
Pool Heater [1]	16,715 Therms/yr	6,111 Therms/yr	1,986 Therms/yr	14,729 Therms/yr
Dehumidifier [1]	69,727 kWh/yr	16,715 kWh/yr	16,715 kWh/yr	53,012 kWh/yr
Supply Fan in Dehumidifier and Exhaust Fans [2]	252,966 kWh/yr	115,604 kWh/yr	115,604 kWh/yr	137,362 kWh/yr
Space Heater [3]	7,588 Therms/yr	1,530 Therms/yr	1,530 Therms/yr	6,058 Therms/yr
Natural Gas Total	24,303 Therms/yr			20,787 Therms/yr
Electricity Total	322,693 kWh/yr			190,374 kWh/yr
Water Savings				115,045 gal/yr

Notes
[1] See PoolCalc sheets for calculation of savings in pool heater and dehumidifier
[2] See Fan Energy Savings sheet for calculation of savings in air supply and exhaust fans
[3] See Exhaust Air Heat Loss Reduction sheets

Pool Occupancy Schedule

		From	To	Weeks	Day/wk	Hr/day	Hr/yr
Spring swim and dive	M-F except Wed	Feb	May	17	4	6	408
Spring swim and dive	Sat am	Feb	May	17	1	2	34
Spring swim and dive	Wed	Feb	May	17	1	13	221
Fall water polo	M-F except Wed	Aug	Nov	13	5	6	390
PE classes	1-2 classes/day	Aug	June	36	5	2	360
							1413

Max Pool Uncovered Sched

School Year	180 day/yr, 6a - 5p			36	5	11	1980
Spring swim and dive	Sat am	Feb	May	17	1	2	34
Spring swim and dive	Wed eve additional hours	Feb	May	17	1	4	68
							2082

Exhaust Schedule

	Daytype	12:00 AM	1:00 AM	2:00 AM	3:00 AM	4:00 AM	5:00 AM	6:00 AM	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM	8:00 PM	9:00 PM	10:00 PM	11:00 PM
Baseline	all days	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500
With Covers	schooldays	0	0	0	0	0	0	0	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	0	0	0	0	0	0
With Covers	Sat-Sun-Hol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Indoor Temp 80 degrees F

Baseline Exhaust Heat Loss	2,428	MMBtu/yr
Exhaust Heat Loss with Covers	490	MMBtu/yr
Savings in Heat Loss	1,939	
Estimated amount from Boiler	25%	
Space Heating Boiler Efficiency	80%	
Natural Gas Savings	6,058	

Outdoor Air Temperatures, degrees F

Date	Daytype	12:00 AM	1:00 AM	2:00 AM	3:00 AM	4:00 AM	5:00 AM	6:00 AM	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM	8:00 PM	9:00 PM	10:00 PM	11:00 PM
Wed 1/1		39	40	37	39	35	35	35	36	37	42	43	44	45	45	46	45	44	43	40	39	40	38	37	36
Thu 1/2		36	35	33	34	33	34	32	33	37	40	42	44	46	45	47	47	47	45	44	44	44	44	43	42
Fri 1/3		41	41	40	41	41	41	42	42	44	49	52	54	53	53	54	53	51	51	50	50	50	51	50	51
Sat 1/4		50	50	50	50	50	48	48	48	51	51	53	53	53	53	53	53	53	53	53	53	53	53	53	53
Sun 1/5		53	53	53	53	53	53	52	51	52	55	55	56	56	57	56	57	56	56	55	55	55	55	54	52
Mon 1/6	schoolday	51	50	50	50	50	51	50	52	52	51	53	56	58	59	59	60	57	55	54	54	52	51	50	51
Tue 1/7	schoolday	51	50	49	50	48	48	48	49	49	49	51	53	54	53	53	53	53	52	53	52	54	54	54	53
Wed 1/8	schoolday	52	51	50	49	50	50	49	50	52	54	53	56	55	54	55	55	54	52	51	51	50	48	46	48
Thu 1/9	schoolday	47	42	42	41	40	40	40	42	46	48	46	45	50	53	52	53	52	51	49	48	49	47	45	41
Fri 1/10	schoolday	40	41	39	39	38	40	38	39	45	46	47	49	50	51	51	51	52	50	50	48	44	46	46	45
Sat 1/11		44	41	40	39	40	42	43	43	44	43	43	48	50	51	51	54	50	49	49	45	49	43	43	40
Sun 1/12		40	39	38	39	37	37	37	40	44	48	50	51	54	55	55	55	54	51	51	47	45	45	48	42
Mon 1/13	schoolday	41	42	41	43	42	39	41	44	46	48	49	50	52	53	54	53	52	51	51	51	50	50	47	45
Tue 1/14	schoolday	45	42	42	42	42	40	39	41	43	44	45	44	51	55	57	56	54	53	53	52	51	48	51	50
Wed 1/15	schoolday	46	45	43	43	42	43	42	43	50	53	55	57	60	62	63	64	62	58	59	59	56	56	56	53
Thu 1/16	schoolday	50	50	50	52	51	50	45	49	52	55	57	58	58	59	60	59	56	55	56	48	51	49	53	50
Fri 1/17	schoolday	47	49	48	49	48	45	45	45	48	52	55	57	57	59	60	58	55	53	48	46	46	43	43	42
Sat 1/18		40	36	38	37	37	36	37	40	43	45	47	48	50	52	52	53	52	49	48	47	45	43	42	43
Sun 1/19		42	42	42	42	42	40	40	40	45	47	48	50	50	51	52	53	51	49	49	48	48	43	43	37
Mon 1/20		38	37	36	35	33	36	34	36	41	46	51	51	53	55	56	54	52	50	49	47	43	41	41	41
Tue 1/21	schoolday	40	36	35	35	36	33	35	36	41	44	47	48	50	51	53	52	50	47	47	47	48	48	48	48
Wed 1/22	schoolday	48	48	48	46	47	43	44	44	46	50	48	52	52	53	51	51	50	49	47	47	48	46	45	44
Thu 1/23	schoolday	44	42	41	39	38	37	37	40	41	47	47	49	49	50	48	50	49	46	46	43	43	40	44	43
Fri 1/24		41	42	39	39	38	39	40	41	42	44	47	47	50	52	52	52	52	49	48	47	45	45	42	41
Sat 1/25		39	37	37	37	36	35	36	38	43	44	45	47	47	49	49	52	50	48	48	47	47	45	43	43
Sun 1/26		44	41	40	41	40	39	40	43	44	45	49	54	57	59	59	59	57	54	52	53	52	53	51	48
Mon 1/27	schoolday	47	45	45	46	44	42	41	45	51	52	54	57	58	58	60	60	56	54	53	52	50	49	48	43
Tue 1/28	schoolday	43	41	40	38	39	37	38	39	45	47	50	51	52	56	61	58	54	52	53	53	53	53	53	52
Wed 1/29	schoolday	52	52	51	51	51	50	50	50	51	53	57	55	53	53	48	49	48	48	47	46	46	45	45	45
Thu 1/30	schoolday	45	46	45	45	46	46	46	45	46	48	51	53	54	53	52	53	51	50	48	49	48	49	48	47
Fri 1/31	schoolday	46	46	45	43	44	44	43	45	46	50	51	50	51	52	50	53	52	50	48	49	49	49	49	49
Sat 2/1		48	48	47	46	46	46	46	47	48	49	51	54	56	56	57	57	55	54	52	52	51	51	49	47
Sun 2/2		45	44	43	42	43	43	44	45	45	46	47	49	50	50	51	51	50	50	49	48	46	45	45	46
Mon 2/3	schoolday	46	45	45	44	44	44	44	44	45	45	47	50	52	53	55	56	54	53	51	50	50	49	48	47
Tue 2/4	schoolday	46	46	45	45	44	43	42	44	46	48	51	53	56	57	59	60	58	56	54	54	53	53	51	48
Wed 2/5	schoolday	46	46	45	45	45	44	44	46	49	51	52	54	55	55	56	56	55	54	53	53	52	52	52	53
Thu 2/6	schoolday	53	52	51	50	50	51	51	51	51	51	53	55	57	58	59	60	58	55	53	52	52	51	51	50
Fri 2/7	schoolday	50	48	47	45	46	46	47	47	48	48	51	55	58	58	59	59	57	56	54	54	55	55	54	54
Sat 2/8		53	53	53	53	52	51	50	52	54	56	56	57	57	56	55	54	54	54	54	53	53	52	51	51

Project M-1: EMS Expansion to Jackets Pool HVAC

Pool Dehumidifier Fan Savings

	Existing	*Proposed*
Fan H.P.	40	40
Motor Efficiency [1]	**93.0%**	**94.1%**
Ave. Fan Load Factor (%)	90%	90%
Fan kW	28.9	*(see below)*
Operating Schedule		*same*
TotalOperating Hours	8,760	8,760
Equipment Use Factor	100%	100%
Total Fan Operating Hours	8,760	8,760
Fan kWh	252,966	*(see below)*

Proposed Operation of Pool Dehumifier Fan

Motor Characteristics with VFD						Duty Cycle Estimate		
Motor Speed	Volume or Flow	Ideal Motor H.P. (% of rated)	Actual Motor H.P. (% of rated)	Motor H.P.	Motor kW	% of Total Operating Hours	Hour per Year	kWh
20%	20%	0.8%	10.4%	4.2	3.0	60%	5,256	15,601
30%	30%	2.7%	20.0%	8.0	5.7	0%	0	0
40%	40%	6.4%	23.0%	9.2	6.6	0%	0	0
50%	50%	12.5%	28.0%	11.2	8.0	0%	0	0
60%	60%	21.6%	36.0%	14.4	10.3	0%	0	0
70%	70%	34.3%	47.0%	18.8	13.4	0%	0	0
80%	80%	51.2%	61.0%	24.4	17.4	0%	0	0
90%	90%	72.9%	79.0%	31.6	22.5	0%	0	0
100%	100%	100.0%	100.0%	40.0	28.5	40%	3,504	100,004
						100%	8,760	**115,604**

Pool Room Exhaust Fans

	Existing	*Proposed*
Number of Fans	2	2
Fan H.P.	1	1
Motor Efficiency [1]	**85.0%**	**85.0%**
Ave. Fan Load Factor (%)	84%	84%
Fan kW	1.5	1.5
Operating Schedule		
TotalOperating Hours	8,760	3,504
Equipment Use Factor	100%	100%
Total Fan Operating Hours	8,760	3,504
Fan kWh	12,916	5,166

Project Summary

Total kW Saved	-
Total kWh Saved	145,112
% Savings from Baseline	57.4%

Notes

[1] Analysis also includes replacement of energy efficient motor with new inverter duty premium effiency motor

Heating & Dehumidification Costs due to Evaporation from Swimming Pools

INPUT
OUTPUT

Pass mouse over cells of base case to view comments
No password for protection

Water Surface Area (ft2)	6,225
Cost of heating fuel ($/MMBtu)	$6.84
Cost of dehumidification fuel ($/kWh)	$0.0950

Cost Conversion	
$0.0950	$/kWh
$27.84	$/MMBtu

	Base	ECM 1	ECM 2	ECM 3	ECM 4	ECM 5	ECM 6	ECM 7			
Description		Automate covers	Heat Recovery								
Water temperature (oF)	79	79	79	79	79	79	79	79			
Room air temperature (oF)	81	81	81	81	81	81	81	81			
Room relative humidity (%)	50%	50%	50%	50%	50%	50%	50%	50%	(Will be rounded to nearest 10%)		
Average number of people in pool	3	20	20	20	20	20	20	20			Av
Hours per year uncovered	8760	**2100**	2100	2100	2100	2100	2100	2100			
Occupied Time (% of uncovered hours)	15%	75%	75%	75%	75%	75%	75%	75%			Occupie
Efficiency or COP of water heater	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80			Ef
Is there dehumidification?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes			
Efficiency or COP of dehumidification	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00		1.18	Efficier
% Latent Heat Recovery (ht pmp dehum)	0%	0%	**75%**	75%	75%	75%	75%	75%			% Latent I
Other losses as a percent of total	10%	10%	10%	10%	10%	10%	10%	10%			Ot

HEATING AND DEHUMIDIFICATION DUE TO EVAPORATION FROM POOL SURFACE

Case	Indoor Temp oF	Indoor RH %	Water Temp oF	Heating Use MMBtu/yr	Heating Use $/yr	Dehumidification Use kWh/yr	Dehumidification Use $/yr	Heating Savings MMBtu/yr	Heating Savings $/yr	Dehumidification Savings kWh/yr	Dehumidification Savings $/yr	Total Savings $/yr	
Base	81	50%	79	1672	$11,436	69,727	$6,624	--	--	--	--		
ECM 1	81	55%	79	611	$4,181	16,715	$1,588	1060	$7,255	53012	$5,036	$12,291	75.7%
ECM 2	81	55%	79	199	$1,359	16,715	$1,588	1473	$10,077	53012	$5,036	$15,113	76.3%
ECM 3	81	55%	79	199	$1,359	16,715	$1,588	1473	$10,077	53012	$5,036	$15,113	
ECM 4	81	55%	79	199	$1,359	16,715	$1,588	1473	$10,077	53012	$5,036	$15,113	
ECM 5	81	55%	79	199	$1,359	16,715	$1,588	1473	$10,077	53012	$5,036	$15,113	
ECM 6	81	55%	79	199	$1,359	16,715	$1,588	1473	$10,077	53012	$5,036	$15,113	
ECM 7	81	55%	79	199	$1,359	16,715	$1,588	1473	$10,077	53012	$5,036	$15,113	

If you get a divide by zero error for dehumidification, enter a non-zero efficiency.

Project Cost Estimate

Project M-2 EMS Expansion and Variable Frequency Drive (VFD)

Cost Factors

Tax Rate	9.5%
Sub Contractor Overhead & Profit Multiplier	1.20
City Location Price Multiplier	1.168

Item #	Description	Qty.	Units	Unit Material Cost ($)	Unit Labor Hours	Average Labor Rate	Unit Labor Cost ($)	Unit Equipment Cost ($)	Total Unit Cost ($)	Material Cost ($)	Labor Cost ($)	Equipment Cost ($)	Taxes ($)	TOTAL DIRECT COST ($)	CONTRACTOR COST WITH SUB O&P
1	Demolition & Disposal	1	Ea.	$ -	4	$ 32	$ 128		$ 128	$ -	$ 128	$ -	$ -	$ 150	$ 179
2	New 25-hp Inverter Duty Pump Motor	1	Ea.	$ 5,145	4	$ 55	$ 220		$ 5,365	$ 5,145	$ 220	$ -	$ 489	$ 6,837	$ 8,205
3	New Variable Frequency Drive (VFD)	1	Ea.	$ 1,383	18	$ 55	$ 990		$ 2,373	$ 1,383	$ 990	$ -	$ 131	$ 2,925	$ 3,510
4	EMS field controller and interface to pool chemicals and UV light controls	1	Ea.	$ 4,000	16	$ 55	$ 880		$ 4,880	$ 4,000	$ 880	$ -	$ 380	$ 6,144	$ 7,372
5	Low Voltage Wiring; Communication Wiring; and Conduit (ft)	250	linear feet	$ 2.50	0.15	$ 55	$ 8		$ 11	$ 625	$ 2,063	$ -	$ 59	$ 3,208	$ 3,850
6	Start-up and Commissioning	1	Ea.		6	$ 55	$ 330		$ 330	$ -	$ 330	$ -	$ -	$ 385	$ 463
	INSTALLING CONTRACTOR COST														$ 23,579
	General Contractor O&P	0%													$ -
	Construction Contingency	15%													$ 3,537
	Construction Cost with Contingency														
	Soft Costs Markup (i.e. design, CM, Cx)	20%													$ 4,716
	TOTAL PROJECT BUDGET														**$ 31,832**

Notes

Project Savings Estimate

Project M-2 — **EMS Expansion and Variable Frequency Drive (VFD) for Jackets Pool at Berkeley High School**

Nameplate Data

Equipment:	Pool Circulation Pump
Qty.	1
Make	GE
Model	Severe Duty 5K264SAC221
S/N	SVP3192M901A
Speed	1770 rpm
Electrical	230/460V 3 ph 62.8/31.4A Fr L284HPH16 TEFC Des B Ins F

Baseline Use

	Existing	*Proposed*
Pump H.P. [1]	25	25
Motor Efficiency	**91.0%**	**93.6%**
Ave. Motor Load Factor (%)	90%	90%
Pump kW	18.4	*(see below)*
Operating Schedule	continuous	*same*
Pump kWh	161,579	*(see below)*

Proposed Use:

Motor Characteristics with VFD						Duty Cycle Estimate		
Motor Speed	Volume or Flow	Ideal Motor H.P. (% of rated)	Actual Motor H.P. (% of rated)	Motor H.P.	Motor kW	% of Total Operating Hours	Hour per Year	kWh
30%	30%	2.7%	50.7%	12.7	9.1	0%	0	0
40%	40%	6.4%	51.8%	13.0	9.3	0%	0	0
50%	50%	12.5%	54.3%	13.6	9.7	60%	5,256	51,181
60%	60%	21.6%	58.6%	14.6	10.5	0%	0	0
70%	70%	34.3%	65.0%	16.3	11.7	0%	0	0
80%	80%	51.2%	74.1%	18.5	13.3	0%	0	0
90%	90%	72.9%	86.0%	21.5	15.4	0%	0	0
100%	100%	100.0%	100.0%	25.0	17.9	40%	3,504	62,836
Totals						**100%**	**8,760**	**114,017**

Project Summary

Total kW Saved	-
Total kWh Saved	47,562
% Savings from Baseline	29.4%
Electricity Rate ($/kWh) [2]	$0.095
Total Electricity Savings ($)	$4,518
Project Cost ($)	$31,832
Incentive Rate ($/kWh)	$0.08
Estimated Incentive ($)	$3,805
Project Cost with Incentive ($)	$28,027
Simple Payback Period w/out Incentive (years)	7.0
Simple Payback Period with Incentive (years)	6.2

Facility	kW Saved	kWh Saved	Rate ($/kWh)	Natural Gas Therms Saved	Rate ($/Therm)	Project Cost ($)	Cost Savings ($)	Payback Period without Incentive (Years)	Approx. Incentive ($)	Project Costs w/ Incentive ($)	Payback Period with Incentive (Years)
Berkeley High-Jackets Pool	--	47,562	$0.095	--	$0.684	$31,832	$4,518	7.0	$3,805	$28,027	6.2

Project Cost Estimate

Project M-3: EMS expansion and variable frequency drives for air handler fans on Buildings G and H at Berkeley High School

Cost Factors

Tax Rate	9.5%
Sub Contractor Overhead & Profit Multiplier	1.20
City Location Price Multiplier	1.168

Item #	Description	Qty.	Units	Unit Material Cost ($)	Unit Labor Hours	Average Labor Rate	Unit Labor Cost ($)	Unit Equipment Cost ($)	Total Unit Cost ($)	Material Cost ($)	Labor Cost ($)	Equipment Cost ($)	Taxes ($)	TOTAL DIRECT COST ($)	CONTRACTOR COST WITH SUB O&P
1	Motor Demolition & Disposal	1	Ea.	$ -	2	$ 55	$ 110	$ 5,000	$ 5,110	$ -	$ 110	$ 5,000	$ -	$ 5,968	$ 7,162
2	New 7.5-hp Premium Efficiency Motor	2	Ea.	$ 1,200	6	$ 55	$ 330		$ 1,530	$ 2,400	$ 660	$ -	$ 228	$ 3,840	$ 4,608
3	New 10-hp Premium Efficiency Motor	4	Ea.	$ 1,300	6	$ 55	$ 330		$ 1,630	$ 5,200	$ 1,320	$ -	$ 494	$ 8,192	$ 9,831
4	New 15-hp Premium Efficiency Motor	4	Ea.	$ 1,600	6	$ 55	$ 330		$ 1,930	$ 6,400	$ 1,320	$ -	$ 608	$ 9,727	$ 11,673
5	New 20-hp Premium Efficiency Motor	4	Ea.	$ 1,800	6	$ 55	$ 330		$ 2,130	$ 7,200	$ 1,320	$ -	$ 684	$ 10,750	$ 12,900
6	New 25-hp Premium Efficiency Motor	2	Ea.	$ 2,000	6	$ 55	$ 330		$ 2,330	$ 4,000	$ 660	$ -	$ 380	$ 5,887	$ 7,064
7	New Variable Frequency Drive (15 HP)	1	Ea.	$ 1,000	8	$ 55	$ 440		$ 1,440	$ 1,000	$ 440	$ -	$ 95	$ 1,793	$ 2,151
8	New Variable Frequency Drive (20 HP)	2	Ea.	$ 1,300	8	$ 55	$ 440		$ 1,740	$ 2,600	$ 880	$ -	$ 247	$ 4,353	$ 5,224
9	New Variable Frequency Drive (30 HP)	2	Ea.	$ 1,800	8	$ 55	$ 440		$ 2,240	$ 3,600	$ 880	$ -	$ 342	$ 5,632	$ 6,759
10	New Variable Frequency Drive (40 HP)	2	Ea.	$ 2,400	8	$ 55	$ 440		$ 2,840	$ 4,800	$ 880	$ -	$ 456	$ 7,167	$ 8,600
11	New Variable Frequency Drive (50 HP)	1	Ea.	$ 2,900	8	$ 55	$ 440		$ 3,340	$ 2,900	$ 440	$ -	$ 276	$ 4,223	$ 5,067
12	Add control points to existing energy management syster	12	Ea.	$ 750	8	$ 55	$ 440		$ 1,190	$ 9,000	$ 5,280	$ -	$ 855	$ 17,678	$ 21,213
13	Programming	1	Ea.	$ -	8	$ 55	$ 440		$ 440	$ -	$ 440	$ -	$ -	$ 514	$ 617
14	Start up & Testing	1	Ea.	$ -	16	$ 55	$ 880		$ 880	$ -	$ 880	$ -	$ -	$ 1,028	$ 1,233
15	Training	1	Ea.		4	$ 55	$ 220		$ 220	$ -	$ 220	$ -	$ -	$ 257	$ 308
	INSTALLING CONTRACTOR COST														$ 104,411
	General Contractor O&P	0%													$ -
	Construction Contingency	15%													$ 15,662
	Construction Cost with Contingency														
	Soft Costs Markup (i.e. design, CM, Cx)	20%													$ 20,882
	TOTAL PROJECT BUDGET														**$ 140,956**

Project Savings Estimate

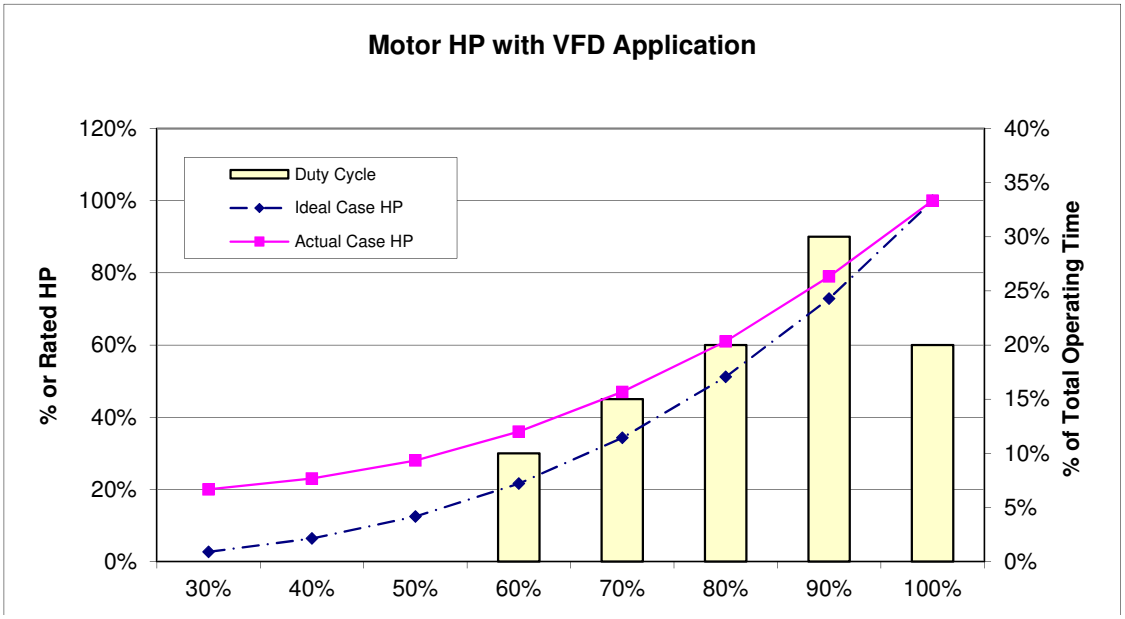
Project M-3:	**EMS expansion and variable frequency drives for air handler fans on Buildings G and H at Berkeley High School**

Baseline Use

	Existing	*Proposed*
Total Fan H.P.	245	245
Motor Efficiency [1]	**90.7%**	**92.8%**
Ave. Fan Load Factor (%)	80%	80%
Fan kW	161.1	*(see below)*
Operating Schedule [2]	schooldays 6 am - 7 pm, 180 days/yr	*same*
Total Fan Operating Hours	1,800	1,800
Fan kWh	290,032	*(see below)*

Proposed Use - *per Air Handler*

Motor Characteristics with VFD						Duty Cycle Estimate		
Motor Speed	Volume or Flow	Ideal Motor H.P. (% of rated)	Actual Motor H.P. (% of rated)	Motor H.P.	Motor kW	% of Total Operating Hours	Hour per Year	kWh
30%	30%	2.7%	20.0%	49.0	31.5	0%	0	0
40%	40%	6.4%	23.0%	56.4	36.2	0%	0	0
50%	50%	12.5%	28.0%	68.6	44.1	0%	450	19,855
60%	60%	21.6%	36.0%	88.2	56.7	10%	473	26,833
70%	70%	34.3%	47.0%	115.2	74.1	15%	337	24,959
80%	80%	51.2%	61.0%	149.5	96.1	20%	230	22,109
90%	90%	72.9%	79.0%	193.6	124.5	30%	84	10,457
100%	100%	100.0%	100.0%	245.0	157.6	20%	226	35,613
						95%	1,800	**139,826**



Project M-3: **EMS expansion and variable frequency drives for air handler fans on Buildings G and H at Berkeley High School**

% Flow

Project Summary

Total kW Saved	-
Total kWh Saved	150,205
% Savings from Baseline	51.8%
Total Motor HP	245
kWh Savings per HP	613
Electricity Rate ($/kWh) [3]	$0.095
Total Electricity Savings ($)	$14,269
Estimated Cost per HVAC Unit	$35,239
Number of Air Handlers	4
Project Cost ($)	$140,956
Simple Payback Period w/out Incentive (years)	9.9

Notes

[1] Analysis also includes replacement of std. eff. motor with new premium eff. motor
[2] as reported by District staff
[3] Rate excludes demand savings. See Appendix-F for details of rate analysis

Facility	kW Saved	kWh Saved	Rate ($/kWh)	Natural Gas Therms Saved	Rate ($/Therm)	Project Cost ($)	Cost Savings ($)	Payback Period without Incentive (Years)	Approx. Incentive ($)
Berkeley High-G&H Building Air Handlers	--	150,205	$0.095	--	$0.684	$140,956	$14,269	9.9	$12,016

G&H Building Air Handlers

Unit	cfm	SF's	HP ea	EF's	HP ea	motor load	SF eff	EF eff	kW	SF eff (new	EF eff (new)	
AH1	16200	2	10	2	7.5	80%	89.5%	88.5%	23.5	91.7%	91.0%	22.9
AH2	25210	2	15	2	10	80%	91.0%	89.5%	33.0	93.0%	91.7%	32.3
AH3	50600	2	25	2	20	80%	91.7%	91.0%	58.8	93.6%	93.0%	57.5
AH4	37420	2	20	2	15	80%	91.0%	91.0%	45.9	93.0%	93.0%	44.9
Totals	129430		140		105				161.1			157.6
						average motor efficiency			91%			93%

Air Handler Operating Schedule

	Daytype	12:00 AM	1:00 AM	2:00 AM	3:00 AM	4:00 AM	5:00 AM	6:00 AM	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM	8:00 PM	9:00 PM	10:00 PM	11:00 PM
Baseline	schooldays	off	off	off	off	off	off	off	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	off	off	off	off	off	off	off
Baseline	Sat-Sun-Hol	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off
Variable Speed	schooldays	off	off	off	off	off	off	off	100%	variable	variable	variable	variable	variable	variable	variable	variable	variable	off	off	off	off	off	off	off
Variable Speed	Sat-Sun-Hol	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off

Variable Speed Operating Schedule

100% flow below	45	degrees F
50% flow at	60	degrees F
100% flow above	75	degrees F

Outdoor Air Temperatures, degrees F

Date	Daytype	12:00 AM	1:00 AM	2:00 AM	3:00 AM	4:00 AM	5:00 AM	6:00 AM	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM	8:00 PM	9:00 PM	10:00 PM	11:00 PM
Wed 1/1		39	40	37	39	35	35	35	36	37	42	43	44	45	45	46	45	44	43	40	39	40	38	37	36
Thu 1/2		36	35	33	34	33	34	32	33	37	40	42	44	46	45	47	47	47	45	44	44	44	44	43	42
Fri 1/3		41	41	40	41	41	41	42	42	44	49	52	54	53	53	54	53	51	51	50	50	50	51	50	51
Sat 1/4		50	50	50	50	50	48	48	48	51	51	53	53	53	53	53	53	53	53	53	53	53	53	53	53
Sun 1/5		53	53	53	53	53	53	52	51	52	55	55	56	56	57	56	57	56	56	55	55	55	55	54	52
Mon 1/6	schoolday	51	50	50	50	50	51	50	52	52	51	53	56	58	59	59	60	57	55	54	54	52	51	50	51
Tue 1/7	schoolday	51	50	49	50	48	48	48	49	49	49	51	53	54	53	53	53	53	52	53	52	54	54	54	53
Wed 1/8	schoolday	52	51	50	49	50	50	49	50	52	54	53	56	55	54	55	55	54	52	51	51	50	48	46	48
Thu 1/9	schoolday	47	42	42	41	40	40	40	42	46	48	46	45	50	53	52	53	52	51	49	48	49	47	45	41
Fri 1/10	schoolday	40	41	39	39	38	40	38	39	45	46	47	49	50	51	51	51	52	50	50	48	44	46	46	45
Sat 1/11		44	41	40	39	40	42	43	43	44	43	43	48	50	51	51	54	50	49	49	45	49	43	43	40
Sun 1/12		40	39	38	39	37	37	37	40	44	48	50	51	54	55	55	55	54	51	51	47	45	45	48	42
Mon 1/13	schoolday	41	42	41	43	42	39	41	44	46	48	49	50	52	53	54	53	52	51	51	51	50	50	47	45
Tue 1/14	schoolday	45	42	42	42	42	40	39	41	43	44	45	44	51	55	57	56	54	53	53	52	51	48	51	50
Wed 1/15	schoolday	46	45	43	43	42	43	42	43	50	53	55	57	60	62	63	64	62	58	59	59	56	56	56	53
Thu 1/16	schoolday	50	50	50	52	51	50	45	49	52	55	57	58	58	59	60	59	56	55	56	48	51	49	53	50
Fri 1/17	schoolday	47	49	48	49	48	45	45	45	48	52	55	57	57	59	60	58	55	53	48	46	46	43	43	42
Sat 1/18		40	36	38	37	37	36	37	40	43	45	47	48	50	52	52	53	52	49	48	47	45	43	42	43
Sun 1/19		42	42	42	42	42	40	40	40	45	47	48	50	50	51	52	53	51	49	49	48	48	43	43	37
Mon 1/20		38	37	36	35	33	36	34	36	41	46	51	51	53	55	56	54	52	50	49	47	43	41	41	41
Tue 1/21	schoolday	40	36	35	35	36	33	35	36	41	44	47	48	50	51	53	52	50	47	47	47	48	48	48	48
Wed 1/22	schoolday	48	48	48	46	47	43	44	44	46	50	48	52	52	53	51	51	50	49	47	47	48	46	45	44
Thu 1/23	schoolday	44	42	41	39	38	37	37	40	41	47	47	49	49	50	48	50	49	46	46	43	43	40	44	43
Fri 1/24		41	42	39	39	38	39	40	41	42	44	47	47	50	52	52	52	52	49	48	47	45	45	42	41
Sat 1/25		39	37	37	37	36	35	36	38	43	44	45	47	47	49	49	52	50	48	48	47	47	45	43	43
Sun 1/26		44	41	40	41	40	39	40	43	44	45	49	54	57	59	59	59	57	54	52	53	52	53	51	48

Project Cost Estimate

Project M-3 alt: **New Variable Air Volume air handlers on Buildings G and H at Berkeley High School**

Cost Factors

Tax Rate	9.5%
Sub Contractor Overhead & Profit Multiplier	1.20
City Location Price Multiplier	1.168

Item #	Description	Qty.	Units	Unit Material Cost ($)	Unit Labor Hours	Average Labor Rate	Unit Labor Cost ($)	Unit Equipment Cost ($)	Total Unit Cost ($)	Material Cost ($)	Labor Cost ($)	Equipment Cost ($)	Taxes ($)	TOTAL DIRECT COST ($)	CONTRACTOR COST WITH SUB O&P
1	Air Handler Demolition & Disposal	4	Ea.	$ 5,000	36	$ 55	$ 1,980	$ 5,000	$ 11,980	$ 20,000	$ 7,920	$ 20,000	$ 1,900	$ 58,190	$ 69,828
2	New AHU-1	1	Ea.	$ 87,000	120	$ 55	$ 6,600	$ 5,000	$ 98,600	$ 87,000	$ 6,600	$ 5,000	$ 8,265	$ 124,818	$ 149,782
3	New AHU-2	1	Ea.	$ 88,000	120	$ 55	$ 6,600	$ 5,000	$ 99,600	$ 88,000	$ 6,600	$ 5,000	$ 8,360	$ 126,097	$ 151,317
4	New AHU-3	1	Ea.	$ 91,000	120	$ 55	$ 6,600	$ 5,000	$ 102,600	$ 91,000	$ 6,600	$ 5,000	$ 8,645	$ 129,934	$ 155,921
5	New AHU-4	1	Ea.	$ 89,000	120	$ 55	$ 6,600	$ 5,000	$ 100,600	$ 89,000	$ 6,600	$ 5,000	$ 8,455	$ 127,376	$ 152,851
6	Add controls interface	4	Ea.	$ 7,500	8	$ 55	$ 440		$ 7,940	$ 30,000	$ 1,760	$ -	$ 2,850	$ 40,424	$ 48,509
7	Programming	1	Ea.	$ -	8	$ 55	$ 440		$ 440	$ -	$ 440	$ -	$ -	$ 514	$ 617
8	Start up & Testing	1	Ea.	$ -	16	$ 55	$ 880		$ 880	$ -	$ 880	$ -	$ -	$ 1,028	$ 1,233
9	Training	1	Ea.		4	$ 55	$ 220		$ 220	$ -	$ 220	$ -	$ -	$ 257	$ 308
	INSTALLING CONTRACTOR COST														$ 730,367
	General Contractor O&P	0%													$ -
	Construction Contingency	15%													$ 109,555
	Construction Cost with Contingency														
	Soft Costs Markup (i.e. design, CM, Cx)	20%													$ 146,073
	TOTAL PROJECT BUDGET														**$ 985,995**

Notes
Costs for air handlers and other items based on RS Means 2014

Means Mechanical Cost Data
VAV air handler (cfm) material costs

20,000 cfm	$76,000
30,000 cfm	$92,000

Interpolated and Extrapolated Data

16,200 cfm	$69,920
25,210 cfm	$84,336
50,600 cfm	$124,960
37,420 cfm	$103,872
129,430 cfm	$383,088

Average cost $2.96 per cfm

Budgetary cost provided by vendor (Norman-Wright)
$2.12 per cfm

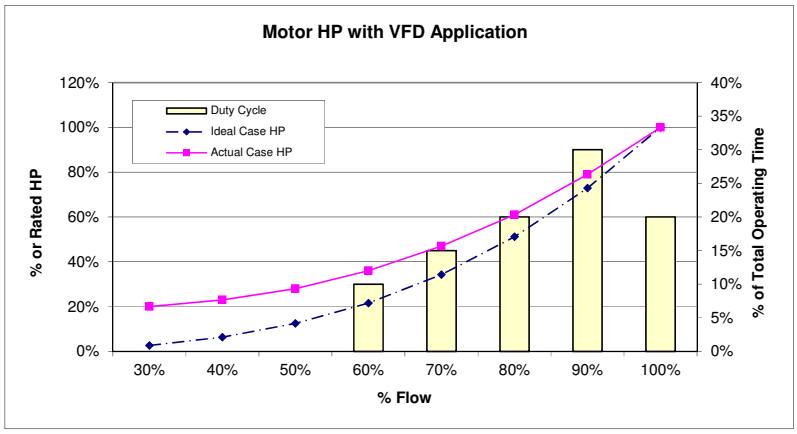
Project M-3 alt: **New Variable Air Volume air handlers on Buildings G and H at Berkeley High School**

Nameplate Data

Total Fan H.P.	245	107.5
Motor Efficiency [1]	**90.7%**	**92.6%**
Ave. Fan Load Factor (%)	80%	80%
Fan kW	161.1	69.3
Operating Schedule [2]	schooldays 6 am - 4 pm, 180 days/yr	*same*
Total Fan Operating Hours	1,800	1,800
Fan kWh	290,032	*(see below)*

Proposed Use - *per Air Handler*

Motor Characteristics with VFD						Duty Cycle Estimate		
Motor Speed	Volume or Flow	Ideal Motor H.P. (% of rated)	Actual Motor H.P. (% of rated)	Motor H.P.	Motor kW	% of Total Operating Hours	Hour per Year	kWh
30%	30%	2.7%	20.0%	21.5	13.9	0%	0	0
40%	40%	6.4%	23.0%	24.7	15.9	0%	0	0
50%	50%	12.5%	28.0%	30.1	19.4	0%	450	8,730
60%	60%	21.6%	36.0%	38.7	24.9	10%	473	11,798
70%	70%	34.3%	47.0%	50.5	32.6	15%	337	10,974
80%	80%	51.2%	61.0%	65.6	42.3	20%	230	9,721
90%	90%	72.9%	79.0%	84.9	54.7	30%	84	4,598
100%	100%	100.0%	100.0%	107.5	69.3	20%	226	15,659
						95%	1,800	**61,480**



Project Summary

Total kW Saved	91.8
Total kWh Saved	228,552
% Savings from Baseline	78.8%
Existing Motor HP	245
kWh Savings per HP	933
Electricity Rate ($/kWh) [3]	$0.165
Total Electricity Savings ($)	$37,654
Estimated Cost per HVAC Unit	$246,499
Number of Air Handlers	4
Project Cost ($)	$985,995
Simple Payback Period w/out Incentive (years)	26.2

Notes

[1] Analysis also includes increase in efficiency of the fan motors
[2] as reported by District staff
[3] Rate includes demand savings. See Appendix-F for details of rate analysis

M3 alt New Air Handlers for G Buildings at Berkeley High School

Existing G&H Building Air Handlers

Air Handling Unit	Air Flow, cubic feet per minute	Number of Supply Fans (SF)	Horsepower each	Number of Exhaust Fans (EF)	Horsepower each	motor load	Estimated SF brake horsepower	estimated SF total static pressure	Estimated EF brake horsepower	estimated EF total static pressure	SF eff	EF eff	kW
AH1	16200	2	10	2	7.5	80%	16	5.0 in. w.c.	12.0	4.6 in. w.c.	89.5%	88.5%	23.5
AH2	25210	2	15	2	10	80%	24	4.8 in. w.c.	16.0	3.9 in. w.c.	91.0%	89.5%	33.0
AH3	50600	2	25	2	20	80%	40	4.0 in. w.c.	32.0	3.9 in. w.c.	91.7%	91.0%	58.8
AH4	37420	2	20	2	15	80%	32	4.3 in. w.c.	24.0	4.0 in. w.c.	91.0%	91.0%	45.9
Totals	129430		140		105								161.1
											average motor efficiency		91%

Proposed New G&H Building Air Handlers

Air Handling Unit	Air Flow, cubic feet per minute	Number of Supply Fans (SF)	Horsepower each	Number of Exhaust Fans (EF)	Horsepower each	motor load	Estimated SF brake horsepower	estimated SF total static pressure	Estimated EF brake horsepower	estimated EF total static pressure	SF eff	EF eff	kW
AH1	16200	1	10	1	5	80%	8	2.5 in. w.c.	4.0	1.5 in. w.c.	91.7%	89.5%	9.8
AH2	25210	1	15	1	7.5	80%	12	2.4 in. w.c.	6.0	1.5 in. w.c.	93.0%	91.0%	14.5
AH3	50600	1	25	1	15	80%	20	2.0 in. w.c.	12.0	1.5 in. w.c.	93.6%	93.0%	25.6
AH4	37420	1	20	1	10	80%	16	2.2 in. w.c.	8.0	1.3 in. w.c.	93.0%	91.7%	19.3
Totals	129430		70		37.5								69.3
		Add contro	4		7500						average motor efficiency		93%

Open Drip-Proof (ODP)							Totally Enclosed Fan-Cooled (TEFC)						
	1200 rpm (6 pole)		1800 rpm (4 pole)		3600 rpm (2 pole)			1200 rpm (6 pole)		1800 rpm (4 pole)		3600 rpm (2 pole)	
HP	EPAct or N	NEMA Prer	EPACT or N	NEMA Prer	EPAct or N	NEMA Prer	HP	EPAct or NEM	NEMA Prer	EPAct or NEM	NEMA Prer	EPAct or N	NEMA Premium Efficiency
1	80	82.5	82.5	85.5	-	77	1	80	82.5	82.5	85.5	75.5	77
1.5	84	86.5	84	86.5	82.5	84	1.5	85.5	87.5	84	86.5	82.5	84
2	85.5	87.5	84	86.5	84	85.5	2	86.5	88.5	84	86.5	84	85.5
3	86.5	88.5	86.5	89.5	84	85.5	3	87.5	89.5	87.5	89.5	85.5	86.5
5	87.5	89.5	87.5	89.5	85.5	86.5	5	87.5	89.5	87.5	89.5	87.5	88.5
7.5	88.5	90.2	88.5	91	87.5	88.5	7.5	89.5	91.0	89.5	91.7	88.5	89.5
10	90.2	91.7	89.5	91.7	88.5	89.5	10	89.5	91.0	89.5	91.7	89.5	90.2
15	90.2	91.7	91	93	89.5	90.2	15	90.2	91.7	91	92.4	90.2	91
20	91	92.4	91	93	90.2	91	20	90.2	91.7	91	93	90.2	91
25	91.7	93	91.7	93.6	91	91.7	25	91.7	93.0	92.4	93.6	91	91.7

30	92.4	93.6	92.4	94.1	91	91.7	30	91.7	93.0	92.4	93.6	91	91.7
40	93	94.1	93	94.1	91.7	92.4	40	93	94.1	93	94.1	91.7	92.4
50	Costs for ai	94.1	93	94.5	92.4	93	50	93	94.1	93	94.5	92.4	93
60	93.6	94.5	93.6	95	93	93.6	60	93.6	94.5	93.6	95	93	93.6
75	93.6	94.5	94.1	95	93	93.6	75	93.6	94.5	94.1	95.4	93	93.6
100	94.1	95	94.1	95.4	93	93.6	100	94.1	95.0	94.5	95.4	93.6	94.1
125	94.1	95	94.5	95.4	93.6	94.1	125	94.1	95.0	94.5	95.4	94.5	95
150	94.5	95.4	95	95.8	93.6	94.1	150	95	95.8	95	95.8	94.5	95
200	94.5	95.4	95	95.8	94.5	95	200	95	95.8	95	96.2	95	95.4
250	20000	76000	95.4	95.8	94.5	95	250	95	95.8	95	96.2	95.4	95.8
300	30000	92000	95.4	95.8	95	95.4	300	95	95.8	95.4	96.2	95.4	95.8
350	95.4	95.8	95.4	95.8	95	95.4	350	95	95.8	95.4	96.2	95.4	95.8
400	Interpolate	95.8	95.4	95.8	95.4	95.8	400	-	95.8	95.4	96.2	95.4	95.8
450	-	96.2	95.8	96.2	95.8	96.2	450	-	95.8	95.4	96.2	95.4	95.8
500	-	96.2	95.8	96.2	95.8	96.2	500	-	95.8	95.8	96.2	95.4	95.8
1500	-	96.2	95.8	96.2	95.8	96.2	500	-	95.8	95.8	96.2	95.4	95.8

Nominal full load efficiencies of energy efficient motors. (Table 12-11 of MG 1-2003)
Nominal efficiencies for "NEMA Premium" induction motors. (Table 12-12 of MG 1-2003)

Air Handler Operating Schedule

	Daytype	12:00 AM	1:00 AM	2:00 AM	3:00 AM	4:00 AM	5:00 AM	6:00 AM	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM	8:00 PM	9:00 PM	10:00 PM	11:00 PM
Baseline	schooldays	off	off	off	off	off	off	off	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	off	off	off	off	off	off	off
Baseline	Sat-Sun-Hol	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off
Variable Speed	schooldays	off	off	off	off	off	off	off	100%	variable	variable	variable	variable	variable	variable	variable	variable	variable	off	off	off	off	off	off	off
Variable Speed	Sat-Sun-Hol	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off

Variable Speed Operating Schedule

100% flow below	45	degrees F
50% flow at	60	degrees F
100% flow above	75	degrees F

Outdoor Air Temperatures, degrees F

Date	Daytype	12:00 AM	1:00 AM	2:00 AM	3:00 AM	4:00 AM	5:00 AM	6:00 AM	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM	8:00 PM	9:00 PM	10:00 PM	11:00 PM
Wed 1/1		39	40	37	39	35	35	35	36	37	42	43	44	45	45	46	45	44	Costs for ai	40	39	40	38	37	36
Thu 1/2		20000	30000	33	Interpolatec	33	34	32	33	37	40	42	44	46	45	47	47	47	45	44	44	44	44	43	42
Fri 1/3		41	41	40	41	41	41	42	42	44	49	52	54	53	53	54	53	51	51	50	50	50	51	50	51
Sat 1/4		50	50	50	50	50	48	48	48	51	51	53	53	53	53	53	53	53	53	53	53	53	53	53	53
Sun 1/5		53	53	53	53	53	53	52	51	52	55	55	56	56	57	56	57	56	56	55	55	55	55	54	52
Mon 1/6	schoolday	51	50	50	50	50	51	50	52	52	51	53	56	58	59	59	60	57	55	54	54	52	51	50	51
Tue 1/7	schoolday	51	50	49	50	48	48	48	49	49	49	51	53	54	53	53	53	53	52	53	52	54	54	54	53
Wed 1/8	schoolday	52	51	50	49	50	50	49	50	52	54	53	56	55	54	55	55	54	52	51	51	50	48	46	48
Thu 1/9	schoolday	47	42	42	41	40	40	40	42	46	48	46	45	50	53	52	53	52	51	49	48	49	47	45	41
Fri 1/10	schoolday	40	41	39	39	38	40	38	39	45	46	47	49	50	51	51	51	52	50	50	48	44	46	46	45
Sat 1/11		44	41	40	39	40	42	43	43	44	43	43	48	50	51	51	54	50	49	49	45	49	43	43	40
Sun 1/12		40	39	38	39	37	37	37	40	44	48	50	51	54	55	55	55	54	51	51	47	45	45	48	42
Mon 1/13	schoolday	41	42	41	43	42	39	41	44	46	48	49	50	52	53	54	53	52	51	51	51	50	50	47	45
Tue 1/14	schoolday	45	42	42	42	42	40	39	41	43	44	45	44	51	55	57	56	54	53	53	52	51	48	51	50
Wed 1/15	schoolday	46	45	43	43	42	43	42	43	50	53	55	57	60	62	63	64	62	58	59	59	56	56	56	53
Thu 1/16	schoolday	50	50	50	52	51	50	45	49	52	55	57	58	58	59	60	59	56	55	56	48	51	49	53	50
Fri 1/17	schoolday	47	49	48	49	48	45	45	45	48	52	55	57	57	59	60	58	55	53	48	46	46	43	43	42
Sat 1/18		40	36	38	37	37	36	37	40	43	45	47	48	50	52	52	53	52	49	48	47	45	43	42	43
Sun 1/19		42	42	42	42	42	40	40	40	45	47	48	50	50	51	52	53	51	49	49	48	48	43	43	37
Mon 1/20		38	37	36	35	33	36	34	36	41	46	51	51	53	55	56	54	52	50	49	47	43	41	41	41
Tue 1/21	schoolday	40	36	35	35	36	33	35	36	41	44	47	48	50	51	53	52	50	47	47	47	48	48	48	48
Wed 1/22	schoolday	48	48	48	46	47	43	44	44	46	50	48	52	52	53	51	51	50	49	47	47	48	46	45	44
Thu 1/23	schoolday	44	42	41	39	38	37	37	40	41	47	47	49	49	50	48	50	49	46	46	43	43	40	44	43
Fri 1/24		41	42	39	39	38	39	40	41	42	44	47	47	50	52	52	52	52	49	48	47	45	45	42	41
Sat 1/25		39	37	37	37	36	35	36	38	43	44	45	47	47	49	49	52	50	48	48	47	47	45	43	43
Sun 1/26		44	41	40	41	40	39	40	43	44	45	49	54	57	59	59	59	57	54	52	53	52	53	51	48
Mon 1/27	schoolday	47	45	45	46	44	42	41	45	51	52	54	57	58	58	60	60	56	54	53	52	50	49	48	43
Tue 1/28	schoolday	43	41	40	38	39	37	38	39	45	47	50	51	52	56	61	58	54	52	53	53	53	53	53	52
Wed 1/29	schoolday	52	52	51	51	51	50	50	50	51	53	57	55	53	53	48	49	48	48	47	46	46	45	45	45
Thu 1/30	schoolday	45	46	45	45	46	46	46	45	46	48	51	53	54	53	52	53	51	50	48	49	48	49	48	47
Fri 1/31	schoolday	46	46	45	43	44	44	43	45	46	50	51	50	51	52	50	53	52	50	48	49	49	49	49	49
Sat 2/1		48	48	47	46	46	46	46	47	48	49	51	54	56	56	57	57	55	54	52	52	51	51	49	47
Sun 2/2		45	44	43	42	43	43	44	45	45	46	47	49	50	50	51	51	50	50	49	48	46	45	45	46
Mon 2/3	schoolday	46	45	45	44	44	44	44	44	45	45	47	50	52	53	55	56	54	53	51	50	50	49	48	47
Tue 2/4	schoolday	46	46	45	45	44	43	42	44	46	48	51	53	56	57	59	60	58	56	54	54	53	53	51	48

Project Cost Estimate

Project PV-1 Solar PV

Cost Factors

Tax Rate	9.5%
Sub Contractor Overhead & Profit (%)	1.20
City Location Price Multiplier	1.168

Cragmont Elementary

Item #	Description	Qty.	Units	Unit Material Cost ($) [1]	Unit Labor Hours	Average Labor Rate [1]	Unit Labor Cost ($)	Unit Equipment Cost ($)	Total Unit Cost ($)	Material Cost ($)	Labor Cost ($)	Equipment Cost ($)	Taxes ($)	TOTAL DIRECT COST ($)	CONTRACTOR COST WITH SUB O&P
									% of total project cost:	11%	9%	27%	4%	51%	
1	Cragmont Elementary									$ 34,271	$ 28,763	$ 82,617	$ 11,104.38	$ 156,755.62	$ 305,990
	INSTALLING CONTRACTOR COST														$ 305,990
	General Contractor O&P														$ -
	Construction Contingency														$ -
	Construction Cost with Contingency														
	Soft Costs Markup (i.e. design, CM, Cx)														$ -
	TOTAL PROJECT BUDGET														**$ 305,990**

Berkeley High School

Item #	Description	Qty.	Units	Unit Material Cost ($) [1]	Unit Labor Hours	Average Labor Rate [1]	Unit Labor Cost ($)	Unit Equipment Cost ($)	Total Unit Cost ($)	Material Cost ($)	Labor Cost ($)	Equipment Cost ($)	Taxes ($)	TOTAL DIRECT COST ($)	CONTRACTOR COST WITH SUB O&P
1	Berkeley High School Donahue Gym								$ -	$ 50,370	$ 42,275	$ 121,428	$ 16,320.88	$ 230,394.74	$ 449,735
	INSTALLING CONTRACTOR COST														$ 449,735
	General Contractor O&P														$ -
	Construction Contingency														$ -
	Construction Cost with Contingency														
	Soft Costs Markup (i.e. design, CM, Cx)														$ -
	TOTAL PROJECT BUDGET														**$ 449,735**

Project Savings Estimate

Project PV-1 Solar PV

System Analysis

	Cragmont	Berkeley High	
Solar PV module capacity	82.7	121.6	kW
AC Power capacity			
Estimated Annual Production	124,400	169,900	kWh/yr

Project Summary

Electricity Savings (kWh)	124,400	169,900	
Electricity Rate ($/kWh)	$ 0.186	$ 0.165	
Energy Savings ($)	$ 23,138	$ 28,034	
Project Costs ($)	$ 305,990	$ 449,735	
Simple Payback Period (Years)	13.2	16.0	
California Solar Initiative Incentives			
Status:	not acceptin	not accepting applications	
Expected Performance-based Buydown	$0.70	$0.70	
Performance-based Incentives	$0.88	$0.88	
Estimated Self Generation Program Incentive			
Total Estimated Incentive ($)	$0	$0	
Project Cost with Incentive ($)	$305,990	$449,735	
Simple Payback with Incentive (years)	13.2	16.0	

Appendix D

Berkeley Weather Data

Berkeley Weather Data

Source: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca0693

BERKELEY, CALIFORNIA (040693)

Period of Record Monthly Climate Summary

Period of Record : 01/01/1893 to 12/31/2014

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	55.9	59.1	61.4	64.0	66.6	70.0	70.3	70.1	71.8	69.6	63.2	56.7	64.9
Average Min. Temperature (F)	42.7	45.1	46.0	47.6	50.0	52.5	53.8	54.4	54.7	52.4	48.0	43.7	49.2
Average Total Precipitation (in.)	4.98	4.07	3.27	1.64	0.75	0.19	0.03	0.06	0.26	1.26	2.79	4.11	23.41
Average Total SnowFall (in.)	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Average Snow Depth (in.)	0	0	0	0	0	0	0	0	0	0	0	0	0

Percent of possible observations for period of record.
Max. Temp.: 94.4% Min. Temp.: 94.4% Precipitation: 95.2% Snowfall: 95.2% Snow Depth: 95%
Check Station Metadata or Metadata graphics for more detail about data completeness.

Western Regional Climate Center, wrcc@dri.edu

BERKELEY, CALIFORNIA

Period of Record General Climate Summary - Temperature

Station:(040693) BERKELEY															
From Year=1893 To Year=2012															
	Monthly Averages			Daily Extremes				Monthly Extremes				Max. Temp.		Min. Temp.	
	Max.	Min.	Mean	High	Date	Low	Date	Highest Mean	Year	Lowest Mean	Year	>= 90 F	<= 32 F	<= 32 F	<= 0 F

	F	F	F	F	dd/yyyy or yyyymmdd	F	dd/yyyy or yyyymmdd	F	-	F	-	# Days	# Days	# Days	# Days
January	55.9	42.7	49.3	77	26/1899	25	21/1937	53.9	1970	42.0	1937	0.0	0.0	0.6	0.0
February	59.1	45.1	52.2	80	18/1899	29	12/1905	57.3	1963	46.7	1894	0.0	0.0	0.1	0.0
March	61.4	46.0	53.7	87	17/1914	33	03/1966	60.0	2004	47.8	1897	0.0	0.0	0.0	0.0
April	64.0	47.6	55.8	95	27/2004	36	19/1896	59.5	1989	49.8	1967	0.1	0.0	0.0	0.0
May	66.6	50.0	58.3	101	31/2001	36	09/1922	64.2	1997	53.6	1933	0.3	0.0	0.0	0.0
June	70.0	52.5	61.3	107	15/2000	40	16/1913	66.6	1981	56.6	1965	0.6	0.0	0.0	0.0
July	70.3	53.8	62.0	99	23/2006	40	05/1953	66.3	2006	58.3	1944	0.2	0.0	0.0	0.0
August	70.1	54.4	62.3	104	25/2010	42	18/1916	67.2	2003	58.4	1928	0.2	0.0	0.0	0.0
September	71.8	54.7	63.2	106	16/1913	38	27/1916	68.5	1984	58.3	1910	1.1	0.0	0.0	0.0
October	69.6	52.4	61.0	99	01/1980	38	26/1919	65.2	1959	55.4	1916	0.4	0.0	0.0	0.0
November	63.2	48.0	55.6	86	04/1921	33	28/1905	60.5	1932	50.7	1994	0.0	0.0	0.0	0.0

December	56.7	43.7	50.2	80	12/1942	25	09/1972	55.7	1958	45.5	1908	0.0	0.0	0.3	0.0
Annual	64.9	49.2	57.1	107	20000615	25	19370121	59.3	1959	55.2	1893	2.9	0.0	1.1	0.0
Winter	57.2	43.9	50.6	80	18990218	25	19370121	55.0	1970	45.0	1949	0.0	0.0	1.1	0.0
Spring	64.0	47.9	55.9	101	20010531	33	19660303	60.2	2004	53.1	1929	0.3	0.0	0.0	0.0
Summer	70.1	53.6	61.8	107	20000615	40	19130616	65.6	1997	59.0	1924	1.0	0.0	0.0	0.0
Fall	68.2	51.7	59.9	106	19130916	33	19051128	62.6	1959	56.8	1910	1.5	0.0	0.0	0.0

Table updated on Oct 31, 2012
For monthly and annual means, thresholds, and sums:
Months with 5 or more missing days are not considered
Years with 1 or more missing months are not considered
Seasons are climatological not calendar seasons
Winter = Dec., Jan., and Feb. Spring = Mar., Apr., and May
Summer = Jun., Jul., and Aug. Fall = Sep., Oct., and Nov.

Western Regional Climate Center, wrcc@dri.edu

Station:(040693) BERKELEY													
From Year=1893 To Year=2012													
Heating Degree Days for Selected Base Temperature (F)													
Base	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
65	487	363	351	282	216	131	107	99	88	146	285	458	3012

60	332	224	204	144	84	30	15	12	12	42	147	303	1548
57	241	146	125	75	29	5	1	1	1	12	79	213	928
55	183	100	81	40	10	1	0	0	0	4	46	157	622
50	66	25	15	4	0	0	0	0	0	0	7	51	168

Station:(040693) BERKELEY													
From Year=1893 To Year=2012													
Cooling Degree Days for Selected Base Temperature (F)													
Base	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
55	6	20	41	63	113	189	218	225	247	189	64	10	1384
57	2	9	23	38	70	133	157	164	188	135	37	4	960
60	0	3	9	17	32	68	77	82	108	72	14	1	484
65	0	0	2	5	9	19	15	14	35	21	2	0	122
70	0	0	0	1	3	6	3	2	11	4	0	0	30

Appendix E
Manufacturers Product Literature

Disclaimer:
References to specific brand names, products or manufacturers are provided for illustrative purposes only and shall not be considered endorsements by the Energy Commission, the State of California, its employees, contractors, and subcontractors

Energy Advantage T8

F32T8 28W ADV841 EW ALTO

Philips Energy Advantage T8 lamps offer high energy savings without sacrificing performance.

Product data

- General Characteristics

Base	Medium Bi-Pin [Medium Bi-Pin Fluorescent]
Base Information	Green Base
Bulb	T8
Energy Saving	Energy Saving
Rated Avg Life [12-Hr Prog St]	44000 hr
Rated Avg Life [12-Hr Inst St]	38000 hr
Rated Avg Life [3-Hr Prog St]	38000 hr
Rated Avg Life [3-Hr Inst St]	32000 hr

- Light Technical Characteristics

Color Code	Advantage 841 [CCT of 4100K]
Color Rendering Index	85 Ra8
Color Designation	Advantage 841
Color Temperature	4100 K
Initial lumen	2725 Lm
Design Mean Lumens	2645 Lm

- Electrical Characteristics

Watts	28 W

- Environmental Characteristics

Mercury (Hg) Content	1.7 mg
Picogram per Lumen Hour	27 p/LuHr

- Product Dimensions

Nominal Length [inch]	48

- Footnotes

Footnotes Fluorescent/CFL	920 [Circle E- The encircled E means this bulb meets Federal minimum efficiency standards.]

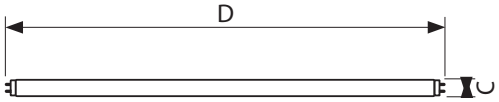
- Product Data

Product number	281030
Full product name	F32T8 28W ADV841 EW ALTO
Short product name	F32T8/ADV841/EW/ALTO 28W
Pieces per Sku	1
eop_pck_cfg	30
Skus/Case	30
Bar code on pack	46677281038
Bar code on case	50046677281033
Logistics code(s)	927852284204
eop_net_weight_pp	0.001 kg

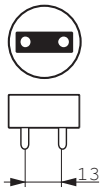
PHILIPS

sense and simplicity

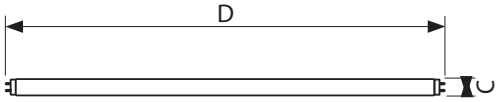
Dimensional drawing



G13, T8



G13



G13, T8

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T8 Series

4' Linear LED Lamp

Product Description

The Cree® linear LED T8 lamp delivers up to 2100 lumens of enhanced spectrum 90+ CRI light while achieving up to 105 lumens per watt at the system level. The innovative design allows more uplight than standard LED tubes, thereby providing a more uniform light output. The T8 lamp is available in a wide array of color temperatures and operates using existing fluorescent T8 electronic instant start, programmed/rapid start and dimmable fluorescent ballasts. The T8 lamp is easy to install and fits into linear fluorescent fixtures, making it a perfect upgrade solution where energy savings and long life are critical.

Performance Summary

- Upgrades existing T8 fluorescent lamps
- Utilizes Cree TrueWhite® Technology
- **System Efficacy:** 90-105 LPW at system level
- **Initial Delivered Lumens:** 1700-2500 lumens per LED lamp*
- **Lamp Watts:** As low as 16.5 watts*
- **CRI:** 90+
- **CCT:** 3000K, 3500K, 4000K, 5000K
- **Input Voltage:** 120-480 VAC, determined by fluorescent ballast
- **Rated Life:** 50,000 hours
- **Controls:** Dimmable (ballast dependent)
- **Mounting:** Linear fluorescent fixtures with dry or damp rating
- **Limited Warranty†:** 5 years

† See www.cree.com/lighting/products/warranty for warranty terms
* See wattage vs. lumen chart for lumens by specific ballast factor (BF)

4' LED Lamp
MOL- 48" (1219mm)

Ordering Information

Example: LEDT8P 48 21L 40K B1

LEDT8P 48					
Product	Initial Delivered Lumens	CCT	Voltage	Control	Options
LEDT8P 48	**17L** 16.8W, 1700 lumens - 103 LPW **21L** 19.5W, 2150 lumens - 110 LPW	**30K** 3000K - Available in 17L only **35K** 3500K **40K** 4000K **50K** 5000K - Available in 17L only	**Blank** 120-480 Volt Ballast Dependent	**Blank** Dimmable	**B1** Single boxed lamps **T25** Tray pack lamp (Bulk Pack) - Available in 35K and 40K CCTs only

Product Specifications

CREE TRUEWHITE® TECHNOLOGY

A revolutionary way to generate high-quality white light, Cree TrueWhite® Technology is a patented approach that delivers an exclusive combination of 90+ CRI, beautiful light characteristics and lifelong color consistency, all while maintaining high luminous efficacy – a true no compromise solution.

CONSTRUCTION & MATERIALS

- Lightweight aluminum heat sink housing provides strength and durability
- Shatterproof design
- Suitable for use with shunted and non-shunted sockets

OPTICAL SYSTEM

- Specialized lens design for optimal light distribution and smooth visual effect
- Measured and designed to achieve optimal light performance in existing fluorescent troffers

ELECTRICAL SYSTEM

- Integral, high-efficiency driver to remodulate current to LEDs
- Utilizes existing fluorescent ballast
- **Power Factor:** = 0.9 nominal
- **Input Power:** Ballast dependent
- **Input Voltage:** 120–277V, 347, 480V, 50/60Hz
- **Battery Backup:** Operates on fluorescent emergency ballasts
- **Operating Temperature Range:** -25˚C - + 45˚C (13˚F - + 113˚F)
- **Total Harmonic Distortion:** < 20%
- Not for use with T12 magnetic or electronic ballasts
- Not for use with T8 magnetic or HO ballasts
- Not for use or to be wired to "mains voltage"

CONTROLS

- Dimmable (ballast dependent)

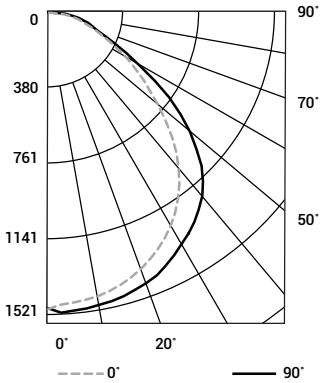
REGULATORY & VOLUNTARY QUALIFICATIONS

- UL Listed to UL 1993, UL 8750, CSA C22.2 No. 1993-12 & CSA C22.2 No. 250.13-12
- Suitable for damp locations
- Designed for indoor use
- DLC qualified when ordered with 21L product and 30K, 35K and 40K CCTs. Please refer to www.designlights.org/QPL for most current information

Photometry

(2) LEDT8P 48 21L 35K INSTALLED IN A 2 X 4 RECESSED TROFFER BASED ON CESTL REPORT TEST #: PL04179-001

Fixture photometry has been conducted by a NVLAP accredited testing laboratory in accordance with IESNA LM-79-08. IESNA LM-79-08 specifies the entire luminaire as the source resulting in a fixture efficiency of 100%.



Coefficients Of Utilization - Zonal Cavity Method				
RC %:	80			
RW %:	70	50	30	10
RCR: 0	119	119	119	119
1	109	105	101	97
2	100	92	86	81
3	92	82	74	68
4	84	73	64	58
5	78	65	57	50
6	72	59	50	44
7	67	54	45	39
8	62	49	41	35
9	58	45	37	32
10	55	42	34	29

Effective Floor Cavity Reflectance: 20%

Average Luminance Table (cd/m²)				
	Horizontal Angle			
		0°	45°	90°
Vertical Angle	45°	1,797	1,957	2,221
	55°	1,467	1,712	1,869
	65°	1,167	1,166	1,254
	75°	1,026	757	1,176
	85°	1,171	1,069	1,444

Zonal Lumen Summary			
Zone	Lumens	% Lamp	Luminaire
0–30	1,182	N/A	30.2%
0–40	1,944	N/A	49.6%
0–60	3,298	N/A	84.2%
0–90	3,918	N/A	100%
0–180	3,918	N/A	100%

Reference www.cree.com/Lighting/Products/Indoor/Lamps/T8-Series for detailed photometric data

Product Information

Product Number	UPC	Description	Lamp Type	CCT	Lamps per Pack	CRI	Initial Delivered Lumens	Rated Life (Hrs)
LEDT8P 48 21L 35K B1	849665001935	Linear LED T8 Replacement Lamp	T8	3500K	1	90	2100	50,000
LEDT8P 48 21L 40K B1	849665001942	Linear LED T8 Replacement Lamp	T8	4000K	1	90	2100	50,000
LEDT8P 48 17L 30K B1	849665001966	Linear LED T8 Replacement Lamp	T8	3000K	1	90	1700	50,000
LEDT8P 48 17L 35K B1	849665001973	Linear LED T8 Replacement Lamp	T8	3500K	1	90	1700	50,000
LEDT8P 48 17L 40K B1	849665001980	Linear LED T8 Replacement Lamp	T8	4000K	1	90	1700	50,000
LEDT8P 48 17L 50K B1	849665001997	Linear LED T8 Replacement Lamp	T8	5000K	1	90	1700	50,000

Watts vs. Lumens

LEDT8 48 21L				
		Lamp Watts	System Watts	Lamp Lumens (Bare)
Low	.77 Ballast Factor	16.5	18.0	1,877
Normal	.88 Ballast Factor	19.5	21.0	2,151
Normal	1.0 Ballast Factor	22.2	23.7	2,424
High	1.1 Ballast Factor	25.6	27.1	2,668
High	1.15 Ballast Factor	27.0	28.5	2,768
High	1.18 Ballast Factor	27.9	29.4	2,822

LEDT8 48 17L				
		Lamp Watts	System Watts	Lamp Lumens (Bare)
Low	.77 Ballast Factor	16.8	18.3	1,734
Normal	.88 Ballast Factor	19.9	21.4	1,973
Normal	1.0 Ballast Factor	23.5	25.0	2,229
High	1.1 Ballast Factor	26.7	28.2	2,421
High	1.15 Ballast Factor	28.1	29.6	2,504
High	1.18 Ballast Factor	29.1	30.6	2,555

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US: www.cree.com/lighting T (800) 236-6800 F (262) 504-5415

Canada: www.cree.com/canada T (800) 473-1234 F (800) 890-7507

Cree FAQs

10-Year Limited Warranty - LED Lighting Fixtures, BetaLED® Technology, Cree TrueWhite® Technology and Cree® Essentia® LED Architectural Downlight

Q: Which products are covered? Are there exclusions?

A: Cree's warranty covers the broadest product range in the industry. Please visit www.cree.com/lighting/products/warranty for detailed information.

Here is the list of exclusions:

1. All lamps (LRP-38™ LED lamps, LBR-30™ LED lamps and lamp accessories)
2. Entire series of CR downlights
3. LR24™ LED troffers
4. Emergency backup batteries
5. BetaLED® Technology outdoor, CE-compliant, Class II products
6. Third-party integrated controls
7. Button and Twistlock photocells
8. Occupancy controls

Q: Is labor included in the warranty?

A: No, the warranty covers the repair or replacement of the product only.

Q: What is the "10% LED failure"?

A: The product will be considered defective if at least 10% of the LEDs fail to illuminate.

Q: Does the "10% LED failure" clause cover the driver?

A: Yes, if the driver fails and causes more than 10% of the LEDs to not operate properly, it would be considered defective and be covered.

Q: What is Class II and what products fall under this category?

A: Class II refers to international and/or European luminaires that employ a reinforced insulation system without a protective earth ground and are designated as a Class II luminaire. This is an International and/or European code that is defined by IEC/EN60598.

Q: I heard XSP Series is Class 2 UL. Is it covered?

A: The XSP Series of luminaires are covered by the new 10-year limited warranty.

Q: I see CR Series LED downlights are not covered. What downlights are covered?

A: All downlights, excluding the CR Series LED downlights, are covered under the 10-year limited warranty. The warranty for the CR Series LED downlights remains at five years.

Q: Is the CR150™ LED downlight covered by the 10-year limited warranty?

A: All downlights, excluding the CR Series, are covered under the 10-year limited warranty. However, the CR150™ may be reviewed for inclusion. Please contact your Cree sales representative for further information.

Q: The warranty states 10 years, but some spec sheets give specific hours of life. What is the difference?

A: All of the Cree lighting specification sheets that require an update to the warranty messaging are being revised to state 10 years. This will take some time to complete due to the number of specification sheets existing. Our rated lifetimes are estimated according to industry standards to determine when the product will operate at 70 percent or greater of its initial lumen output (L70).

Q: Why did the EB14 products change from a five year warranty to a one year warranty?

A: All accessories now fall under a common warranty which is: "period of ONE (1) YEAR from the date of original purchase." In some cases, the warranty may be longer if the length of the warranty extended to Cree by a third party manufacturer is longer than one year.

Q: Is the 10-year limited warranty retroactive?

A: No, this warranty is effective for purchases of product on or after the effective date listed in the revised warranty. Please visit www.cree.com/lighting/products/warranty for detailed information.

If there are any further questions, please contact lightingmarketing@cree.com.

Cree, Inc.
www.cree.com/lighting

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Additional Media

1650 Lumens - LED - 4 ft. Tube - 16 Watt

4100K Cool White - NO REWIRING REQUIRED - LifeBulb LBT8F1641

5 / 5

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1 - 99	$12.99	ea
100 +	$9.99	ea

Quantity: 1

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LED-T816W41K

Energy Saving Calculator

LED Replacement	16	Watts
Existing Lamp	32	Watts
Lamps Replaced	1	
Cost per kWh	0.11	

Savings over life of lamp: $88 Click here to change values

Make the switch to LED lighting easy with the LifeBulb LBT8F1641 LED lamp. This quick-fit T8 lamp can be installed in your existing fluorescent fixtures without rewiring your lamp fixture. As a high performance 16-watt LED, it combines consistent operation with simple installation and 50,000 hours of rated lifespan. Save more money and use less energy with LifeBulb LEDs!

- Terrific for office buildings, schools, warehouses, parking garages, and manufacturing facilities
- Has a frosted glass lens with wide, 240-degree beam angle design
- No rewiring required - works with existing instant start ballasts
- Operates on 120 to 277 and 347 ballast input voltages
- Emits a smooth cool white, 4100K color temperature
- Direct replacement for 32-watt fluorescent lamps
- UL listed for damp locations
- Flicker-free operation

Brochures & Spec Sheets

LifeBulb LBT8F1641 Spec Sheet

Ballast Compatibility

Specifications

Stock Code:	LED-T816W41K	Brand:	LifeBulb
Part No.:	LBT8F1641	UPC:	858976005402
Wattage:	16 Watt	Voltage:	120/277/347
Beam Angle:	240 Degree	Bulb Shape:	T8
Base Type:	Medium Bi-Pin/G13	Dimmable:	No
Color Temperature:	4100 Kelvin	CRI:	83
Compatibility:	Instant Start	Length:	48 in.
Diameter:	1 in.	Fluorescent Equal:	32 Watt
Life Hours:	50,000	Lumens (Initial):	1650
Lumens Per Watt:	103	Power Factor:	0.95

Customers Also Purchased

1800 Lumens - LED - 4 ft. Tube - 18 Watt - 4100K Cool White

0 reviews

$14.99

LED - 10 Watt - A19 - 60 Watt Equal - 800 Lumens - 2700K War

33 reviews

$5.49

2200 Lumens - LED - 4 ft. Tube - 22 Watt - 5000K Stark White

2 reviews

$19.99

Lens:	Frosted Glass
DLC Listed:	Yes
Case Quantity:	25

UL Listed:	Damp Locations
Warranty:	5 Years

2200 Lumens - LED - 4 ft. Tube - 22 Watt - 4100K Cool White

1 review

$16.49

3 Watt - LED - S8 - DC Index Bayonet Base - 3000K - 12V DC

2 reviews

$8.40

Customer Reviews

Authentic Reviews

5 / 5

Helps with Freezer Ban (good for cold and the T8 Ban)

May 1, 2015

LedSpecialist

from Dallas, TX

This lamp works with the existing instant-start ballasts already in play, which is perfect since many of the 700 series T8s are becoming harder to replace, as they're no longer in production. Add in the popular 4100K color temperature and the fact that it works in cold and damp places (freezer lockers), and it's an excellent replacement for fluorescent T8s.
Otherwise it's a top-tier LED T8. Flicker-free, bright, and with a beam angle that's equivalent to a housed fluorescent bulb. All-in-all an excellent tube for a competitive price.

Effectiveness 5 / 5

Value 5 / 5

Yes, I recommend this product.

helpful 0 0

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Additional Media

2200 Lumens - LED - 4 ft. Tube - 22 Watt

4100K Cool White - NO REWIRING REQUIRED - GCP 558

5 / 5

Read 1 review | Write a review

g+1 0 Like 0

Energy Saving Calculator

LED Replacement 22 Watts
Existing Lamp 32 Watts
Lamps Replaced 1
Cost per kWh 0.11

Savings over life of lamp: $55

Click here to change values

$16.49 ea

New 20% Lower Price - No Coupon Needed!

Quantity: 1

Add To Cart

LED-558

GLOBAL Consumer Products, Inc

Capable of replacing your existing fluorescent T8 lamps without any additional wiring, the GCP 558 T8 LED tube lamp provides exceptional LED lighting with reduced energy and maintenance costs. Measuring four feet in length and operating at 22 watts, this lamp has a cool white color temperature of 4100K, a rated lifetime of 50,000 hours and a brilliant lumen output of 2200. Built with an internal driver designed to work with your existing instant start fluorescent ballast, this T8 LED lamp functions with a voltage range between 110 and 277 volts. Operating with the pre-installed fluorescent ballast means this lamp is dimmable if the instant start ballast is also dimmable. Installation has never been simpler and does not require a licensed electrician since the lamp requires no special changes and can be swapped or combined with your existing fluorescents. No rewiring allows the fixture to maintain its original UL compliance.

Brochures & Spec Sheets

- Overdrive 558 Spec Sheet
- Correct Application of Lampholders
- T8 LED Comparison Sheet
- Warranty
- Brochure
- T8 Lifetime
- Overdrive FAQ

Specifications

Stock Code:	LED-558	**Brand:**	Global Consumer
Part No.:	558	**UPC:**	879939005581
Wattage:	22 Watt	**Voltage:**	120/277
Beam Angle:	110 Degree	**Bulb Shape:**	T8
Base Type:	Medium Bi-Pin	**Dimmable:**	Yes
Color Temperature:	4100 Kelvin	**CRI:**	82
Compatibility:	Instant Start	**Length:**	47.165 in.
Diameter:	1 in.	**Fluorescent Equal:**	32 Watt
Life Hours:	50,000	**Light Source:**	LED
Lumens (Initial):	2200	**Lumens Per Watt:**	100

Customers Also Purchased

2200 Lumens - LED - 4 ft. Tube - 22 Watt - 5000K Stark White

2 reviews

$19.99

1100 Lumens - LED - 2 ft. Tube - 10 Watt - 5000K Stark White

0 reviews

$19.00

1650 Lumens - LED - 4 ft. Tube - 16 Watt - 4100K Cool White

0 reviews

$12.99

Operating Temp:	-4°F to 113°F	**Weight:**	1.1 lb.
ETL Listed:	Yes	**DLC Listed:**	Yes
Warranty:	5 Years	**Case Quantity:**	20

Customer Reviews

Authentic Reviews

5 / 5

Easy installalation and AMAZING light output. LOVE,LOVE

April 23, 2015

Lightumup

from California. **Age:** 45-54 **Gender:** female

This is a must have LED T8 . I have this in my house and office. I recenty was at a Carl's Jr and I could tell it was the same manufacture, Beautiful color, not too bright PERFECT.
I have seen some junk and you definitely need to read the FAQ and etc. when purchasing LED's..

Effectiveness 5 / 5

Value 5 / 5

Yes, I recommend this product.

helpful 0 0

Post a comment

Be the first to comment on this review

LED - 10 Watt - A19 - 60 Watt Equal - 800 Lumens - 2700K War

33 reviews

$5.49

6 Watt - Dimmable LED - Decorative Torpedo - Frosted Bent Ti

7 reviews

$11.99

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NORIBACHI

FLOODLIGHT.XXL

FIXTURE CODE: **FLXXL**

LIGHT ENGINE RETROFITS

- L70 Rated life of 100,000+ hours
- Minimum CRI: 70; Custom CRI available upon request.
- Operating temp: -30° C to +60° C
- No toxic chemicals/ROHS compliant
- ETL certified, meets UL and CSA standards
- Eligible for Rebates
- 50-90% energy savings
- Manufactured in the USA

INSTALLATION

- Licensed electrician required
- Contact Noribachi for additional support

WARRANTY

- 5 year manufacturer's warranty
- **10YR** - Optional 10 year manufacturer's warranty
- US manufacturing and quality control

CERTIFICATIONS

APPEARANCE

HOUSING	*LENS*	*MOUNTING*	*DIFFUSION*
• BRONZE • **COL** - CUSTOM	• TEMPERED GLASS	• HANDLE YOKE • POLE TOP	• NONE • LUMINIT FILM

FIXTURE INFORMATION

- EPA Rating 2.61
- IP Rating: 65

ELECTRICAL CHARACTERISTICS

- Standard AC input: 120-277 VAC
- EMI filter: 47CFR, part 2, part 15
- Power factor: >.9
- Total harmonic distortion: <20%
- Surge protection: IEC/EN 61000-4-5 EMC test standard

OPTIONAL UPGRADES

- **HY** - Handle Yoke Mount
- **PT** - Pole Top Mount
- **V1** - Visor for 19" Reflector
- **V2** - Visor for Type 3 Distribution
- **V3** - Visor for Type 4, 5 & 6 Distribution
- **HV2** - 480V greater than 150W
- **HV3** - 480V greater than 300W

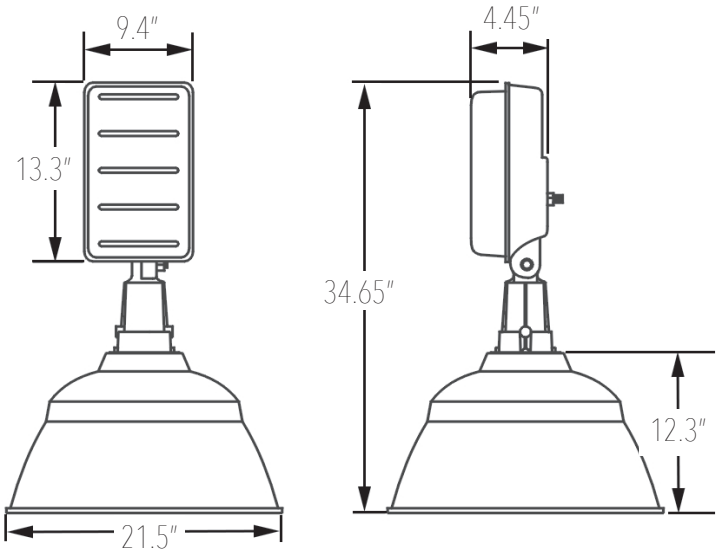
OPTIONAL BEAM SPREAD AND TYPE DISTRIBUTION

- **80D** - Optional 80° Beam Spread

DIMENSIONS

HEIGHT: 21.5"
LENGTH: 34.65"
DEPTH: 12.3"

MOUNT LENGTH: 13.3"
MOUNT WIDTH: 9.4"
MOUNT HEIGHT: 4.45"



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FLOODLIGHT.XXL

AVAILABLE LIGHT ENGINE RETROFITS

HEX-105

DRIVE CURRENT	WATTAGE	REPLACES	LUMEN OUTPUT	CATALOG #
B	158W	400-650W	22,155lm	HEX-105-B-CW-MT-FLXXL

HEX-126

DRIVE CURRENT	WATTAGE	REPLACES	LUMEN OUTPUT	CATALOG #
B	189W	550-800W	26,586lm	HEX-126-B-CW-MT-FLXXL

HEX-168

DRIVE CURRENT	WATTAGE	REPLACES	LUMEN OUTPUT	CATALOG #
B	252W	725-1200W	35,448lm	HEX-168-B-CW-MT-FLXXL

HEX-189

DRIVE CURRENT	WATTAGE	REPLACES	LUMEN OUTPUT	CATALOG #
B	284W	850-1300W	39,879lm	HEX-189-B-CW-MT-FLXXL

HEX-210

DRIVE CURRENT	WATTAGE	REPLACES	LUMEN OUTPUT	CATALOG #
B	315W	1000-1450W	44,310lm	HEX-210-B-CW-MT-FLXXL

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AVAILABLE LIGHT ENGINE RETROFITS

HEX-252

DRIVE CURRENT	WATTAGE	REPLACES	LUMEN OUTPUT	CATALOG #
B	378W	1250-1700W	53,172lm	HEX-252-B-CW-MT-FLXXL

HEX-378

DRIVE CURRENT	WATTAGE	REPLACES	LUMEN OUTPUT	CATALOG #
B	567W	1500W+	79,758lm	HEX-378-B-CW-MT-FLXXL

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Proforma Invoice

4928 West Rosecrans Ave
Hawthorne, CA 90250

Phone 877-553-2810 Finance@noribachi.com
Fax 310-644-8980 www.noribachi.com

Date	Invoice #
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Bill To
Kuhn & Kuhn Energy 31 Arcangel Court Fairfax, CA 94939

Ship To
C/O Peter Kuhn Kuhn & Kuhn Energy 31 Arcangel Court Fairfax, CA 94939

Ship Date	Ship Via	Purchase Order #	Terms	Due Date
	Best Way			

	Qty	Rate	Amount
HEX-378-B-CW-MT-FLXXL	32	$ 1,429.00	$ 45,728.00
			$ -
Noribachi will take care of shipping			
			Subtotal $ 45,728.00
			Sales Tax $ 4,115.52
			Total $ 49,843.52
			Payments/Credits $ -
		Balance Due	$ 49,843.52

A finance charge of 1.5% will be assessed if payment is not received by the due date.

Please make checks payable to:
Noribachi Corporation
4928 West Rosecrans Ave
Hawthorne, CA 90250

PHOTOCELLS

Leviton's Photocell sensors precisely monitor either task or ambient light levels. As part of a Leviton energy management system, photocells work with other components in the system to automatically adjust light levels to a user-defined level. Photocells are most suitable for installation in rooms with windows and open spaces receiving substantial ambient light.

Photocells must be hardwired to a compatible Leviton lighting control system. The photocell measures ambient light in a specific area and sends this data to a dimmer or relay that, in turn, adjusts fixtures to a constant lighting level as measured in that specific area. Daylight Harvesting is achieved as lights in a room (with windows or significant, artificial ambient light) automatically brighten or dim depending on how much light the photocell detects.

Daylight Harvesting

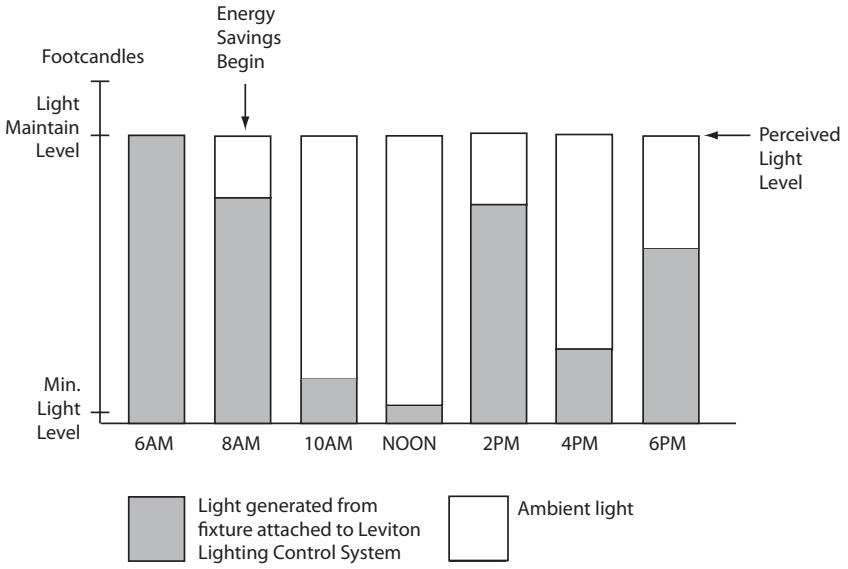
With Daylight Harvesting, ambient (often natural) light supplements in-room, artificial light in order to keep a constant lighting level while saving energy. This constant level is programmed into a compatible control device. Once hardwired to the photocell, the dimmer or relay will receive the photocell's real-time light measurement and maintain a steady level within the photocell's area of detection.

Rules of Operation

Measured light level = Light Maintain Level Action: Output to lights remains constant

Measured light level < Light Maintain Level Action: Lights are brightened

Measured light level > Light Maintain Level Action: Lights are dimmed



FEATURES

- Indoor photocells are designed with a flat Fresnel lens that looks downward in a 60° cone of reference to measure actual light on the work surface, and reducing the influence of stray light striking the photocell from nearby windows or incidental side lighting
- Outdoor photocells are IP54 rated to guarantee ultimate protection from dirt, dust, oil, and other non-corrosive material
- Measures light from any source in the visible spectrum within a 60° cone or 180° angle of response depending on the model
- Constant lighting at the optimal level for greater visual comfort and acuity, which contributes to improved productivity
- Provides convenient, automatic hands-free daylight harvesting when integrated with Leviton lighting control products
- Lowers electric bills by reducing usage of lighting where ambient natural light is also present
- Lumen maintenance opportunity compatible
- ODC0P-00W photocell with 60° clear lens operates between 0-70FC; ODC0P-000 should be surface mounted or direct to ceiling box
- ODC0P-S0W switching photocell with 60° clear lens operates between 1-750FC; ODC0P-S0W should be surface mounted or direct to ceiling box
- PCIND indoor photocell with 60° clear Fresnel lens is default setting = 0-100FC sensing range; can be field adjusted to 750FC max sensing range; PCIND should be mounted to the ceiling, facing down
- PCIND-0SV side view photocell for applications where ceiling mounting is required yet the view should be of the lighting entering the space through a window; or, for installation to the wall of skylights where the view should be up into the skylight; default setting = 0-3FC sensing range; can be field configured with a jumper for a 3FC, 30FC, 300FC, or 600FC max sensing range
- PCOUT outdoor photocell is enclosed in a weatherproof housing with a visor for shading and lens protection; default setting = 0-250FC sensing range
- PCOUT-0SV side view photocell for applications where wall mounting is required yet the view should be of the lighting entering the space through a top/side and/or face of the photocell; reference placement diagrams; default setting = 0-3FC sensing range; can be field configured with a jumper for a 3FC, 30FC, 300FC, or 600FC max sensing range
- PCATR atrium photocell with opaque dome lens filters 33% of light level in upper atrium; default setting = 0-1000FC sensing range; can be field adjusted to 2500FC max sensing range
- PCSKY skylight photocell with dark dome lens filters 90% of light level in skylight; default setting = 0-2000FC sensing range; can be field adjusted to 7500FC max sensing range

ORDERING INFORMATION

CAT. NO.	DESCRIPTION	LENS	SENSING RANGE
ODC0P-00W	Photocell	Clear	0-70FC
ODC0P-S0W	Switching Photocell	Clear	1-750FC
PCIND-000	Indoor Photocell	Fresnel	50-750FC
PCIDN-0SV	Indoor Side View Photocell	Clear Hood	0-30FC
PCOUT-000	Outdoor Photocell	Clear Hood	50-750FC
PCOUT-0SV	Outdoor Side View Photocell	Diffuse	0-300FC
PCATR-000	Atrium Photocell	Dome/Frost	200-2500FC
PCSKY-000	Skylight Photocell	Dome/Frost	1000-7500FC

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LEVITON ODC0P-S0W 10V PHOTOCELL

Technical Description:
10V PHOTOCELL

UPC: 07847767010

Mfr Part #: ODC0P-S0W

Manufacturer: LEVITON

Your Price: $97.95 / ea

Total Available: Leviton Orders Over $75 Usually Ship Next Day

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CONTACT: Peter Kuhn

TELEPHONE:

CONTACT:

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150415.2	4/15/15		N/A	N/A	PRE-PAID	UPS+TRUCK

TERMS: NET 30

EXACT POOL SIZE: 82 FT. x 82 FT. = 6724 SQ. FT.

BLANKET COST: $ 19,162.00 TOTAL: $ 19,162.00

REEL SYSTEM COST: $ 18,000.00 EACH x 4 TOTAL: $ 72,000.00

INSTALLATION AND/OR FREIGHT: $ 12,000.00 / 1,800.00 TOTAL: $ 13,800.00

OTHER: $ TOTAL: $

TOTAL QUOTE: $ 104,962.00

SKETCH OF POOL WITH UNIQUE FEATURES AND DIMENSIONS

Customer to supply all electrical to include control wiring. Quote also assumes walls to be structurally sound. Structural evaluation/steel, if needed, not included. If payment/performance bond is needed please add 3.5%. Any taxes, permit, inspection fees, if applicable, to be added on a pass through basis. Taxes not included, tax exempt certificate to be provided if project tax exempt.

Peter Staiger

Digitally signed by Peter Staiger
DN: cn=Peter Staiger, o=Alta Enterprises, Inc., ou, email=pstaiger@altaenterprises.com, c=US
Date: 2015.04.15 12:00:42 -06'00'

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Air Conditioning
Hydronic Systems

norman–wright.com

QUOTATION

TO: COMCAST
ATTN: PETER KUHN

DATE: April 16, 2015
PAGE: 1 of 2

TERMS:	Net 30 Days	FOB:	Factory FFA	SHIP TIME:	FRT. ALLOW:	Included

This Quotation Subject To Acceptance Within 30 Days.
To the prices and terms quoted, add any manufacturers' gross receipts, sales or use tax, either Federal, State or City, payable on the transaction under any affecting statue. Orders will be invoiced at price in effect at time of shipping, unless otherwise specified. All orders subject to factory acceptance. No material will be accepted for return without permission. Orders may not be canceled without written permission from the manufacturers'. Cancellation charges may be involved. No warranty is offered or implied, other than the standard warranty of the manufacturer. Written copies available on request. Unless otherwise stated, we do not include: seismic calculations, disconnect switches, starters, controls, thermostats, damper motors, internal wiring, drives, belt guards, filters, gauges, vibration isolators, and start-up service or supervision. Programming of DDC controls is not included in this quotation.

PROJECT: BERKELEY HIGH SCHOOL
REF: 17877 M/N RS-182-43

The following is our quote to convert the above unit from SIEMENS controller to Supervisaire microprocessor controller.

Supervisaire Controller Upgrade (Required). **$ 19,500.00 NET+TAX**

(Include unit mounted keypad, sensors, control panel drawing and technical support).

- **A control plate with all components mounted and wired to replace the actual control panel.**
- **All remote wiring such as compressor, fan motor, damper motors, pressure switches, auxiliary pool heater, auxiliary space heater, emergency compressor switch, display panel, solenoid valves, event and non-event signal, alarm, and sensors to be wired to the control panel by others. This is a preliminary list of field wiring.**

Remote operator panel. (Optional) **$1070.00 NET+TAX**

Please see the attached for following BMS protocols if required. Choose only one protocol if required. Price not include in the Supervisaire upgrade cost.

Note: We do not provide labor and startup after retrofit. The above pricing is for parts, drawings and technical support only. Also we will need the dimensions of the electrical plate with the holes location so that we can build the same.

- **Delivery 8 to 10 weeks.**
- **This quote is valid for 60 days.**

Norman S. Wright Mechanical,

Stuart Bass / Chris Nguyen

TERMS AND CONDITIONS

1. These terms and conditions apply to all purchases by Buyer (as referenced on the first page) from Norman S. Wright Mechanical Equipment Corp. (hereafter "Seller"). Seller's offer to sell equipment to Buyer expressly limits acceptance to the terms and conditions set forth herein. Notification of objection is hereby given to any term in any response to this offer that does not exactly match the terms of this offer.
2. To the extent Buyer has or had a balance due to, credit application with, or account with Seller, these terms and conditions shall supersede and control any terms governing the Buyer's previous or other account, except that any personal guarantees shall continue in full force and effect unless specifically revoked in writing. The terms set forth herein, and on any Credit Agreement, quotation, order acknowledgement from Seller to Buyer or invoices presented to Buyer for payment are the entire agreement between the parties.
3. Payment shall be due **NET 30 DAYS** from the date of invoice. Discount of 1% is allowed for payment in full received by Seller before the tenth (10th) of the month following invoices. If Buyer's Credit Application with Seller is not approved, Buyer must deposit of 100% of the purchase price with Seller before the order will be released. Payment for merchandise received shall be made as per these terms and shall not be dependent upon receipt of payment by Buyer from third parties. Service charges shall accrue on amounts not paid by the 25th of the month following invoice at the rate of one and one-half percent (1½%) per month (18% per annum).
4. If Buyer's account balance remains unpaid 45 days following the date of the purchase, Seller, at its sole discretion, may determine the account to be in default and may immediately cease extending further credit to Buyer.
5. When reasonable grounds for insecurity arise with respect to Buyer's ability to pay, Seller may in writing demand adequate assurance of due performance. Buyer's failure to provide such assurance of due performance as is adequate under the circumstances of the particular case within five (5) calendar days of the demand is a default under this Agreement. Adequate assurances may include providing a bond or bonds, in the Seller's sole discretion.
6. In the event of default, Seller shall have no obligation to deliver or order materials subject to an outstanding purchase order unless and until Seller receives payment in full for those materials and all outstanding balances. Seller may apply the payments made by Buyer in any manner that Seller, in its sole discretion, deems appropriate, including application of payment to service charges first, and then principal.
7. Seller may change the terms of this agreement, including the rate of service charge, at any time upon 30 days notice of such change. Seller may cancel Buyer's credit account at any time, without notice, and with or without cause. In such event, Buyer agrees to immediately pay the outstanding balance.
8. In the event Seller incurs any legal fees in connection with collecting monies due, Seller shall be entitled to recover its attorneys' fees, expert's fees, costs of suit and/or collection agency fees. If more than one person or entity signs this application, it is understood and agreed that all entities and persons are jointly and severally liable for payment. In the event of litigation, Buyer and Seller agree to submit to the exclusive jurisdiction of the courts of the State of California for all disputes arising out of or concerning this Agreement.
9. In the event Buyer believes, or has reason to believe, that Seller has provided materials, equipment, or other products which are damaged or are in any way incorrect or unsuitable ("defective"), Buyer shall provide Seller with written notice of the same within twenty-four hours of discovery of the defect, or when Buyer should have discovered the defect.
10. **EXCLUSION AND LIMITATION OF WARRANTIES. Seller's liability for defective equipment shall be limited to any warranty provided by the manufacturer. THE EXPRESS WARRANTY CONTAINED HEREIN IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Buyer waives all warranties, express or implied, except for those furnished by the manufacturer who furnished the material to seller. In no event shall Seller's liability exceed 250% of the amount paid to seller for providing such materials. The Parties acknowledge and agree that the foregoing sentence is an express, negotiated agreement allocating and limiting liability in accordance with applicable law, including without limitation, section 2782.5 of the Civil Code.**

11. **<u>WAIVER OF CONSEQUENTIAL DAMAGES AND LIMITATION OF REMEDIES</u>. By accepting shipment, Buyer waives any and all special or consequential damages arising out of or any way related to all purchases by Buyer from Seller. Buyer specifically waives any and all damages for delay, including reimbursement of liquidated damages that may be imposed on Buyer.**
12. Delivery of products, title and risk of loss pass to Buyer FOB place of manufacture. All shipping dates are approximate and are not guaranteed.
13. Buyer's delivery of notice or revocation of these terms and conditions shall in no way relieve Buyer from any liability or for any indebtedness incurred prior to Seller's actual receipt of such notice. To the extent that materials or products furnished by Seller are intended by Buyer to be incorporated into a construction work of improvement, Buyer shall fully and promptly furnish to Seller any and all project information necessary for Seller to perfect any actual or potential mechanic's liens, stop notice or bond rights.
14. The terms and conditions set forth herein shall apply to all equipment and/or materials furnished to Buyer by Seller. To the extent that a current or subsequent Purchase Order expressly incorporates by reference the terms of any contract documents, the terms set forth herein shall amend and modify the Purchase Order and any contract documents, and shall supersede and control any conflicting language in the Purchase Order or any of the contract documents. Terms in a subsequent Purchase Order that are inconsistent with the Terms and Conditions set forth herein shall apply if and only if the specific inconsistent terms have been initialed by a Seller's authorized representative. Seller hereby expressly rejects any terms in the contract documents or in the Purchase Order that are inconsistent with the Terms and Conditions set forth herein. Seller's obligations, if any, to supply equipment and/or materials on credit are expressly made conditional on Buyer's assent to the terms and conditions herein.
15. Buyer shall assign to Seller any and all mechanic's lien, stop notice, bond claims or rights that Buyer has or may have with respect to the project under the Mechanic's Lien, Stop Notice and/or Bond Laws pertaining to public or private construction, or against contract proceeds or retainages payable to Buyer with respect to such project. In no event shall the assignment release Buyer of the underlying obligation to pay Seller the entire debt owed to Seller. Further, Buyer's assignment to Seller of the claims or rights as discussed in this paragraph is in addition to any other security given to Seller or that Seller may have received from Buyer. Buyer shall hold all payments received in connection with materials furnished to it by Seller in trust for Seller.
16. Any and all returned items are subject to a minimum 25% restocking charge. A copy of the invoice must accompany returned goods. There will be no return on special order material. All claims for shortages must be noted on delivery tickets and reported within five days after receipt of the order. All returns must be in resalable condition. No returns will be accepted on custom manufactured equipment.
17. To the fullest extent allowed by law, Buyer agrees to indemnify, defend and hold Seller harmless from any claims, demands, liabilities, damages, causes of action, expenses, including attorneys' and expert's fees ("claims") arising out of or in connection with any of the materials, supplies or equipment provided by Seller, notwithstanding any active or passive negligence on the part of Seller. This indemnification shall not apply to claims directly resulting from Seller's sole negligence or willful misconduct of Seller.
18. Seller shall have no liability for non-performance due to acts of God; acts of Buyer; war (declared or undeclared); terrorism or other criminal conduct; fire, flood, weather; sabotage; strikes, labor or civil disturbances; governmental requests, restrictions, laws, regulations, orders, omissions or actions; unavailability of, or delays in utilities or transportation; default of suppliers or inability to obtain necessary equipment or materials through no fault of its own; embargoes or any other events or causes beyond Seller's reasonable control (each a "Force Majeure Event"). Deliveries or other performance may be suspended or canceled by Seller upon notice to Buyer of a Force Majeure event.
19. In the event any portion of these terms are declared by a court or arbitrator of competent jurisdiction to be invalid, illegal or unenforceable as written, Buyer agrees that the Court or arbitrator shall modify and reform such provision to permit enforcement to the greatest extent permitted by law, and that the enforceability of the remaining provisions of this Agreement shall in no way be affected or impaired.

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TELAIRE

Telaire T5100-GN-5V-LED
Low-Cost Wall Mount CO2 Transmitter with LED Indicators

No Branding, 0 - 5V (switch selectable) CO2 and Temperature output

- **0-5V (switch selectable) CO2 and Temperature output**
- **Simple Design with no Logo on Front**
- **Patented, Absorption Infrared Gas sensing engine provides high accuracy in a compact low cost package**
- **Patented ABC Logic self-calibration system eliminates the need for manual calibration in most applications**
- **Lifetime CO2 calibration guarantee when using ABC Logic**
- **Mounting plate with two-piece terminal blocks provide quick, easy wiring**
- **Gas permeable, water resistant CO2 diffusion filter prevents particulate and water contamination of the sensor**
- **Locking screw secures cover and sensor to the mounting bracket for tamper resistance**
- **Sensors are shipped factory calibrated**
- **Modern enclosure**
- **Low-cost**
- **Reliable (20 years of low-cost infrared sensor manufacturing)**
- **UI software compatible for customizations**
- **CE, RoHS, REACH and WEEE compliant**
- **Lifetime calibration warranty**

Product Information	
Datasheet	867 KB PDF
Manual	394 KB PDF
PDF Help	

The Telaire T5100-GN-5V-LED Wall Mount CO2 Transmitter with LED Indicators is a new low cost, high performance CO2 transmitter for the building controls market. The Telaire T5100GN-5V-LED works seamlessly with building automation systems, and allows you to simply and effectively control fresh air into a ventilated space to regulated standards, providing immediate energy savings.

Ventilation is an important part of maintaining a comfortable, healthy, productive environment for people. Improper ventilation can have a negative impact on occupant health and performance, increase the risk from litigation, and/or waste energy. Demand-controlled ventilation using CO2 sensors prevents energy losses from over-ventilation while maintaining indoor air quality. The most energy savings potential is in buildings where occupancy fluctuates during a 24-hour period.

Numerous organizations now require and/or recommend CO2- based ventilation control in different commercial HVAC applications. Some utility companies also offer rebates to building owners for installing CO2 sensors. The Telaire T5100-GN-5VLED Wall mount sensors are used to control a specific area such as a conference room, classroom, meeting hall, etc. The Telaire 5100 Ventostat Wall Mounted CO2 Transmitter are easy to install and have a clean, modern look that suits most indoor environments.

LED Display
The Telaire T5100-LED series has a 5-color LED display that shows the approximate CO2 concentration. From left to right, the display shows:

- Blue <800 ppm
- Green 800-1200 ppm
- Yellow 1200-1500 ppm
- Red >1500 ppm
- Two red >2000 ppm

CO2 ABC Logic Self Calibration
The Telaire T5100GN5VLED sensors employ the patented ABC (Automatic Background Calibration) Logic self-calibration system. ABC Logic virtually eliminates the need for manual calibration in applications where the indoor CO2 level drops to outside levels during unoccupied periods (e.g. during evening hours). ABC Logic is a special software routine in the sensor that remembers the background readings for 14 consecutive evenings, calculates if there is a sensor drift, and then corrects for it.

With ABC Logic enabled, the sensor will typically reach its operational accuracy after 25 hours of continuous operation at a condition that is exposed to ambient reference levels. Sensors will maintain accuracy specification with ABC Logic enabled, given that it is at least three times in 14 days exposed to the reference value and this reference value is the lowest concentration to which the sensor is exposed.

Note: Applies when used in typical indoor ambient air.

CO2 Calibration Guarantee
Telaire is serious about minimizing maintenance, so each Telaire T5100 sensor comes with a lifetime calibration guarantee.

Specifications	
Sensing Method	Non-dispersive infrared (NDIR) absorption Gold-plated optics Patented ABC Logic self calibration algorithm
CO2 Measurement Range	0 to 2000 ppm (0 ppm = 0 V, 4 mA)
CO2 Accuracy	±30 ppm or 3% of the reading shown, whichever is higher
Active Temperature Accuracy /Range	0 - 50°C (32 - 122°F) ±1°C from 15 - 30°C (±1.8°F from 59 to 86°F)*
Power Supply Requirements	18-30 VAC RMS, 50/60 Hz, or 18 to 42 VDC, polarity protected *AHRAE — regulation 62 states maximum indoor CO2 level of 1000 ppm
Power Consumption	Typical 0.7 W at nominal voltage of 24V AC RMS
Temperature Dependence	0.2% FS per °C (±0.11% per °F)
Stability	<2% of FS over life of sensor (15 years)
Pressure Dependence	0.135% of reading per mm Hg
Certification	CE EMC, RoHS, REACH and WEEE compliant
Signal Update	Every 5 seconds
CO2 Warm-up Time	<2 minutes (operational) 10 minutes (maximum accuracy)
Operating Conditions	32°F to 122°F (0°C to 50°C) 0 to 95% RH, non-condensing
Storage Conditions	-40°F to 158°F (-40°C to 70°C)
Flammability Classification	UL94 5VA
Display	5 color LED display
Temperature	0 - 50°C active output
Warranty	24 months on mechanical defects Calibration - lifetime warranty (ABC Logic on.)

Ordering Information			
Model	**Description**	**Buy Online**	**Price**
T5100-GN-5V-LED	Telaire T5100-GN-5V-LED 0-5V Low-Cost Wall Mount CO2 Transmitter with LED Indicators, No Branding	Buy Now	Sale $242.95 (Reg. $270.00)
Related Products			
T5100-5V-LED	Telaire T5100-5V-LED 0 - 5V Low-Cost Wall Mount CO2 Transmitter with LED Indicators	Buy Now	$270.00
T5100-10V-LED	Telaire T5100-10V-LED 0 - 10V Low-Cost Wall Mount CO2 Transmitter with LED Indicators	Buy Now	$270.00
T5100-I-LED	Telaire T5100-I-LED 4-20 mA Current Low-Cost Wall Mount CO2 Transmitter with LED Indicators	Buy Now	Sale $195.95 (Reg. $270.00)
T5100-GN-10V-LED	Telaire T5100-GN-10V-LED 0 - 10V Low-Cost Wall Mount CO2 Transmitter with LED Indicator, No Branding	Buy Now	Sale $242.95 (Reg. $270.00)
T5100-GN-I-LED	Telaire T5100-GN-I-LED 4-20mV Low-Cost Wall Mount CO2 Transmitter with LED Indicators, No Branding	Buy Now	Sale $242.95 (Reg. $270.00)
Included Accessories			
	_ **1** - Screw Set _ **1** - Mounting Base _ **1** - User's Manual	Included	
Optional Accessories			
1508	Telaire 1508 Aspiration Box Enclosure	Buy Now	$175.00

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E209	AC MOTOR 40HP 1800RPM 324T 230/460VAC 3-PH CAST-IRON BLUE CHIP Normally ships direct from AutomationDirect. 30-day returns are not offered on this item. **Due to weight restrictions this item must ship via Freight.**	2643.00	1		2643.00		
GS3-4040	GS3 40HP AC DRIVE 460VAC 3 PHASE **Due to weight restrictions this item must ship via Freight.**	2001.00	1		2001.00		

Subtotal: $4644.00

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	GSDA-DP	DIG POTENTIOMETER 120-240VAC +/- 12VDC OR 0-24VDC NEMA 4X *more...*	$215.00	0			GS3-4040
	LR-4040	LINE REACTOR 460V 40HP 3PH DRIVE INPUT OR OUTPUT, 3% IMPEDANCE *more...*	$198.00	0			GS3-4040
Representative Photo	MTA-BASE-W324T	MOTOR BASE ADJUSTABLE FOR 324T FRAME DOUBLE ADJUSTING SCREWS PRIMER FINISH *more...*	$81.00	0			E209
		Managed Ethernet Switches					GS3-4040
		Tools & Test Equipment > Handheld Tachometers					E209
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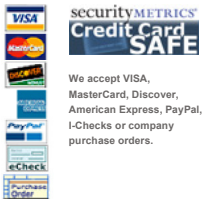

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BALDOR • RELIANCE

CECP84103T-4

25HP, 1770RPM, 3PH, 60HZ, 284TC, 1052M, TEFC, F

Product Information Packet PDF

List Price	5,145.00 USD
Multiplier Symbol	SD
Ship Weight	430 LB
UPC	781568351598

SPECS DRAWINGS NAMEPLATE PERFORMANCE PARTS

Output	25.000 hp
Phase	3
Synchronous Speed	1,800 rpm
Frequency	60 Hz
Voltage	460 V
Enclosure	TEFC
Frame Material	Iron
Frame	284TC
XP Division	Division II
Brand	Baldor-Reliance
Agency Approvals	CCSA US CSA CSA EEV UR
Ambient Temperature	40 °C

Lifting Lugs	Std Lifting Lugs
Locked Bearing Indicator	Locked Bearing
Max Speed	2,700 rpm
Motor Lead Exit	KO Box
Motor Lead Quantity/Wire Size	3 @ 10 AWG
Motor Lead Termination	Ring Terminals
Motor Standards	NEMA
Motor Type	1052M
Mounting Arrangement	F1
Number of Poles	4
Overall Length (C Dim)	27.93 in

Auxillary Box	No Auxillary Box
Auxillary Box Lead Termination	None
Base Indicator	Rigid
Bearing Grease Type	POLYREX EM (-20F +300F)
Blower	None
Constant Torque Speed Range	1.3
Current	30.0 A
Design Code	B
Drip Cover	No Drip Cover
Duty Rating	CONT
Efficiency @ 100% Load	93.6%
Electrically Isolated Bearing	No electrically isolated
Feedback Device	No feedback
Front Face Code	Standard
Front Shaft Indicator	None
Heater Indicator	No heater
High Voltage Full Load Amps	30.0 A
Insulation Class	F
Inverter Code	Inverter duty
KVA Code	G

Power Factor	85
Product Family	Chem Process S/P 32-8 IEEE 841
Pulley End Bearing Type	Ball Bearing
Pulley Face Code	C-Face
Pulley Shaft Indicator	Standard
Rodent Screen	No Rodent Screen
Service Factor	1.15
Shaft Diameter	1.875 in
Shaft Extension Location	Pulley End
Shaft Ground Indicator	No Shaft Grounding
Shaft Rotation	Reversible
Shaft Slinger Indicator	No Slinger
Speed	1,770 rpm
Speed Code	Single Speed
Starting Method	DOL
Thermal Device - Bearing	None
Thermal Device - Winding	None
Vibration Sensor Indicator	No Vibration Sensor
Winding Thermal 1	None
Winding Thermal 2	None
XP Temp Code	T3C

Blue Chip XRI® – Ultra High Efficiency Motors

**** 230/460V and 575V Motors Available ****

MARATHON ELECTRIC®

Features

- Meets NEMA premium efficiencies
- Inverter duty
- 10:1 variable torque, 20:1 constant torque on VFD with 1.0 service factor
- Class F insulation
- Continuous duty at 40° C ambient
- Cast iron frame construction with rigid base mounting
- F1 standard conduit box location, non-reversible
- 1.15 service factor
- Shaft slinger
- Utilizes double shielded ball bearings
- Exxon Polyrex® EM bearing grease
- Electrically reversible
- UL Recognized, CSA Certified, and CE Mark
- Three year warranty (through Marathon Electric)

Motor Shipping Schedule		
*Same or one day **	*Up to 7 days*	*Up to 10 days*

Color indicates shipping lead time in business days. Check stock status online.
** Certain heavy and oversized items can be shipped only via LTL. Check our web site for current shipping method constraints by part number.*

Applications

Typical uses include material handling, machine tools, fans, conveyors, cranes and hoists, metal processing, test stands, pumps, compressors, textile processing, and other industrial machinery installed in dusty or dirty environments.

230/460V Motor Specifications

Part Number *	Price	HP	Base RPM	Volts	Enclosure	NEMA Frame	Model No.	N.P. F.L. Amps	Weight (lb) *
E205	$1,133.00	15	1800	230/460	TEFC	254T	254TTFNA6026	37.5 / 18.8	322
E206	$1,415.00	20	1800	230/460	TEFC	256T	256TTFNA6026	48 / 24.1	368
E207	$1,684.00	25	1800	230/460	TEFC	284T	284TTFNA6026	62 / 31	495
E208	$1,964.00	30	1800	230/460	TEFC	286T	286TTFNA6026	73 / 36.5	423
E209	$2,566.00	40	1800	230/460	TEFC	324T	324TTFS6026	95 / 47.5	675
E210	$3,113.00	50	1800	230/460	TEFC	326T	326TTFS6026	120 / 60	745
E211	$4,393.00	60	1800	230/460	TEFC	364T	364TTFS6036	138 / 69	920
E212	$5,569.00	75	1800	230/460	TEFC	365T	365TTFS6036	172 / 86	1125
E213	$6,880.00	100	1800	230/460	TEFC	405T	405TTFS6036	226 / 113	1400

** Refer to the Motor Shipping Schedule table for shipping information.*

Note: Please review the AutomationDirect Terms & Conditions for warranty and service on this product. Warranty service can be arranged through numerous Marathon Electric service centers. See list of service centers on our Web site at www.automationdirect.com.

575V Motor Specifications

Part Number *	Price	HP	Base RPM	Volts	Enclosure	NEMA Frame	Model No.	N.P. F.L. Amps	Weight (lb) *
E307	$1,088.00	15	1800	575	TEFC	254T	254TTFNA6030	15.0	326
E308	$1,355.00	20	1800	575	TEFC	256T	256TTFNA6030	19.3	368
E309	$1,615.00	25	1800	575	TEFC	284T	284TTFNA6030	24.8	565
E310	$1,877.00	30	1800	575	TEFC	286T	286TTFNA6030	29.2	514
E311	$2,493.00	40	1800	575	TEFC	324T	324TTFS6030	38.8	675
E312	$3,350.00	50	1800	575	TEFC	326T	326TTFS6030	48.0	640
E313	$4,393.00	60	1800	575	TEFC	364T	364TTFS6040	55.2	1025
E315	$5,569.00	75	1800	575	TEFC	365T	365TTFS6040	68.8	1125
E314	$6,880.00	100	1800	575	TEFC	405T	405TTFS6040	90.4	1400

** Refer to the Motor Shipping Schedule table for shipping information.*

Note: Please review the AutomationDirect Terms & Conditions for warranty and service on this product. Warranty service can be arranged through numerous Marathon Electric service centers. See list of service centers on our Web site at www.automationdirect.com.

Company Information
Drives
Soft Starters
Motors
Power Transmission
Motion: Servos and Steppers
Motor Controls
Sensors: Proximity
Sensors: Photoelectric
Sensors: Encoders
Sensors: Limit Switches
Sensors: Current
Sensors: Pressure
Sensors: Temperature
Sensors: Level
Sensors: Flow Switches
Pushbuttons and Lights
Stacklights
Signal Devices
Process
Relays and Timers
Pneumatics: Air Prep
Pneumatics: Directional Control Valves
Pneumatics: Cylinders
Pneumatics: Tubing
Pneumatics: Air Fittings
Appendix Book 2
Terms and Conditions

Subject: Berkeley H.S.
From: "Rubio, Mike" <mrubio@norman-wright.com>
Date: 5/13/2015 3:52 PM
To: "'peter@kuhnenergy.com'" <peter@kuhnenergy.com>

Peter: A budget price for replacing the existing Qty. 4 Heatex rooftop units with Daikin Model RAH VAV Heating Only Units with economizers and controls, total 129,410 cfm = **$2.12 / cfm**

Michael Rubio

Norman S. Wright Company

Tel 415.467.7600
Fax 415.467.0900
Cell 415.305.4159

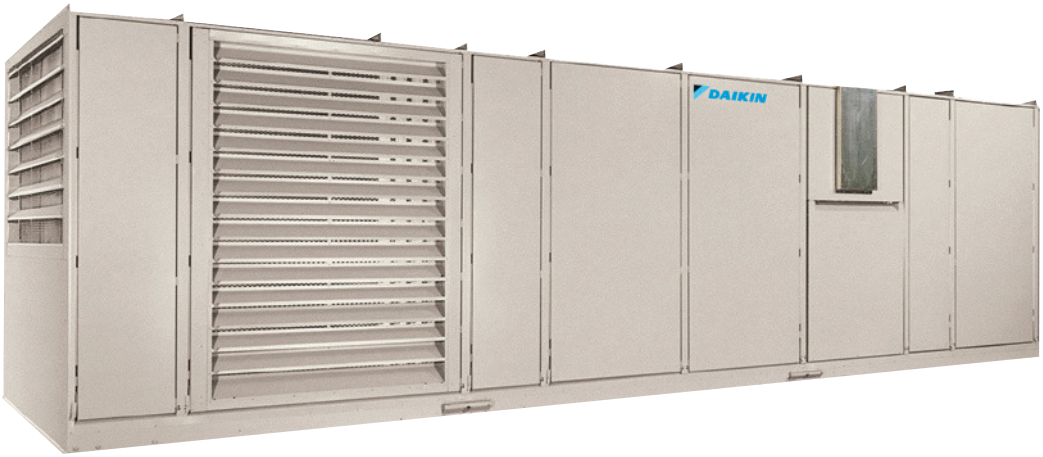
Local Manufacturer's Representative for ABB Variable Frequency Drives now in stock locally.

Disclosure: The author of this e-mail is not a licensed professional engineer and does not furnish design services. Any engineering information or advice contained within this e-mail is the opinion of the author only based on the information available to him/her at the time, which may not be complete. Any engineering information or advice contained within this e-mail is not intended to and cannot be used by anyone as a substitute for the independent professional judgment or due diligence of the design professionals (including, without limitation, the engineer of record) involved in the project.

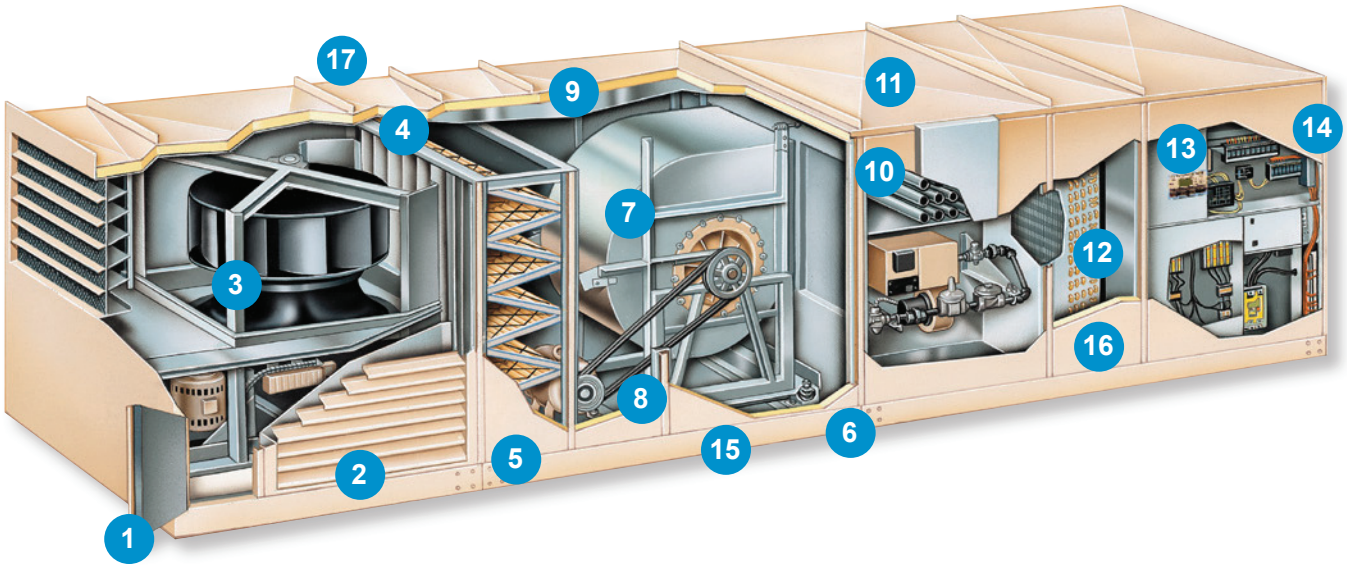
Catalog 218-3

RoofPak™
Applied Rooftop System Air Handler

Type RAH 047C and 077C 12,000 to 50,00 cfm
Type RDS 708B, 800C and 802C 2,000 to 20,00 cfm



People and ideas you can trust.™



1 Standard insulation

- 1¾ lb fully insulated unit with galvanized steel floor and door liners. All exposed insulation is pinned and retained leaving no exposed edges to delaminate.

2 Outdoor air louvers

- Designed with low inlet velocities to minimize moisture entrainment. Outdoor louvers on both sides of the unit minimize air stratification within the unit.

3 Efficient return fan

- Airfoil design is available with or without spring isolation and seismic restraints. Optional MicroTech III VaneTrol™ control logic on VAV applications provides proper building pressurization.

4 UltraSeal low leak dampers

- Standard on both outside and return air dampers to minimize air leakage and reduce energy costs. UltraSeal dampers have a low leakage rate.

5 Dual side access filter section

- With multiple filter options that have up to 95% efficiency.

6 Exclusive door latch

- Pinioned single point door latch. Unique vinyl door gasket provides positive seal in all sections. Hinged access doors on both sides of each section.Stainless steel hinges. Safety tie back rods on all doors.

7 Efficient supply fan

- Multiple forward curved and airfoil fan selections allow efficient selection for blow-throughand draw-through applications. Fans are DWDI or SWSIand are available with spring isolation and seismic restraints.

8 Drive selection

- Up to 150% service factor available for both fixed and adjustable pitch drives.

9 Insulated double wall construction

- Complete double wall unit construction is available with R6.5 insulation. Double wall construction eliminates damage to insulation, minimizes heat loss, prevents glass fibers from entering airstream, and provides a cleanable surface.

Figure 3: Airfoil fans

Figure 4: SWSI airfoil plenum fans

Supply and Return Air Plenum

- Bottom, side, top and front (RFS only) discharge locations and bottom and back return locations provide application flexibility to match complex system configuration requirements.
- Available with burglar bars or isolation dampers in both the discharge and return openings for additional building security.

Variable Air Volume Control†

- Energy saving, advanced technology, variable frequency drive (VFD), fan speed control is available with the convenience and cost savings of factory mounting and testing.
- All VFD selections are plenum rated and are conveniently mounted within the filtered air stream for extended service life and easy accessibility to maintenance and service personnel.
- To manage building static pressure, dedicated VFDs are used for the supply and return fans.
- MicroTech III controls provide advanced duct and building static pressure control and equipment diagnostics capability.†

Figure 5: Factory-installed variable frequency drive

† Not available on size 708.

Outside/Return Air Section

100% Return Air Option

- Includes a return air plenum with a bottom, back or top return air opening.

0% to 30% Outside Air Option†

Includes return air plenum and 0% to 30% outside air intake hood with patented UltraSeal™ low leak dampers to minimize leakage during off cycles. Damper is field adjusted to a fixed open position that is easily set using the MicroTech III keypad. Compatible with two-position or modulating control.

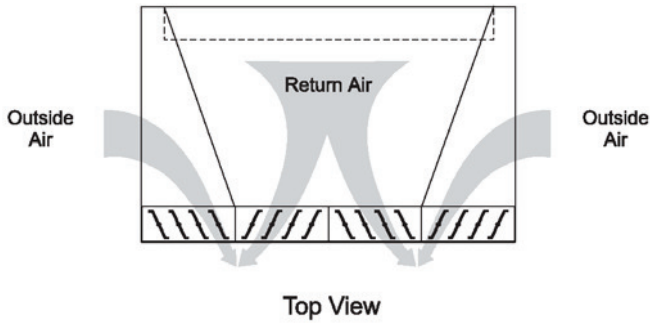
100% Outside Air Option

- Includes a weather hood factory mounted to the filter section, bird screen to help prevent infiltration of foreign objects, and UltraSeal low leak dampers to minimize leakage during off cycles.
- Dampers arranged vertically and compatible with a two-position control to sequence open when the supply fan is running and to close when the supply fan is off.

0% to 100% Economizer Option

- Includes return air plenum with back or bottom opening, exhaust air dampers and UltraSeal low leak economizer intake dampers to minimize leakage during off cycles.
- Available with or without return or exhaust air fans.
- Outside air is introduced from both sides of the unit through outside and return air dampers that are arranged vertically to converge the multiple air streams in circular mixing patterns, minimizing temperature stratification and improving system performance. (Size 708 has two outdoor air hoods on one side opposite the exhaust.)
- 0% to 100% economizer sections use horizontal louvered intakes, eliminating unsightly hood assemblies.
- DesignFlow outdoor air control system measures outside air intake volume and automatically adjusts damper position to maintain minimum volume requirements.*
- Outside air enthalpy, comparative enthalpy or dry-bulb temperature changeover provides control flexibility to bring in the most economical amount of outside air for “free” cooling.†
- Exhaust dampers exhaust air out the back of the unit.

Figure 9: Economizer airflow for 800, 802, 047C, and 077C



Mixing Box (not available on sizes 800 to 802)

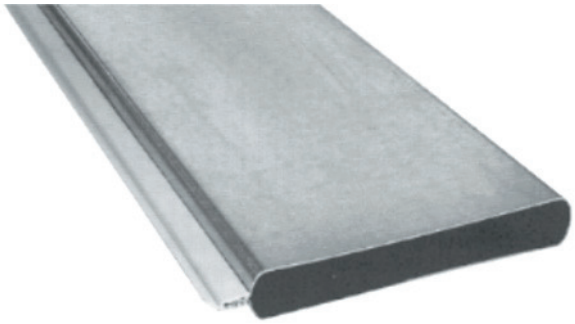
The mixing box option consists of a return air plenum, outside air hood, and UltraSeal low leak mixing dampers. The return air and outside air damper blades are positioned vertically for optimum mixing capability. A factory-mounted modulating spring return type actuator can be installed to operate the interconnected dampers.

The patented UltraSeal low leak dampers are standard equipment on both outdoor and return air dampers. This damper drastically reduces energy losses due to conduction and infiltration. The hollow core airfoil type damper provides 12 times the insulating factor over flat blade dampers. Air leakage is maintained below 1.5 cfm/ft^2 at 1" SP, as tested and confirmed in accordance with AMCA Standard 500. This is accomplished with the following design features:

- Heavy-duty, tubular airfoil blades that eliminate twisting and warping while minimizing air pressure drop.
- Heavy-duty construction allows the use of larger 7" wide blades running the full height of the cabinet. Fewer blades reduces the potential for leakage.
- All blade edges are provided with a unique gasketing design for low pressure differentials experienced on economizer applications.
- Flexible stainless steel side seals between the blade ends and the damper frame provide UltraSeal with one of the lowest leakage rates in the industry.

† Not available on size 708.

Figure 10: UltraSeal damper cross section



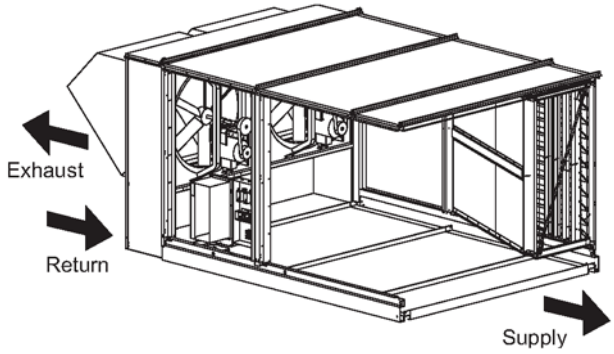
0% to 100% Economizer with Centrifugal Return Fan

Figure 11 shows return fan air flow configuration.

- All 0% to 100% economizer components are included
- Includes a DWDI forward curved, air foil or an SWSI air foil, centrifugal return fan
- Return fans are in series with the supply fan and operate simultaneously with the supply fan to control building pressure and handle the return duct ESP at all times.

NOTE: Return fans and exhaust fans have different performance characteristics and are not interchangeable. See page 29 for application recommendations.

Figure 11: Airflow configuration—exhaust fan



0% to 100% Economizer with Propeller Exhaust Fans (sizes 047 to 077 only)

Figure 11 shows exhaust fan air flow configuration.

- All 0% to 100% economizer components are included.
- Includes one to three propeller fans, depending on required capacity, all controlled from one VFD.
- Exhaust fans are in parallel with the supply fan and may only operate during the economizer mode to control building pressure. They do not handle the return duct at ESP design conditions.

NOTE: Return fans and exhaust fans have different performance characteristics and are not interchangeable. See page 26 for application recommendations.

DesignFlow Precision Ventilation Air Control System†

- Patented precision mass flow sensor assemblies directly measure the total mass volume of air flowing through the outdoor air intakes with accuracy exceeding 95% at the values indicated in Table 2.
- Repeatable accuracy helps provide adequate ventilation air for good indoor air quality (IAQ), energy efficiency, and compliance with ASHRAE Standard 62.1-2001. See Table 2 for ventilation airflow measurement ranges verified by Intertek Testing Services, Inc.
- Pre-engineered, factory-installed, and calibrated system requires no additional field-installed devices.
- MicroTech III controls automatically respond to mass flow sensor signals and adjusts outdoor air damper position to maintain ventilation rate set point.

Table 2: Ventilation airflow measurement range

Unit size	Ventilation airflow measurement range
800C	540 to 9,400 cfm
802C	808 to 13,120 cfm
047C	1080 to 18,000 cfm
077C	1594 to 37,126 cfm

† Not available on size 708.

Variable Air Volume

Daikin RoofPak variable air volume systems (VAV) employ the concept of varying the air quantity to a space at a constant temperature thereby balancing the heat gains or losses and maintaining the desired room temperature. This true variable volume system is commonly referred to as a “squeeze-off” or “pinch-off” system. Unlike a “bypass” or “dump” system, supply air is diverted from areas where it is not required to areas that need cooling and, at system part load conditions, reduces the total fan volume. This ability to reduce supply air quantities not only provides substantial fan energy savings at partial load conditions, but it also minimizes equipment sizing.

Variable volume systems offer the following advantages:

- Lowers system first cost by using system diversity to reduce equipment and duct sizes.
- Lowers operating costs by reducing fan energy demands, especially at part load conditions.
- Lowers first cost by reducing space requirements for duct trunks and mechanical equipment.
- Provides system flexibility to match changing occupancy demands.

Variable Frequency Drives†

Variable frequency drives offer reliable operation over a wide range of airflow, with advantages in sound and energy performance.

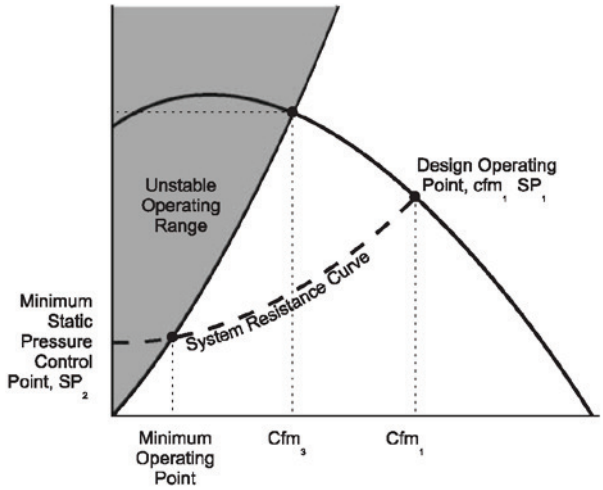
Variable frequency drives provide the most efficient means of variable volume control by taking advantage of the fan law relation between fan speed (rpm) and fan brake horsepower (bhp). Also, since airflow is reduced by changing fan speed, the noise penalties often associated with mechanical control devices, e.g. inlet vanes, are not introduced. The following equation illustrates how fan bhp varies as the cube of the change in fan speed:

$$hp_2 = hp_1 \left(\frac{density_2}{density_1}\right)\left(\frac{rpm_2}{rpm_1}\right)^3$$

In an ideal system, at 50% fan speed, brake horsepower would be reduced to 12.5% of that at full speed.

Variable frequency control varies the speed of the fan by adjusting the frequency and voltage to the motor. Keeping a constant volts/frequency ratio (constant magnetic flux) to the motor allows the motor to run at its peak efficiency over a wide range of speeds and resulting fan airflow volumes. illustrates on a fan curve the effect of varying air volume with a variable frequency drive.

Figure 27: Variable frequency drive control



Airfoil Fans

To further enhance VAV system performance, Daikin RoofPak VAV systems use efficient airfoil fan selections.

Daikin airfoil fan selections feature:

- Higher operating efficiencies than with commonly used, forward curved fans, reducing system energy demands and electrical requirements.
- A non-overloading brake horsepower curve.
- A single wheel design, eliminating potential problems with fan paralleling at light loads.

MicroTech III VAV Fan Tracking Control†

A key element in successful VAV application is the ability to track supply and return air fan volumes so that proper building static pressure is maintained. Daikin, a pioneer in the development of rooftop VAV systems, developed its exclusive VaneTrol fan tracking control logic to solve this issue. Incorporating over 35 years of rooftop VAV system experience, the latest generation MicroTech III controls with VaneTrol logic provide advanced and accurate duct static pressure control plus supply and return fan tracking control that effectively and efficiently manages building static pressure.

The MicroTech III controller provides complete control of your variable frequency drive applications.

Static Pressure Sensing Locations

In placing a duct static pressure sensor, locate a pressure tap near the end of the main duct trunk. Adjust the static pressure control so that at minimum airflow all the terminals receive the minimum static pressure required plus any downstream resistance. Locate a pressure tap in the ductwork free from turbulent effect, at least ten duct diameters downstream and several duct diameters upstream from any major interference including branch takeoffs. Do not sense the static in a branch duct. On installations having multiple duct trunks, multiple floors, or widely varying zones (e.g. east/west), use optional second sensor.

† Not available on size 708.

MicroTech III Controls

MicroTech III unit control systems are preengineered, preprogrammed, and factory tested prior to shipment. These components include:

- Unit controller with user interface display and navigation wheel
- Optional expansion modules
- Communication module (optional)
- Pressure transducers
- Unit-mounted temperature sensors
- Zone temperature sensor packages
- Humidity sensor

Open Choices Benefits for Easy Integration

- Easy, low cost integration into most building automation systems without costly gateway panels.
- Flexibility to select either BACnet or LonWorks communication. Units are LonMark 3.4 certified with the appropriate communications module for LonWorks networks.
- Comprehensive unit control and status information is available at the BAS regardless of communication protocol.
- Long-term choices for equipment adds or replacements, and for service support.
- Flexible alarm notification and prioritization with Intrinsic Alarm Management (BACnet).
- Simplified BAS integration with the ability to set network parameters at the unit controller, reducing installation time and costs.
- Easy monitoring and troubleshooting of communication status from the unit controller to the BAS.

MicroTech III Unit Controller

The unit controller is preprogrammed with the software necessary to control the unit. Use the unit controller keypad display to keep schedules, set points and parameters from being lost, even during a long-term power outage. The unit controller processes system input data and then determines and controls output responses. An optional field- or factorymounted BACnet or LonWorks communication module provides a network interface to the BAS.

Expansion Modules

These boards are used to expand the input and output capability of the unit controller. Each board communicates via serial data communications. These microprocessor based boards provide independent operation and alarm response even if communication is lost with the unit controller.

Communication Module

An optional communication module provides the means to factory or field configure MicroTech III unit controls for interoperability with an independent BAS. Communication modules are available to support industry recognized communication protocols including BACnet MS/TP, BACnet/IP and LonWorks.

Keypad/Display

All MicroTech III unit controllers include a push/pull navigation wheel and display. The display is a supertwist nematic type with highly visible black characters on a yellow background. The 5-line by 22-character format allows for easy to understand plain English display messages. All operating conditions, system alarms, control parameters and schedules can be monitored from the keypad/display. If the correct password has been entered, any adjustable parameter or schedule can be modified from the keypad.

Figure 28: Open Choices Integration

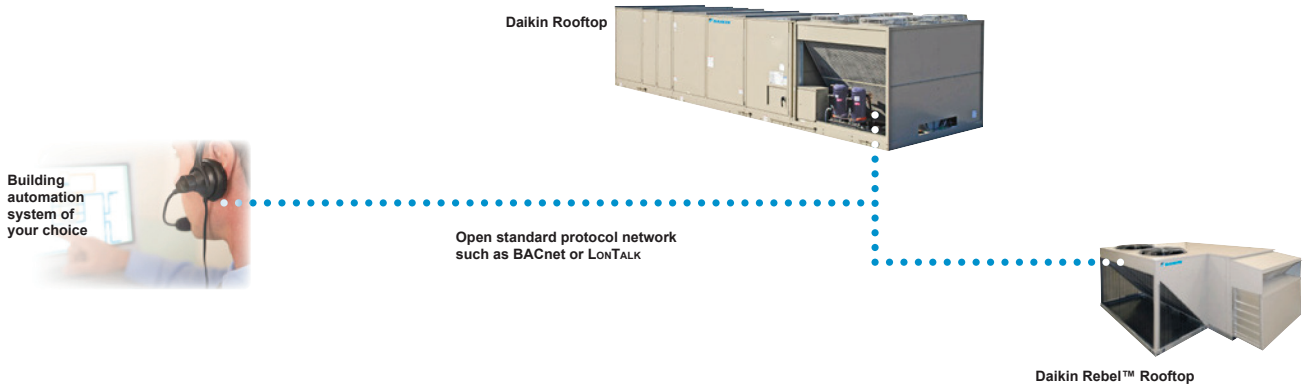


Table 3 shows an example of how supply and return air fan modulation must vary to maintain the correct balance of supply and return air volumes based on the building's parameters and therefore maintain building pressure. Determining the building's correct VaneTrol parameters is easy with MicroTech III's Balance feature. With Balance, start-up time is reduced because final adjustments are made at the keypad.

Table 3: VaneTrol Logic Air Balancing

SAF cfm	RAF cfm	Building exhaust
16000 (100%)	14000 (100%)	2000
14000 (88%)	12000 (80%)	2000
12000 (75%)	10000 (71%)	2000
10000 (63%)	8000 (57%)	2000
8000 (50%)	6000 (43%)	2000

Direct Space Pressure Control (for return or exhaust fans)

Any constant or variable air volume unit equipped with a variable volume return or exhaust fan can be provided with direct building static pressure control capability. With the direct method, building static pressure is measured and processed by the PI algorithm. This algorithm provides precise control of the return fan variable speed drive or inlet vanes to maintain the space pressure set point. The range of the keypad programmable set point is between minus 0.25-in. W.C. and 0.25-in. W.C.

This type of control can be used for either whole building or lab pressurization (positive or negative) applications, or exhaust fan control where VaneTrol control logic does not apply.

Minimum Ventilation Air Volume Control

Consistently maintaining the minimum outdoor air requirements of ASHRAE Standard 62 has been a long standing control challenge for VAV systems. As supply air fan volumes were reduced, the volume of air introduced through a fixed position, minimum outdoor air damper was also reduced, compromising indoor air quality. To meet this challenge, MicroTech III controls feature four user-selected control methods for maintaining outdoor air volume.

- The MicroTech III controller can accept a signal from a DesignFlow Precision Ventilation Air Control System, which is continuously measuring outdoor air volume, and adjust outdoor air damper position to maintain the minimum volume set point.
- MicroTech III controls have a keypad selected control function that automatically adjusts outdoor air damper position in response to changes in supply air fan volume. Regardless of supply air volume, this strategy maintains a nearly constant outdoor air volume at all times.The MicroTech III controller can accept an external 0–10 VDC signal from a CO_2 sensor or other control device and adjust outdoor air damper position.
- If desired, a fixed minimum damper position can be keypad programmed. This selection may be acceptable when ventilation requirements are met through other sources.

During cold ambient conditions where outdoor/return mixed air conditions can become too low, MicroTech III controls maintain the cooling discharge temperature set point by controlling the unit heating system. For applications where ambient temperatures and minimum outdoor air requirements can generate this condition, order the RoofPak unit with modulating heating equipment, such as the SuperMod gas burner.

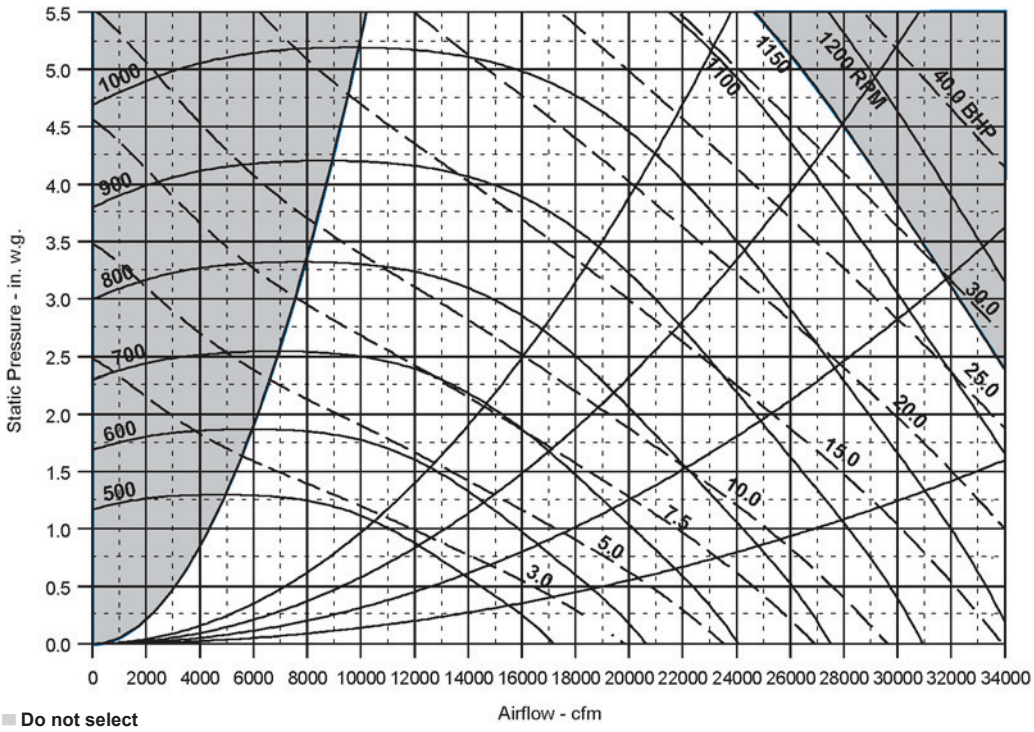
Table 4 illustrates the effect of minimum ventilation control and cold ambient conditions on unit discharge air temperature and how it dictates the need for mixed air tempering capability at the light load/low ambient conditions. It assumes a VAV unit with a 20% outdoor air requirement at design conditions and a 40% minimum airflow requirement.

Table 4: Effect of Minimum Ventilation Control on Discharge Temperature

Supply fan volume (cfm)	Outdoor air volume (cfm)	Outdoor air volume (%)	Outdoor air temp. (°F)	Mixed air temp. (°F)
10,000	2,000	20	95	79
8,000	2,000	25	70	73.8
6,000	2,000	33.3	40	63.3
4,000	2,000	50	0	37.5

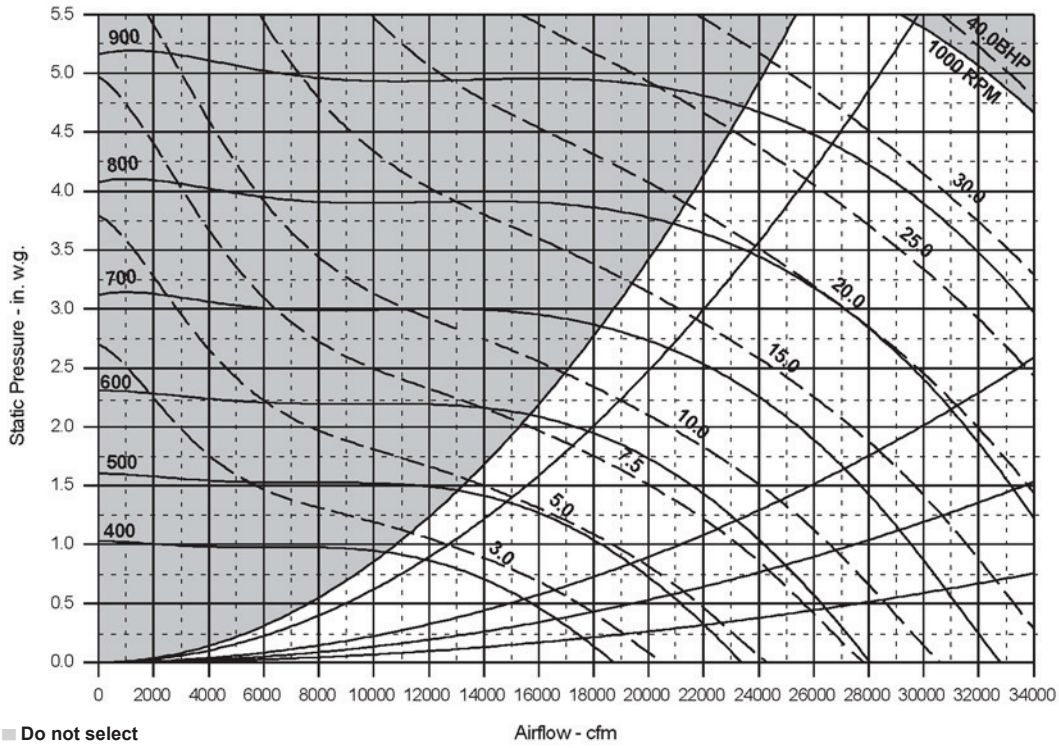
SWSI Supply Fans

Figure 64: RAH 047C, SWSI fan, 40" airfoil



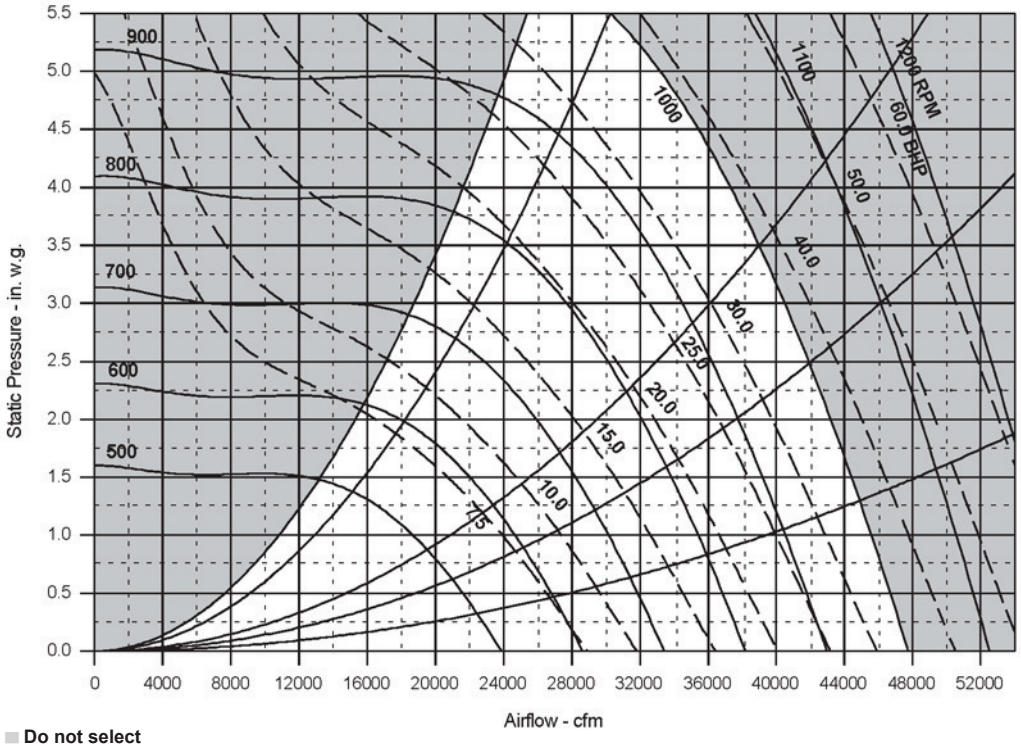
NOTE: Maximum allowable static pressure at fan bulkhead is 5.0 in (i.e., ESP plus blow-through component pressure drops cannot exceed 5.0 in).

Figure 65: RAH 047C, SWSI fan, 44" airfoil



NOTE: Maximum allowable static pressure at fan bulkhead is 5.0 in (i.e., ESP plus blow-through component pressure drops cannot exceed 5.0 in).

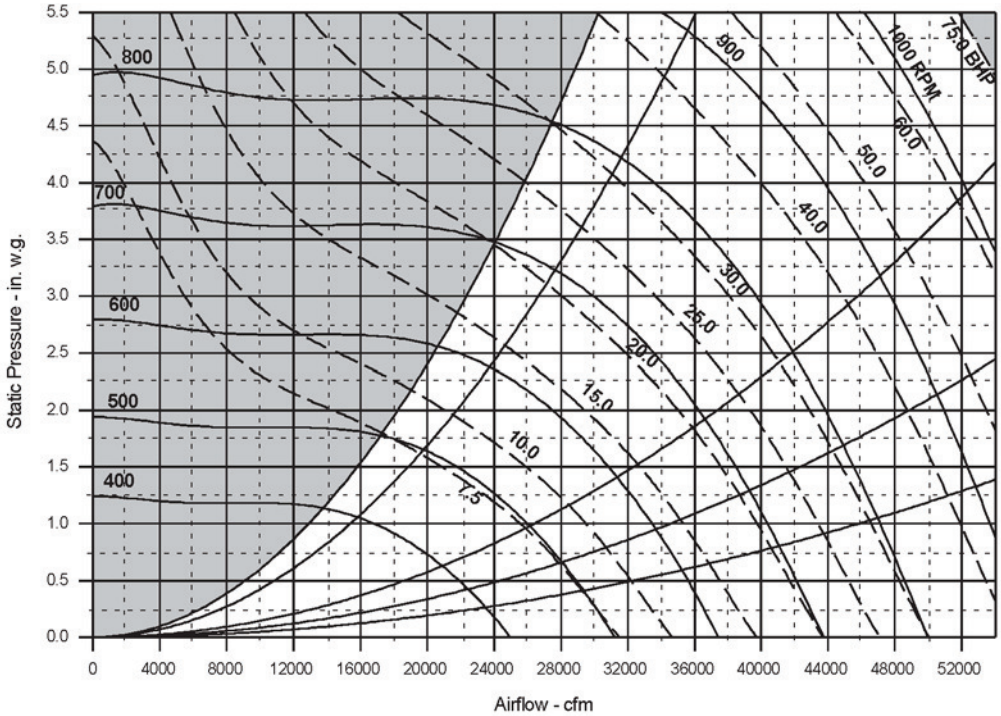
Figure 66: RAH 077C, SWSI fan, 44" airfoil



Do not select

NOTE: Maximum allowable static pressure at fan bulkhead is 5.0 in (i.e., ESP plus blow-through component pressure drops cannot exceed 5.0 in).

Figure 67: RAH 077C, SWSI fan, 49" airfoil



Do not select

NOTE: Maximum allowable static pressure at fan bulkhead is 5.0 in (i.e., ESP plus blow-through component pressure drops cannot exceed 5.0 in).

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Extended Data – E-Series Residential;

SPR-E20-327, SPR-E19-315,
SPR-E20-245, SPR-E18-235

ADDITIONAL MODULE PARAMETERS AND INFORMATION

TESTS AND CERTIFICATIONS	
Standard tests	UL 1703, IEC 61215, IEC 61730
Quality tests	ISO 9001:2008, ISO 14001:2004
EHS Compliance	RoHS, OHSAS 18001:2007
Ammonia test	IEC 62716
Salt-spray test	IEC 61701 (max. severity)
PID test	Potential-Induced Degradation free – 1000V

WARRANTY, IMPACT RESISTANCE, FUSE RATING, J-BOX	
WARRANTIES	25-YEAR LINEAR POWER WARRANTY 25-YEAR LIMITED PRODUCT WARRANTY
Impact Resistance	(hail) 25mm (1 inch) diameter at 23 m/s (52 mph)
Max Series Fuse	20 Amp rating
Connectors	MC4 Compatible with cable lengths, 700mm (128 cell) and 1000mm (96 & 72 cell)
Junction Box	For J-Box specifics, please contact your regional sales team

E-SERIES MAJOR GLOBAL MARKET LISTINGS		
Residential Modules	96-Cell Modules	72-Cell Modules
*Major Market Listings	CEC, JET, KEMCO, MCS, FSEC, CSA, UL, TUV	CEC, JET, MCS, FSEC, CSA, UL, TUV
*Platforms options available in listed markets, but every individual sku may not be available in each referenced market		

PLATFORM ELECTRICAL DATA

STC Values

		At Standard Test Conditions							
Module	Platform (Number of cells)	Nominal Power	Power Tolerance (%)	Rated Voltage (Vmp)	Rated Current (Imp)	Open Circuit Voltage (Voc)	Short Circuit Current, Isc (A)	Max System Voltage UL (Vmax)	Max System Voltage IEC (Vmax)
SPR-E20-327	96	327	+5/-0	54.7	5.98	64.9	6.46	600	1000
SPR-E19-315	96	315	+5/-0	54.7	5.76	64.6	6.14	600	1000
SPR-E20-245	72	245	+5/-0	40.5	6.05	48.8	6.43	600	1000
SPR-E19-235	72	235	+5/-0	40.5	5.80	48.4	6.18	600	1000

PLATFORM ELECTRICAL DATA (continued)

TEMPERATURE COEFFICIENTS & EFFICIENCY REFERENCES

	At Standard Test Conditions		Basic Temperature Data				Efficiency Numbers		
Module	Nominal Power	Avg Power	Current (Isc) Temp. Coeff. (mA/ C)	Voltage (Voc) Temp. Coeff. (mV/ C)	Power Temp. Coeff. (%/ C)	NOCT @ 20 C (Value +/- 2 C)	Average Power Efficiency (%)	Nominal Peak Power per Unit Area (W/m2)	Nominal Peak Power per Unit Area (W/ft2)
SPR-E20-327	327	333	3.5	-176.6	-0.38%	45.0	20.4%	204.2	19.0
SPR-E19-315	315	321	3.5	-176.6	-0.38%	45.0	19.7%	196.8	18.3
SPR-E20-245	245	249	3.5	-132.5	-0.38%	45.0	20.0%	200.2	18.6
SPR-E19-235	235	242	3.5	-132.5	-0.38%	45.0	19.5%	194.5	18.1

PLATFORM PERFORMANCE AT NOCT

(800 W/m^2, 20°C ambient, 1 m/s wind speed)

	At STC	Nominal Electrical data at NOCT (NOCT : 800W/m2, 20 C amb. Temp., 1m/s wind speed)					
Module	Nominal Power	NOCT Pnom	NOCT Vmpp	NOCT Impp	NOCT Voc	NOCT Isc	NOCT % of rated
SPR-E20-327	327	248	51.5	4.82	60.8	5.22	75.9%
SPR-E19-315	315	239	51.5	4.64	60.5	4.97	75.9%
SPR-E20-245	245	182	37.4	4.88	45.7	5.20	74.4%
SPR-E19-235	235	175	37.4	4.68	45.3	5.00	74.4%

PLATFORM PERFORMANCE AT LOW IRRADIANCE

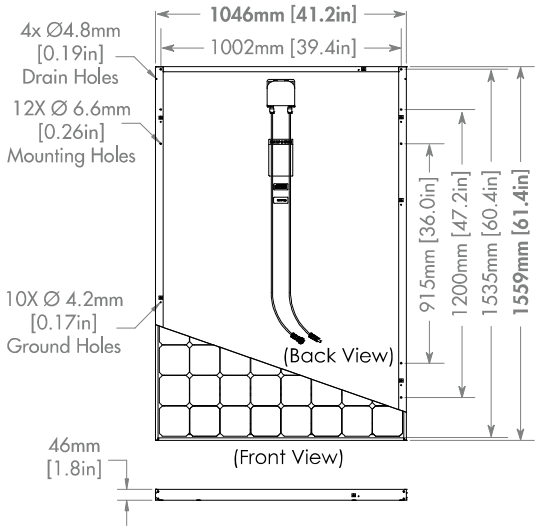
(200 W/m^2, 25°C cell temperature, air mass 1.5 SSID*)

	At STC	Irradiance vs. Power at Low Irradiance (200W/m2 and @25C (SNL coefficients))			
Module	Nominal Power	Low irradiance Pmpp (W)	Low irradiance Vmpp (V)	Low irradiance Impp (A)	Pctg. of nominal power
SPR-E20-327	327	62.8	52.0	1.21	19.2%
SPR-E19-315	315	60.5	52.0	1.16	19.2%
SPR-E20-245	245	47.0	38.5	1.22	19.2%
SPR-E19-235	235	45.1	38.5	1.17	19.2%

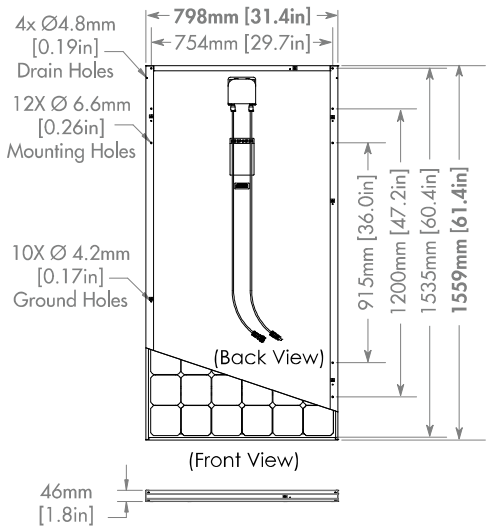
*SSID = Solar Spectral Irradiance Distribution

MODULE PLATFORM DIMENSIONS

96 CELL
(SPR-E20-327, SPR-E19-315)

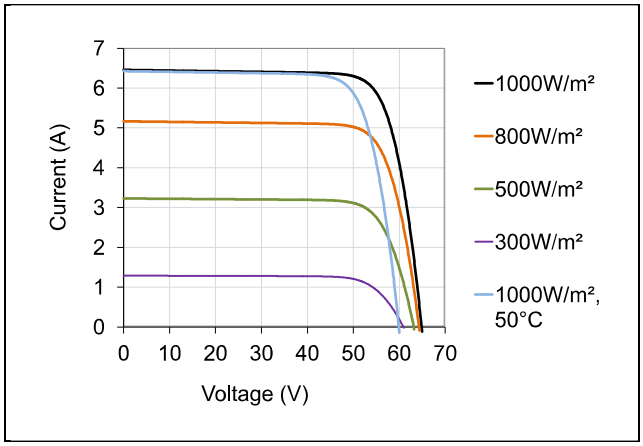


72 CELL
(SPR-E20-245, SPR-E18-235)

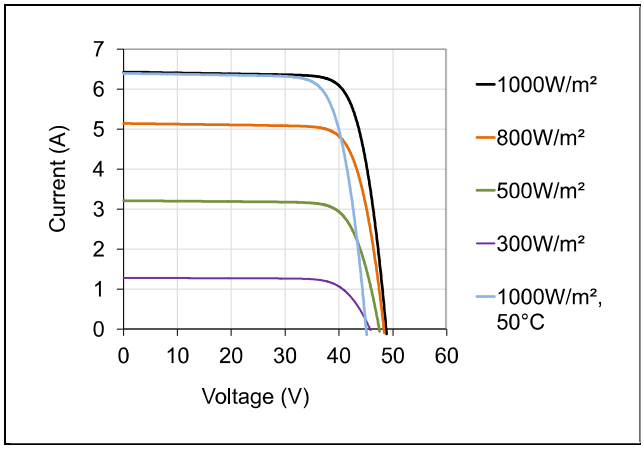


IV CURVES OF PRIMARY PLATFORM MODELS

SPR-E20-327



SPR-E20-245



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SW 275 MONO

SOLARWORLD
REAL VALUE

TUV Power controlled:
Lowest measuring tolerance in industry

Every component is tested to meet
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Designed to withstand heavy
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Sunmodule Plus:
Positive performance tolerance

25-year linear performance warranty
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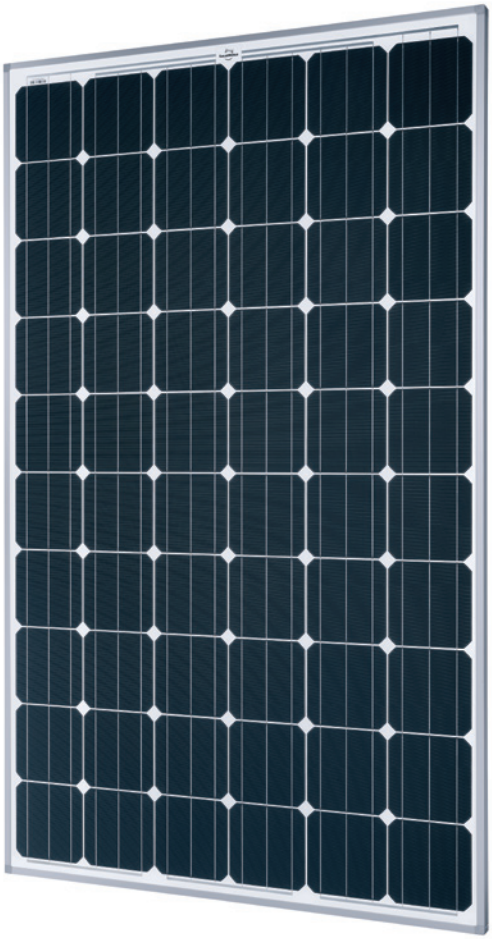

World-class quality
Fully-automated production lines and seamless monitoring of the process and material ensure the quality that the company sets as its benchmark for its sites worldwide.

SolarWorld Plus-Sorting
Plus-Sorting guarantees highest system efficiency. SolarWorld only delivers modules that have greater than or equal to the nameplate rated power.

25-year linear performance guarantee and extension of product warranty to 10 years
SolarWorld guarantees a maximum performance digression of 0.7% p.a. in the course of 25 years, a significant added value compared to the two-phase warranties common in the industry. In addition, SolarWorld is offering a product warranty, which has been extended to 10 years.*

*in accordance with the applicable SolarWorld Limited Warranty at purchase.
www.solarworld.com/warranty

- Qualified, IEC 61215
- Safety tested, IEC 61730
- Periodic Inspection
- Blowing sand resistant

- Ammonia resistance tested
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Sunmodule® Plus
SW 275 MONO

SOLARWORLD
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PERFORMANCE UNDER STANDARD TEST CONDITIONS (STC)*

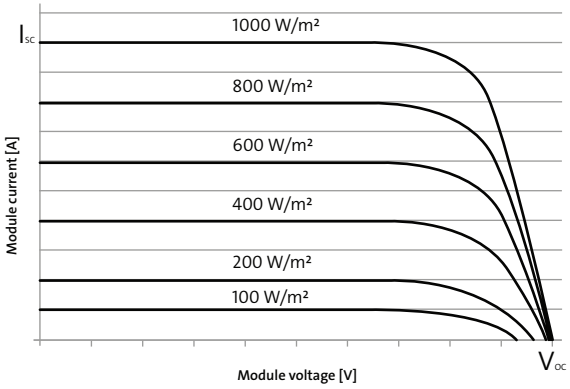
Maximum power	P_{max}	275 Wp
Open circuit voltage	V_{oc}	39.4 V
Maximum power point voltage	V_{mpp}	31.0 V
Short circuit current	I_{sc}	9.58 A
Maximum power point current	I_{mpp}	8.94 A
Module efficiency	η_m	16.40 %

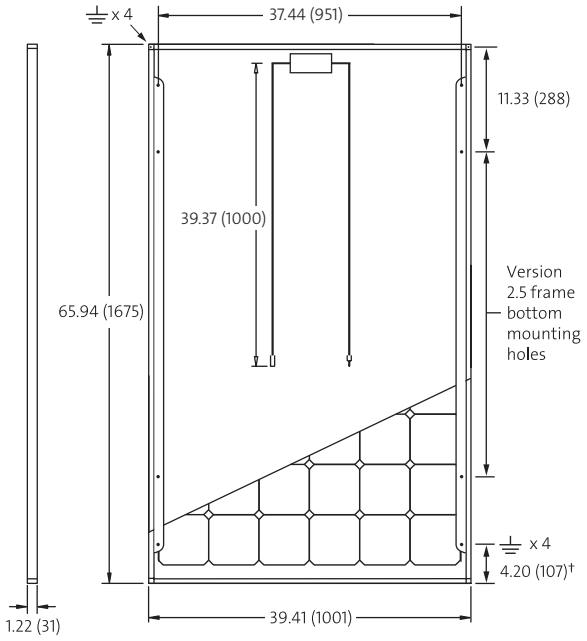
*STC: 1000 W/m², 25°C, AM 1.5

1) Measuring tolerance (P_{max}) traceable to TUV Rheinland: +/- 2% (TUV Power Controlled).

THERMAL CHARACTERISTICS

NOCT	46 °C
TC I_{sc}	0.04 %/°C
TC V_{oc}	-0.30 %/°C
TC P_{mpp}	-0.41 %/°C
Operating temperature	-40°C to 85°C





PERFORMANCE AT 800 W/m², NOCT, AM 1.5

Maximum power	P_{max}	205.0 Wp
Open circuit voltage	V_{oc}	36.1 V
Maximum power point voltage	V_{mpp}	28.4 V
Short circuit current	I_{sc}	7.75 A
Maximum power point current	I_{mpp}	7.22 A

Minor reduction in efficiency under partial load conditions at 25°C: at 200 W/m², 100% (+/-2%) of the STC efficiency (1000 W/m²) is achieved.

COMPONENT MATERIALS

Cells per module	60
Cell type	Mono crystalline
Cell dimensions	6.14 in x 6.14 in (156 mm x 156 mm)
Front	Tempered glass (EN 12150)
Frame	Clear anodized aluminum
Weight	39.5 lbs (17.9 kg)

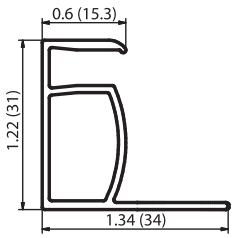
SYSTEM INTEGRATION PARAMETERS

Maximum system voltage SC II / NEC		1000 V
Maximum reverse current		16 A
Number of bypass diodes		3
*Design Loads**	*Two rail system*	113 psf downward 64 psf upward
*Design Loads**	*Three rail system*	170 psf downward 71 psf upward
*Design Loads**	*Edge mounting*	30 psf downward 30 psf upward

* Please refer to the Sunmodule installation instructions for the details associated with these load cases.

ADDITIONAL DATA

Power sorting[1]	-0 Wp / +5 Wp
J-Box	IP65
Module leads	PV wire per UL4703 with H4 connectors
Module type (UL 1703)	1
Glass	Low iron tempered with ARC



VERSION 2.5 FRAME

- Compatible with both "Top-Down" and "Bottom" mounting methods
- ⏚ Grounding Locations:
  - 4 corners of the frame
  - 4 locations along the length of the module in the extended flange†

All units provided are imperial. SI units provided in parentheses.
SolarWorld AG reserves the right to make specification changes without notice.

Efficient

- Maximum efficiency of 98.8%
- Superior power density: 60 kVA at only 165 pounds

Reliable

- Distributed architecture for maximum system availability
- Central control with SMA Inverter Manager

Cost-Effective

- DC input of up to 1,000 V
- Up to 2.5 MW per inverter manager

Innovative

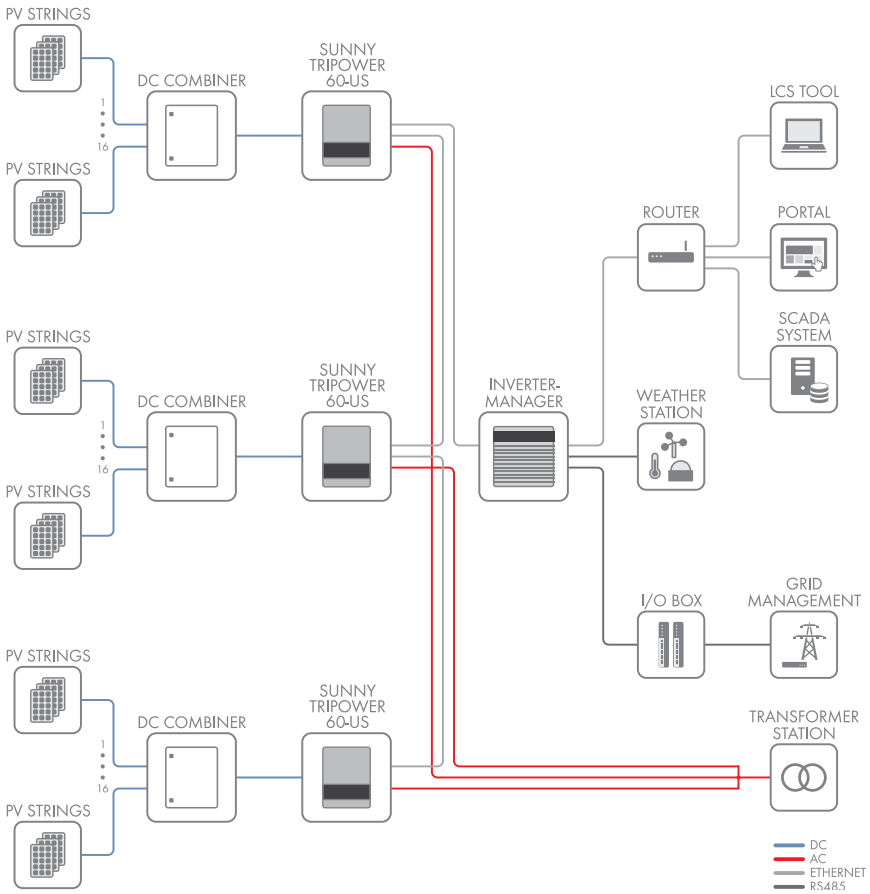
- Suitable for commercial and utility applications
- Complete grid management feature set

SUNNY TRIPOWER 60-US

The efficient solution for medium to large-scale PV Plants

The new Sunny Tripower 60-US is part of an innovative, global system solution for commercial and utility PV plants. This solution combines the advantages of a decentralized system layout with the benefits of centralized inverter designs which results in the best of both worlds. High efficiency, easy installation, simple commissioning and low maintenance requirements contribute decisively to reducing the operating costs for the entire plant.

THE SMART SUNNY TRIPOWER 60-US SYSTEM PHILOSOPHY



UNMATCHED POWER DENSITY

With Maximum Efficiency

The new SMA system solution consists of three components: highly efficient Sunny Tripower 60-US inverters, the SMA Inverter Manager and the LCS commissioning tool. It is precisely this systemized approach that makes the Sunny Tripower 60-US so unique and ensures a high level of performance.

System Cost Reduction
With a compact design of 60 kVA weighing only 165 pounds, the Sunny Tripower 60-US requires little space, reduces on-site preparation work, simplifies installation and lowers maintenance costs.

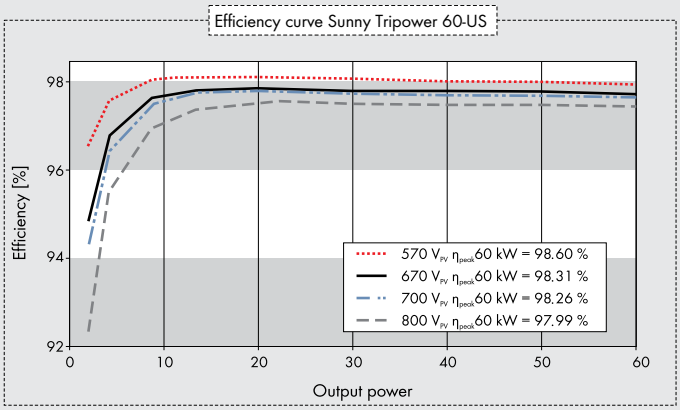
Innovative system management
The SMA Inverter Manager is the central communications component and sole interface for the entire system control. It handles all the important inverter and system management functions for up to 2.5 MW with a single inverter manager.

The Sunny Tripower 60-US benefits from a self-configuring inverter network with automatic IP configuration and device discovery, which eliminates manual setup. The SMA Inverter Manager also creates a seamless inverter control loop which enables complete grid management capabilities.

Simple commissioning
The specially developed LCS tool (Local Commissioning and Service Tool) makes commissioning easy, saves time and reduces costs. The inverter is configured by simply selecting the system-specific configuration files and then transmitting them to all inverters. In addition, individual inverter data is aggregated into a single plant profile for comprehensive plant performance analysis.

Technical data	Sunny Tripower 60-US
Input (DC)	
Max. input voltage	1,000 V
MPP voltage range	570 V to 800 V @400 VAC, 685 V to 800 V @480 VAC
Min. input voltage	565 V @400 VAC, 680 V @480 VAC
Max. input current / short-circuit current	110 A / 150 A
Number of independent MPP inputs / strings per MPP input	1/1 (split up by external PV array junction box)
Output (AC)	
Rated power at nominal voltage	60,000 W
Max. apparent AC power	60,000 VA
Output Phases / line connections	3 / PE
Nominal AC voltage	400 V, 480 V
Nominal AC voltage range	352 V to 440 V @400 VAC, 423 V to 528 V @480 VAC
AC power frequency	50 Hz, 60 Hz
Rated power frequency / rated grid voltage	50 Hz, 60 Hz / 400 V, 480 V
Max. output current	3 x 87 A @ 400 V, 3 x 72 A @ 480 V
Power factor at rated power/displacement power factor adjustable	1/0.8 lagging ... 0.8 leading
Feed-in phases / connection phases	3 / 3
Efficiency	
Max. efficiency / CEC @ 400 VAC / CEC @ 480 VAC	98.8% / 98.0% / 98.5%
Protective devices	
DC-side disconnection point / DC surge arrester (type II) can be integrated	● / ●
Ground fault monitoring / grid monitoring	● / ●
DC reverse polarity protection / AC short-circuit current capability / galvanically isolated	● / ● / –
All-pole sensitive residual-current monitoring unit	●
Protection class (acc. to IEC 62103)/overvoltage category (acc. to IEC 60664-1)	I / AC: III, DC: II
General data	
Dimensions (W / H / D) / weight	570 / 740 / 300 mm (22.4 / 29.1 / 11.8 inch) / 75 kg (165.3 lbs)
Operating temperature range	-25 °C ... +60 °C (-13 °F to +140°F)
Noise emission, typical / Self-consumption (at night)	55 dB(A) / 3W
Topology / cooling concept, degree of protect. (IEC 60529/ UL50E), climatic cat. (IEC 60721-3-4)	Transformerless / active, IP65 / NEMA 3R, 4K4H
Maximum permissible value for relative humidity (non-condensing)	95%
Features	
DC connection / AC connection	Screw terminal / screw terminal
Display / Interface	Graphic / Using external inverter manager: Modbus TCP

● Standard features ○ Optional features – Not available



Type Designation

Sunny Tripower 60-US:
STP 60-US-10 with DC Switch

SMA Inverter Manager:
IM-10: SMA Inverter Manager for max. 42 inverters

I/O Module:
IM-DIO-10: SMA Digital I/O Box with 6 digital inputs

Certificates and Approvals

Sunny Tripower 60-US: IEC 62109-1/IEC 62109-2 (Class I, grounded–communication Class II, PELV), UL1741–w. Non-Isolated EPS Interactive PV Inverters, IEEE 1547, FCC Part 15, Subpart B Class A

SMA Inverter Manager: UL 508, UL 60950-1, CSA C22.2 No. 60950-1-07, EN 60950-1, EN 55022 Class A, EN 61000-3-2 Class D, EN 61000-3-3, EN55024, FCC Part 15, Subpart B Class A

Technical data	SMA Inverter Manager
Voltage supply	
Input voltage	9 - 36 Vdc
Power consumption	< 20 W
General data	
Dimensions (W / H / D) / weight	160 / 125 / 49 mm (6.3 / 4.9 / 1.9 inch) / 940 g (2 lbs)
Degree of protection / assembly	IP21 / DIN top-hat rails or wall mounting
Operating temperature range / relative humidity	-40 to +85 °C / 5 - 95 % (non-condensing)
Cooling concept	Convection
Interfaces	
User interface / Sensor interface	LCS tool for PC / RS-485 for Sunspec Alliance compatible weather stations
Active and reactive power setpoints	Constant values, curves, remotely controlled
Interface to inverter network / Interface to external network	1 Ethernet port (RJ45) / 1 Ethernet port (RJ45) Modbus TCP, SunSpec Alliance
Interface to remote control	6 x DI, Modbus TCP via external I/O module
Data at nominal conditions	

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SMA SUNNY TRIPOWER STP 60-US

$6,798.53
(Sales tax not included)

The new **STP 60-US solar inverter** is an innovative global solution for commercial and utility PV systems. It combines the advantages of decentralized system layouts with the benefits of a centralized inverter design in a solution that brings together the best of both worlds. High efficiency, flexible system design, easy installation, simple commissioning and low maintenance requirements help lower operating costs for the entire plant.

Download SMA SUNNY TRIPOWER STP 60-US datasheet.

ADD TO CART

Input (DC)

- Max. input voltage: 1000 V
- MPP voltage range: 570 V â€“ 800 V @400 Vac, 685 V â€“ 800 V @480 Vac
- Min. input voltage: 565 V @400 Vac, 680 V @480 Vac
- Max. input current / short-circuit current: 110 A / 150 A
- Number of independent MPP inputs / strings per MPP input: 1/1 (split up by external PV array junction box)

Output (AC)

- Rated power at nominal voltage: 60,000 W
- Max. apparent AC power: 60,000 VA
- Nominal AC voltage: 3 / PE, 400 V â€“ 480 V, +/-10 %
- Nominal AC voltage range: 400 V â€“ 480 V
  AC power frequency / range: 50 Hz / 60 Hz +/-10 %
- Rated power frequency / rated grid voltage: 50 Hz, 60 Hz / 400 V, 480 V
- Max. output current: 3 x 87 A
- Power factor at rated power/displacement power factor adjustable: 1/0.8 lagging ... 0.8 leading
- Feed-in phases / connection phases: 3 / 3

Efficiency

- Max. efficiency / European weighted efficiency / CEC: 98.8 % / 98.0 % / 98.5 %

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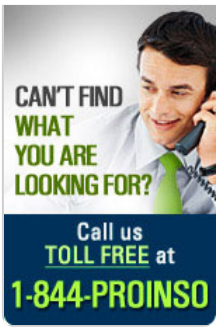

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Model: SB7000TLUS-12
Condition: New
Manufactured by: SMA
Free Shipping on all orders over $250

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Manufactured by: SMA

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SMA STP12000TL-US-10 SUNNY TRIPOWER

The new UL-certified Sunny Tripower TL-US is designed specifically to meet American requirements for mid to large-scale decentralized PV systems. With a peak efficiency of above 98 percent, OptiTrac Global...

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Condition: New
Manufactured by: SMA
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$4,067.59

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SMA STP15000TL-US-10 SUNNY TRIPOWER

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Appendix F
Rate Simulation

Rate Simulation Summary

ELECTRICITY

Comment:

Rate Simulation is a tool used to determine a facility's present-day electricity rate ($/kWh) by means of recently published utility data and a facility's historical energy use patterns. Resulting rates are used in the payback analysis of proposed projects presented in this study. In the simulation, an "Energy Rate" and an "Effective Electricity Rate" are calculated. The "Energy Rate" excludes demand charges (if any), whereas the "Effective Rate" includes all charges. 'Non-Demand-Saving' rates are utilized in projects such as occupancy sensors, 'Demand Saving' rates are utilized in projects such as lighting conversions and HVAC unit replacements.

Facility	Meter	Rate	Energy Use (kWh)	% of Total Energy Use	Energy Cost ($)	Total Cost ($)	Energy Rate ($/kWh)	Effective Rate ($/kWh)
Cragmont Elementary	1009542415	HA10S	170,682	8%	$23,483	$31,720	$0.138	$0.186
Berkeley High School [1]	1004779090	E19SX	1,860,322	92%	$175,805	$306,493	$0.095	$0.165
Total			**2,031,004**	**100%**	**$199,288**	**$338,213**	**$0.098**	**$0.167**

[1] This rate is only for the meter that serves the audited areas: G and H Buildings, Donahue Gym, and Jackets Pool

NATURAL GAS

Facility	Meter	Rate	Energy Use (Therms)	% of Total Energy Use	Energy Cost ($)	Effective Rate ($/Therm)
Cragmont Elementary	48919486	GNR1	5,870	4%	$5,574	$0.950
Berkeley High School [1]	30523031	GNR1	131,028	96%	$89,646	$0.684
Total			**136,898**	**100%**	**$95,220**	**$0.696**

[1] This rate is only for the meter that serves the audited areas: G and H Buildings, Donahue Gym, and Jackets Pool

Site Name: Berkeley High School
Service Address: 2246 MILVIA ST, BERKELEY, CA 94704
Building: (this meter is located next to Donahue Gym and serves Jacket Pool, Jacket Gym, Donahue Gym, and other buildings, not including A Building)
Service Type: **Electricity**
Service Provider: PG&E
Rate Schedule: E19SX
Service Agreement ID: 3220496521
Account ID: 3220496972
Meter #: 1004779090

Note: Summer Season: May-October Winter Season: November - April

Season		Total Energy Rate ($/kWh)	Demand charge ($/kw)	Customer Rate ($/meter/day)
1	**Summer Rate**			$4.60
	Maximum Demand		$15.07	
	On-Peak	$0.1623	$19.04	
	Partial-Peak	$0.1089	$4.42	
	Off-Peak	$0.0740		
2	**Winter Rate**			
	Maximum Demand		$15.07	
	Partial-Peak	$0.1019	$0.24	
	Off-Peak	$0.0780		

Rate Effective : March 1, 2015

					AS PAID											AT CURRENT RATES				
					Summer Energy			*Winter Energy*			*Summer Demand*		*Winter Den*	*Total Charges*		*Charges at Current Rates*				
No.	Month	Date Read	Days Billed	Total Usage	On Peak	Partial Peak	Off Peak	Partial Peak	Off Peak	*Max Demand*	On Peak	Part Peak	Part Peak	Electric Charges	Average Rate	**Energy Charges**	**Demand Charges**	**Total Energy and Demand Cost**	**Average Energy Rate**	**Effective Rate**
				kWh	*kWh*	*kWh*	*kWh*	*kWh*	*kWh*	*kW*	*kW*	*kW*	*kW*	*$*	*$/kWh*	*$*	*$*	*$*	*$/kWh*	*$/kWh*
1	May	6/2/13	32	108,553	25,296	27,299	55,958			266	245	266		$ 18,804	$ 0.173	$11,219	$12,682	$23,901	$0.103	$0.220
2	June	7/1/13	29	100,136	24,524	25,865	49,747			246	244	246		$ 17,752	$ 0.177	$10,478	$12,060	$22,538	$0.105	$0.225
3	July	7/31/13	30	119,346	25,675	28,066	65,605			268	243	260		$ 19,580	$ 0.164	$12,078	$12,584	$24,662	$0.101	$0.207
4	August	8/29/13	29	127,783	26,664	29,793	71,326			294	294	291		$ 21,562	$ 0.169	$12,850	$14,414	$27,263	$0.101	$0.213
5	September	9/30/13	32	165,766	35,088	39,189	91,489			319	319	319		$ 25,989	$ 0.157	$16,732	$15,688	$32,421	$0.101	$0.196
6	October	10/29/13	29	142,070	33,654	37,384	71,032			326	316	326		$ 24,331	$ 0.171	$14,790	$15,842	$30,632	$0.104	$0.216
7	November	12/1/13	33	171,089	3,240	4,254	5,918	65,943	91,734	378	19	378	378	$ 19,753	$ 0.115	$15,296	$11,846	$27,142	$0.089	$0.159
8	December	12/30/13	29	166,256				74,358	91,898	373			373	$ 18,814	$ 0.113	$14,739	$5,711	$20,449	$0.089	$0.123
9	January	1/30/14	31	179,388				81,469	97,919	355			355	$ 20,093	$ 0.112	$15,932	$5,435	$21,367	$0.089	$0.119
10	February	3/3/14	32	183,045				81,538	101,507	362			362	$ 20,517	$ 0.112	$16,219	$5,542	$21,761	$0.089	$0.119
11	March	4/1/14	29	191,739				89,942	101,797	438			438	$ 22,592	$ 0.118	$17,098	$6,706	$23,803	$0.089	$0.124
12	April	5/1/14	30	205,151	1,852	3,093	3,684	89,691	106,831	394	11	394	394	$ 23,563	$ 0.115	$18,375	$12,178	$30,553	$0.090	$0.149
TOTAL			365	1,860,322	175,993	194,943	414,759	482,941	591,686	-	-	-	-	$ 253,350	$ 0.136	$ 175,805	$ 130,688	$ 306,493	$0.095	$0.165

Site Name: Berkeley High School
Service Address: 2246 Milvia St, Berkeley, CA 94704
Buildings: Pool
Service Type: **Natural Gas**
Service Provider: PG&E
Rate Schedule: GNR1
Service Agreement ID: 6482456308
Account ID: 6482456669
Meter #: 30523031

Season	Tier	Delivery Rate	Procurement Rate	Public Purpose Program Surcharge
Summer	First 4,000 Therms	$0.43670	$0.33420	$0.04472
	Excess	$0.17598		
Winter	First 4,000 Therms	$0.54442		
	Excess	$0.21938		
Summer = April through October				

Rate Effective : March 1, 2015

AS PAID

No.	Month	Date Read	Days Billed	Total Usage	Delivery Charges: Natural Gas Charges	Delivery Charges: Ave. Rate	Estimated Procurement Charge [1]: Ave. Rate	Estimated Procurement Charge [1]: Procurement Charge	Estimated Total Charges: Total Charges	Estimated Total Charges: Ave. Rate
				Therms	*$*	*$/Therm*	*$/Therm*	*$*	*$*	*$/Therm*
1	May	6/3/13	32	6,948	$2,041	$ 0.294	$0.53	$3,680	$5,721	$ 0.823
2	June	7/2/13	29	4,017	$1,486	$ 0.370	$0.48	$1,911	$3,397	$ 0.846
3	July	8/1/03	30	4,464	$1,572	$ 0.352	$0.45	$1,989	$3,561	$ 0.798
4	August	8/30/13	29	2,725	$1,030	$ 0.378	$0.43	$1,179	$2,209	$ 0.811
5	September	10/1/13	32	4,677	$1,616	$ 0.345	$0.40	$1,880	$3,495	$ 0.747
6	Oct-Nov	12/2/13	61	14,377	$4,058	$ 0.282	$0.46	$6,613	$10,672	$ 0.742
7	December	12/31/13	29	25,929	$6,625	$ 0.256	$0.47	$12,255	$18,880	$ 0.728
8	January	1/31/14	31	21,231	$6,122	$ 0.288	$0.52	$11,032	$17,154	$ 0.808
9	February	3/4/14	32	18,770	$5,518	$ 0.294	$0.59	$11,099	$16,617	$ 0.885
10	March	4/2/14	29	14,983	$4,528	$ 0.302	$0.64	$9,660	$14,188	$ 0.947
11	April	5/2/14	30	12,907	$3,411	$ 0.264	$0.55	$7,066	$10,477	$ 0.812
TOTAL			364	131,028	$ 38,006	$ 0.290		$ 68,365	$ 106,370	$ 0.812

[1] based on historical GNR1 procurement rates given on http://www.pge.com/nots/rates/tariffs/GRF.SHTML#GNR1

AT CURRENT RATES

Delivery Charges: First 4,000 Therms	Delivery Charges: Excess	Procurement Charges: Estimated Charges [1]	Public Purpose: Program Surcharge	Total Charges: Total Charges	Total Charges: Ave. Rate
$	*$*	*$*	*$*	*$*	*$/Therm*
$1,747	$519	$2,322	$311	$4,898	$ 0.705
$1,747	$3	$1,342	$180	$3,272	$ 0.815
$1,747	$82	$1,492	$200	$3,520	$ 0.789
$1,190	$0	$911	$122	$2,223	$ 0.816
$1,747	$119	$1,563	$209	$3,638	$ 0.778
$1,962	$2,051	$4,805	$643	$9,461	$ 0.658
$2,178	$4,811	$8,665	$1,160	$16,813	$ 0.648
$2,178	$3,780	$7,095	$949	$14,003	$ 0.660
$2,178	$3,240	$6,273	$839	$12,530	$ 0.668
$2,178	$2,409	$5,007	$670	$10,264	$ 0.685
$2,178	$1,954	$4,314	$577	$9,022	$ 0.699
$ 21,028	$ 18,969	$ 43,790	$ 5,860	$ 89,646	$ 0.684

Site Name: CRAGMONT ELEM SCHOOL
Service Address: 830 REGAL RD, BERKELEY, CA 94708
Building: (entire school)
Service Type: **Electricity**
Service Provider: PG&E
Rate Schedule: HA10S
Service Agreement ID: 4316669134
Account ID: 4316669443
Meter #: **1009542415**

Note: Summer Season: May-October Winter Season: November - April

Season		Total Energy Rate ($/kWh)	Demand charge ($/kw)	Customer Rate ($/meter/day)
1	**Summer Rate**			$4.60
	Maximum		$16.23	
	all	$0.1611		
2	**Winter Rate**			
	Maximum		$8.00	
	all	$0.1167		

Rate Effective : March 1 2015

				AS PAID								AT CURRENT RATES				
				Energy			*Demand*			*Total Charges*		*Charges at Current Rates*				
No.	Month	Date Read	Days Billed	Total Energy	Summer Energy	Winter Energy	Max Demand	Summer Demand	Winter Demand	Electric Charges	Ave. Rate	**Energy Charges**	**Demand Charges**	**Total Energy and Demand Cost**	**Average Energy Rate ($/kWh)**	**Effective Rate ($/kWh)**
				kWh	*kWh*	*kWh*	*kW*	*kW*	*kW*	*$*	*$/kWh*	*$*	*$*	*$*	*$/kWh*	*$/kWh*
1	May	6/3/13	32	15,857	15,857		65	65		$ 3,558	$ 0.224	$2,555	$1,055	$3,610	$0.161	$0.228
2	June	7/2/13	29	12,616	12,616		56	56		$ 2,911	$ 0.231	$2,032	$909	$2,941	$0.161	$0.233
3	July	8/1/13	30	10,229	10,229		37	37		$ 2,265	$ 0.221	$1,648	$601	$2,248	$0.161	$0.220
4	August	9/2/13	32	10,575	10,575		56	56		$ 2,600	$ 0.246	$1,704	$909	$2,613	$0.161	$0.247
5	September	10/1/13	29	14,560	14,560		60	60		$ 3,256	$ 0.224	$2,346	$974	$3,319	$0.161	$0.228
6	October	10/30/13	29	13,846	13,846		60	60		$ 3,171	$ 0.229	$2,231	$974	$3,204	$0.161	$0.231
7	November	12/2/13	33	13,890	421	13,469	52		52	$ 2,155	$ 0.155	$1,640	$416	$2,056	$0.118	$0.148
8	December	1/1/14	30	14,644		14,644	54		54	$ 2,201	$ 0.150	$1,710	$432	$2,142	$0.117	$0.146
9	January	2/2/14	32	16,048		16,048	55		55	$ 2,444	$ 0.152	$1,873	$440	$2,313	$0.117	$0.144
10	February	3/4/14	30	16,719		16,719	63		63	$ 2,564	$ 0.153	$1,952	$504	$2,456	$0.117	$0.147
11	March	4/2/14	29	14,967		14,967	61		61	$ 2,363	$ 0.158	$1,747	$488	$2,235	$0.117	$0.149
12	April	5/4/14	32	16,730	2,091	14,639	67		67	$ 2,793	$ 0.167	$2,046	$536	$2,582	$0.122	$0.154
TOTAL			367	170,682	80,195	90,487	-	-	-	$ 32,281	$ 0.189	$ 23,483	$ 8,237	$ 31,720	$0.138	$0.186

Site Name: Cragmont Elementary School
Service Address: 830 Regal Rd, Berkeley, CA 94708
Building: all
Service Type: **Natural Gas**
Service Provider: PG&E
Rate Schedule: GNR1
Service Agreement ID: 4358336634
Account ID: 4358336107
Meter #: 48919486

Season	Tier	Delivery Rate	Procurement Rate	Public Purpose Program Surcharge
Summer	First 4,000 Therms	$0.43670	$0.33420	$0.04472
	Excess	$0.17598		
Winter	First 4,000 Therms	$0.54442		
	Excess	$0.21938		
Summer = April through October				

Rate Effective : March 1, 2015

					AS PAID						AT CURRENT RATES					
					Total Charges		*Estimated Procurement Charge*		*Estimated Total Charges*		*Delivery Charges*		*Procurement Charges*	*Public Purpose*	*Total Charges*	
No.	Month	Date Read	Days Billed	Total Usage	Natural Gas Charges	Ave. Rate	Ave. Rate	Procurement Charge	Total Charges	Ave. Rate	First 4,000 Therms	Excess	Estimated Charges [1]	Program Surcharge	Total Charges	Ave. Rate
				Therms	*$*	*$/Therm*	*$/Therm*	*$*	*$*	*$/Therm*	*$*	*$*	*$*	*$*	*$*	*$/Therm*
1	May	6/4/13	32	26	$67.13	$ 2.58	$0.53	$13.77	$80.90	$ 3.112	$11	$0	$9	$1	$21	$ 0.816
2	June	7/3/13	29	0	$51.90		$0.48	$0.00	$51.90		$0	$0	$0	$0	$0	
3	July	8/2/13	30	6	$55.96	$ 9.33	$0.45	$2.67	$58.63	$ 9.772	$3	$0	$2	$0	$5	$ 0.816
4	August	9/3/13	32	0	$57.26		$0.43	$0.00	$57.26		$0	$0	$0	$0	$0	
5	September	10/2/13	29	0	$51.90		$0.40	$0.00	$51.90		$0	$0	$0	$0	$0	
6	October	10/31/13	29	164	$114.02	$ 0.70	$0.41	$66.58	$180.60	$ 1.101	$72	$0	$55	$7	$134	$ 0.816
7	November	12/3/13	33	559	$314.48	$ 0.56	$0.51	$287.09	$601.57	$ 1.076	$304	$0	$187	$25	$516	$ 0.923
8	December	1/2/14	30	1,767	$864.19	$ 0.49	$0.47	$835.14	$1,699.33	$ 0.962	$962	$0	$591	$79	$1,632	$ 0.923
9	January	2/3/14	32	996	$538.47	$ 0.54	$0.52	$517.53	$1,056.00	$ 1.060	$542	$0	$333	$45	$920	$ 0.923
10	February	3/5/14	30	1,220	$643.08	$ 0.53	$0.59	$721.41	$1,364.49	$ 1.118	$664	$0	$408	$55	$1,126	$ 0.923
11	March	4/3/14	29	661	$364.99	$ 0.55	$0.64	$786.60	$1,429.68	$ 2.163	$360	$0	$221	$30	$610	$ 0.923
12	April	5/5/14	32	471	$241.61	$ 0.51	$0.55	$361.86	$726.85	$ 1.543	$360	$0	$221	$30	$610	$ 0.923
TOTAL			367	5,870	$3,365	$ 0.57	$ 0.61	$ 3,593	$7,359.12	$ 1.25	$ 3,278	$ -	$ 2,025	$ 271	$ 5,574	$ 0.950

Appendix G

Site Visit Photographs

Cragmont Elementary

East wing, looking west

Exterior light over doorway

East wing, from south

Recessed downlights by MP room entrance

Typical classroom lights with occupancy sensor

MP room lights and duct

MP room windows and lights

Library lights

Lighting control panel

Serving line in MP room

Refrigerator and retherm

Heating hot water circulating pumps

Roof of MP room

Roof of N wing

Berkeley High—G and H Buildings

Entrance from W side

Exterior, from SE

W. side of 3 story portion of G building

Typical windows

N. end, looking west

Open window

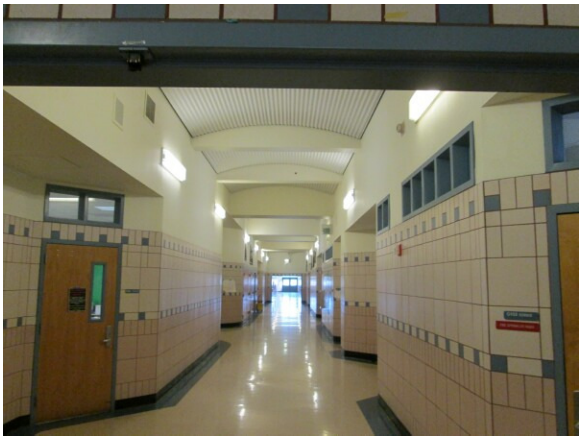
Typical classroom

Classroom windows

Pendant indirect-direct light fixture

Hallway lights

Classroom lights on, with occupancy sensor



Hallway lights

Exit light (compact fluorescent)

Restroom lights with occupancy sensor

Air handler 3

Air handler supply fans and motors

Air handler exhaust fans and motors

Air handler logo of heat exchanger

Air handler 1

Energy management system panel

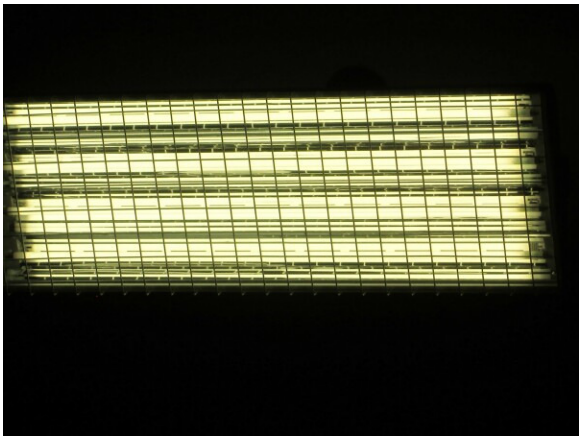
Berkeley High School—Donahue Gym

Donahue Gym from NE

Lobby lights

Gym ceiling and lights

Restroom lights



Pendant high bay T5HO light

Air handler

Air handler supply fan

Electric meter in panel at NE corner of gym

Rooftop looking N

Rooftop looking S

Panel section with breaker space

Berkeley High School—Jackets Pool

Pool room, from NW corner

Double pane glass on W side of pool room

Exterior of pool room, from E

Floodlights on S. wall

S. wall of pool room, with sliding glass doors

Floodlights on W and N walls

Dehumidifier and its condenser

Pool filters

Pool heater

Space heating boiler

Pool pump

Exhaust fan intake on roof of pool room