UNPEPP 2004
University-National Park Energy Partnership Program

Energy Conservation Measures and Photovoltaic System Design for the Kuchel Visitor Center

Redwood National and State Parks
Orick, California

Prepared by: Nicole Campbell
David Carter
Schatz Energy Research Center
Humboldt State University
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SCHATZ ENERGY RESEARCH CENTER

Executive Summary

Located sixty miles south of the Oregon border along the scenic California coast line, the Kuchel Visitor Center (KVC) acts as a gateway to California redwood country. On average, around 5000 visitors from around the world visit KVC each month. In the summer of 2002 Schatz Energy Research Center (SERC) interns, Andrew Sorter and Kelly Miess, installed a solar water heating system in KVC as part of the University-National Park Energy Partnership Program (UNPEPP). As a result of the 2002 project, visitors to KVC are able to see and experience renewable energy technologies in action. Our project seeks to build on Andy and Kelly's work to make KVC a model for efficient and renewable energy technologies.

This project has two parts. Part one quantifies the current energy use at KVC and identifies areas where energy consumption can be reduced without inconveniencing park staff or visitors. A series of recommendations are presented that, if implemented, will reduce the electricity energy use at KVC by 45% from 2727 kWh per month to 1513 kWh per month. The retrofit package is estimated to cost $5,731 (excluding labor) after a rebate of $676 from Pacific Gas and Electric (PG&E). These recommendations offer an estimated monthly savings of $190 and a simple payback period of 2.5 years. The majority of our recommendations involve lighting efficiency measures.

Part two presents three different grid-connected photovoltaic system designs for KVC.

- Our first design is a 6 kW_DC system mounted on the southern east-facing roof (see cover photo). This design can provide 36% of KVC's reduced electrical demand at a cost of $0.17 per kWh for a thirty year lifecycle. The system would cost approximately $21,985 after a rebate of $15,349 from the California Energy Commission (CEC). We estimated the combined payback period for the load reduction measures and the 6 kW_DC system to be 8.2 years.

- Our second design is a 9 kW_DC system mounted on the central, west-facing roof (see Figure 11). This design can provide 55% of KVC's reduced electrical demand at a cost of $0.15 per kWh for a thirty year lifecycle. The system would cost approximately $30,572 after a rebate of $23,023 from the CEC. We estimated the combined payback period for the load reduction measures and the 9kW_DC system to be 9.3 years.

- Our third design is a 15 kW_DC system and is a combination of our first two designs (see Figure 11). This design can provide 91% of KVC's reduced electrical demand at a cost of $0.13 per kWh for a thirty year lifecycle. The system would cost approximately $45,035 after a rebate of $38,372 from the CEC. We estimated the combined payback period for the load reduction measures and the 15 kW_DC system to be 10.3 years.

By installing a grid-connected photovoltaic system in combination with our recommended efficiency and conservation measures, the Redwood National and State Parks can realize significant economic benefits while providing an opportunity for the visiting public to learn about efficient and renewable energy technologies.

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Introduction

Founded in 1997, the University-National Park Energy Partnership Program (UNPEPP). UNPEPP is a national program that provides energy services to the parks and educational opportunities to university students (University-National Park Energy Partnership Program 2004). UNPEPP operates under the Green Energy Parks Program, which "aims to promote the use of energy efficient and renewable energy technologies and practices in our National Parks, and to educate the visiting public about these efforts" (DOI/DOE Memorandum of understanding 2001).

The 2004 UNPEPP project builds on the success of previous partnerships between the Schatz Energy Research Center (SERC) and Redwood National and State Parks (RNSP). The Schatz Energy Research Center, located at Humboldt State University (HSU) in Arcata, California, is dedicated to establishing clean and renewable energy technologies in our society. They accomplish their mission in part by designing and building renewable energy systems and providing energy education for students of all ages (About SERC 2004). This summer's internship marks the fourth in the series of partnerships between SERC and RNSP involving students from HSU.

In 2000, UNPEPP interns designed two photovoltaic (PV) systems and one solar thermal system for facilities in Prairie Creek Redwoods State Park. In 2001, the interns designed a solar hot water system, a grid-connected PV system, and an energy efficient outdoor lighting system for Wolf Creek Outdoor School. These designs were implemented the following year with assistance from Bonneville Power Authority. In 2002, the interns designed and installed a solar water heating system at the Kuchel Visitor Center (KVC), formerly known as the Redwood Information Center (RIC). The objectives of the current project are to perform an electrical energy audit of KVC, to identify energy efficiency upgrades, and to design a grid-connected PV system for the facility.

At our initial meeting with park personnel, on May 24, 2004, we toured the site and discussed the project objectives. We learned that plans were being finalized for a renovation of the main public areas of KVC. The renovation process is scheduled to begin in January 2005. The Park provided us with copies of the plans drafted by Daniel Quan Designs of Oakland California. We made efforts throughout the project to tailor our recommendations to the proposed new arrangements.

Facility Description

The Kuchel Visitor Center is located on the beach south of Orick, California, approximately 60 miles south of the Oregon border (Figure 1).

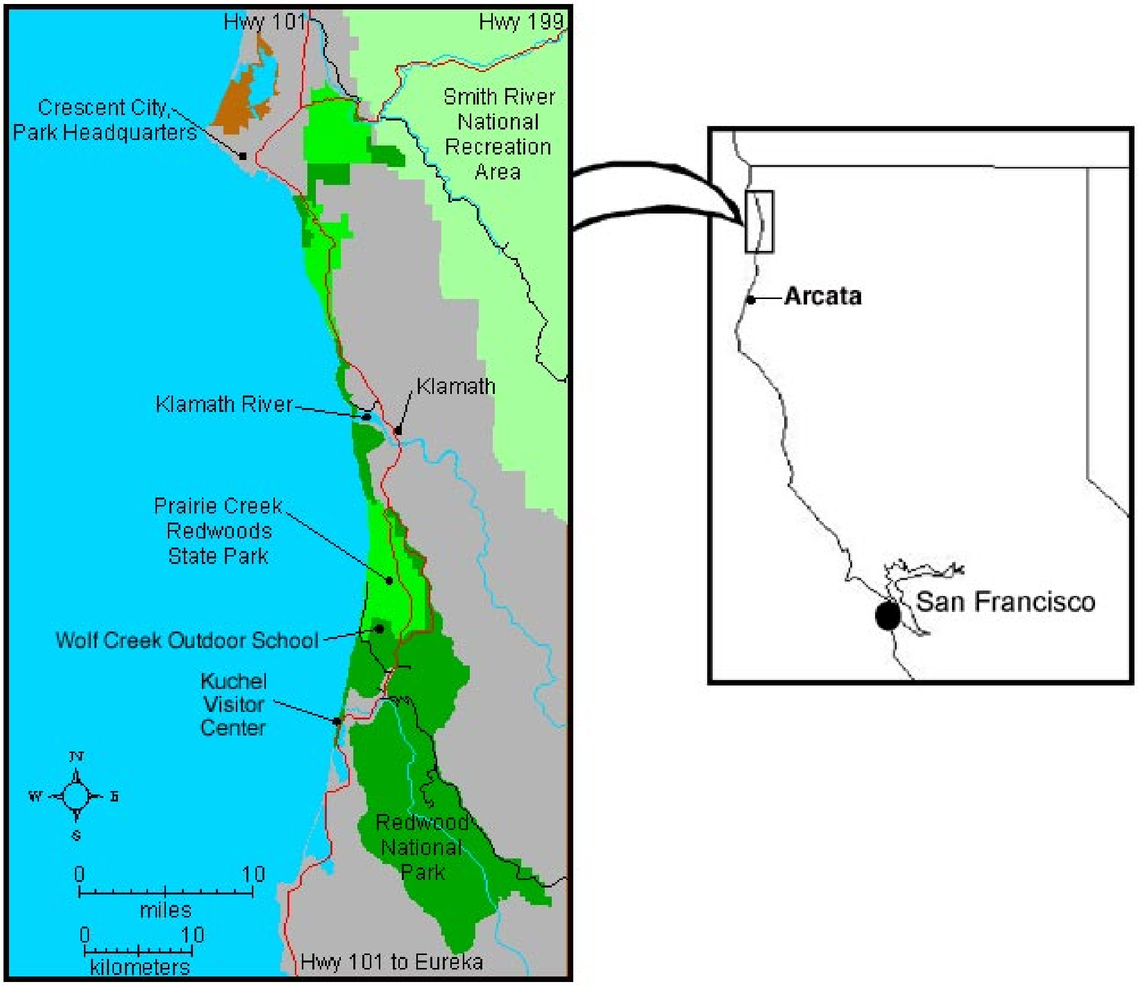


Figure 1: Map showing the location of KVC (NPS 2004).

Constructed in 1984, the facility serves as a welcome center introducing visitors to the redwood coast. The floor plan of the facility is included in **Appendix A**. A 1/4-mile long driveway leads from the highway to the facility. A gate at the highway end of the driveway is locked when the facility is closed. A large lot on the east side of KVC provides parking for visitors, and an information kiosk across from the parking lot provides the first chance for visitors to learn about the area (Figure 2). Two sets of stairs lead to a large covered deck that shares its foundation with the main building and public restrooms. A ramp at the south end of the building provides wheelchair access to this deck. The entrance to the main building is located at the western edge of the covered deck. The 2000-square ft. facility houses a small theater, visitor information and retail sales area, employee offices, a mechanical room, and an employee restroom. The public restrooms are accessed via the main deck near the main entrance.

Figure 2: Dave Carter (left) and Nicole Campbell (right) standing outside KVC.

Energy Audit

An energy audit is the process of quantifying all energy use in a building and identifying appropriate energy saving measures. Energy is the capacity of a system to do work and is calculated as the product of power (rate of energy use) and time. Utility companies measure electric energy in the compound unit kilowatt-hour (kWh), which is calculated by multiplying the instantaneous power rating of an appliance in kilowatts (kW) by the number of hours the appliance operates (h). Therefore, the relevant data in an energy audit are the power levels of all electrical devices, or loads, and the hours of operation, or duty cycle, of each.

Our first task was to perform a comprehensive energy audit of KVC. First, we reviewed the preliminary audit prepared by Andrew Sorter and Kelly Miess during their 2002 internship at KVC. Next, we walked through the facility to verify the loads they had surveyed and their corresponding power levels, and to add items that were not included in the previous audit. The main electrical loads at KVC are:

- Lighting, indoor and outdoor
- Office equipment

- Communications equipment
- Space heating
- Large screen TV with VCR
- Stereo receiver with tape deck and CD player
- Hand dryers
- Sewage pumps

Data Acquisition

Monitoring equipment enabled us to determine the energy use of various devices either by directly recording the energy use in a time period, or by recording the operation hours of the devices.

Some loads, such as lights and toasters, operate at fixed power levels, while others, such as office equipment, fluctuate. To determine the energy use of the constant-power loads, we either measured power directly, or recorded the power rating from the device nameplate. We then multiplied the power value by the operation hours of the load. Operation hours were taken from facility timers, determined from interviews with park staff, or monitored with the devices described in the following sections.

Devices that operate at varying power levels require continuous monitoring to estimate their energy consumption. For these devices we used power meters that record the total energy use over a period of time.

Power Meter

The Brand Electronics Digital Power Meter and the P3 International Kill A Watt™ meter measure both the instantaneous power level and the total energy used by a load in a given time period. As shown in Figure 3, the appliance (a toaster) is plugged into the power meter, which is plugged into the wall socket, and the power level and energy use are displayed on the screen. These meters were used to determine the power levels or energy use of the following loads:

- Jewelry display lights (power)
- Tape player (power)
- Cash register (power)
- Refrigerator (energy)
- Miscellaneous office equipment (power and energy)

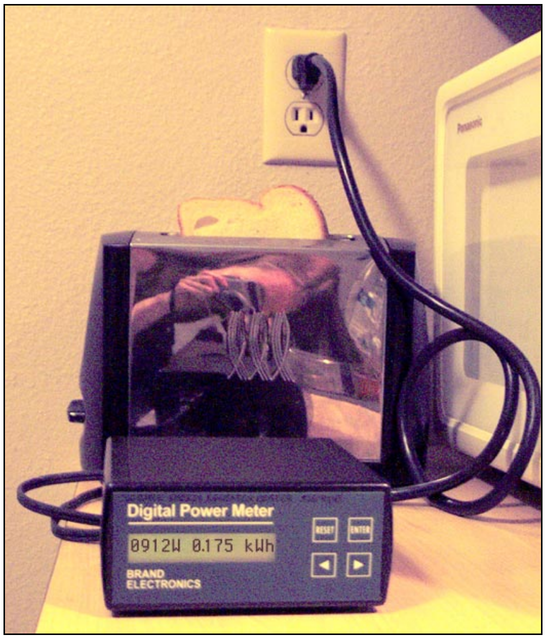


Figure 3: A toaster plugged into the Digital Power Meter.

We also measured the *phantom loads* of all the electronic devices, excluding the communications equipment that could not be unplugged. Phantom loads and all other italicized terms in this report are defined in the **Glossary**.

We measured energy use between May 26th and June 7th, 2004. In the Audio Visual (AV) room we measured the energy use of the television and the VCR with the Kill A Watt™ meter. In the office, we used the Digital Power Meter to measure the total energy used by the computer, monitor, two printers, and scanner. These devices were on a single power strip, allowing us to measure all five with one power meter.

AC-Field Sensor

AC-field sensors recognize the presence of a magnetic field and record a data point when the AC motor turns on or off. We installed Onset Computer Corp. HOBO® on/off loggers, in the public restroom hand-dryers and on the furnace blower to estimate the duty cycles of these devices. We monitored these loads from May 26th to June 7th, 2004.

Light Intensity Sensors

A light intensity sensor records the number of *lumens* incident on the sensor. We installed HOBO® H8 Family loggers with internal light sensors in one of the ceiling-mounted light fixtures in both the office and storage room. The lumen data indicated when the lights turned on (high lumen values) and off (low lumen values). We used these data to estimate the duty cycles of the office and storage room lights. These data were recorded from June 23rd to July 3rd, 2004.

Light Meter

Light meters record the number of *footcandles* incident on their sensor. We used an EXTECH Instruments Light ProbeMeter™ to measure the number of footcandles incident on the surfaces of various displays in the main lobby on June 7th, 2004. We measured the light output of the existing lamps and our recommended lamps on June 23rd, 2004.

Energy Audit Results

After collecting and analyzing the data, we developed a profile for KVC's energy use (Figure 4). An itemized list of the facility's devices and their corresponding power use is included in **Appendix B.**

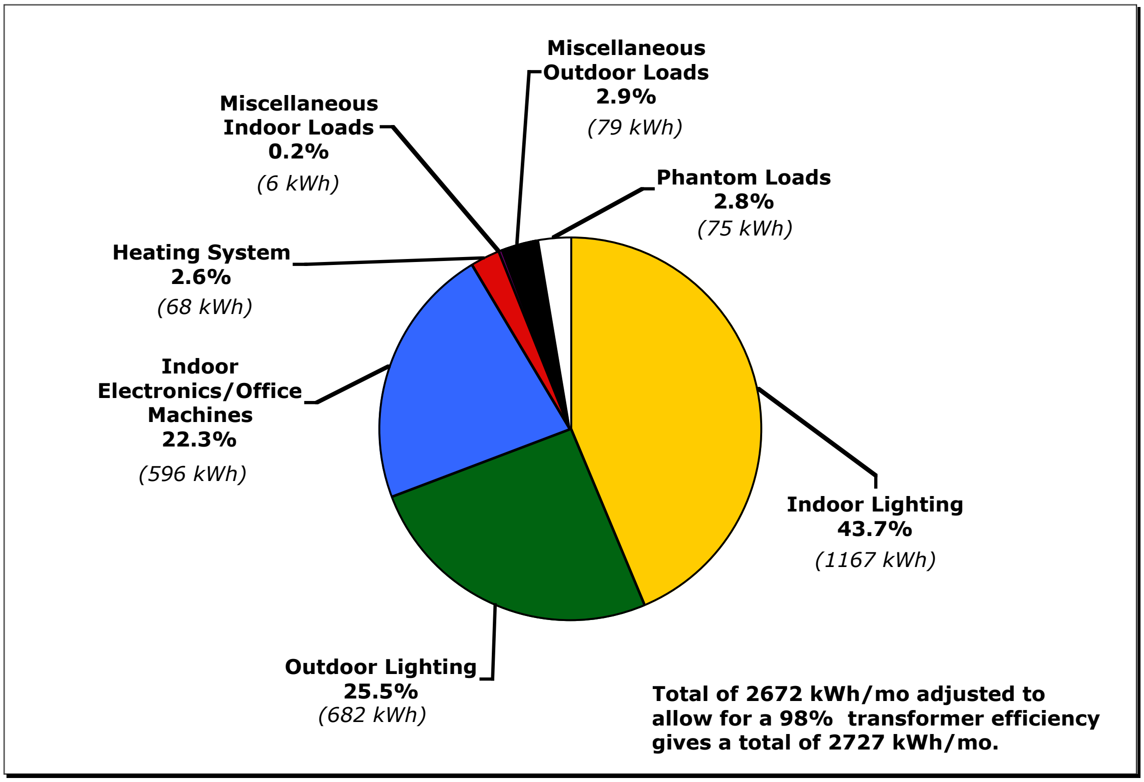


Figure 4: Current monthly electricity use at KVC.

As shown in Figure 5, we compared the load profile to utility bills dating from September 2002 to May 2004, the period between the installation of the solar water heating system and the beginning of our project. The average monthly electricity use for that 1.7-year time period was 2695 kWh/mo, which is within 1% of the 2727 kWh/mo value we estimated in our audit. The post-2002 reduction in KVC electricity use can be attributed to the removal of the electric resistance water heater during the 2002 project and energy efficient retrofits installed by RNSP electrician James Tiffany.

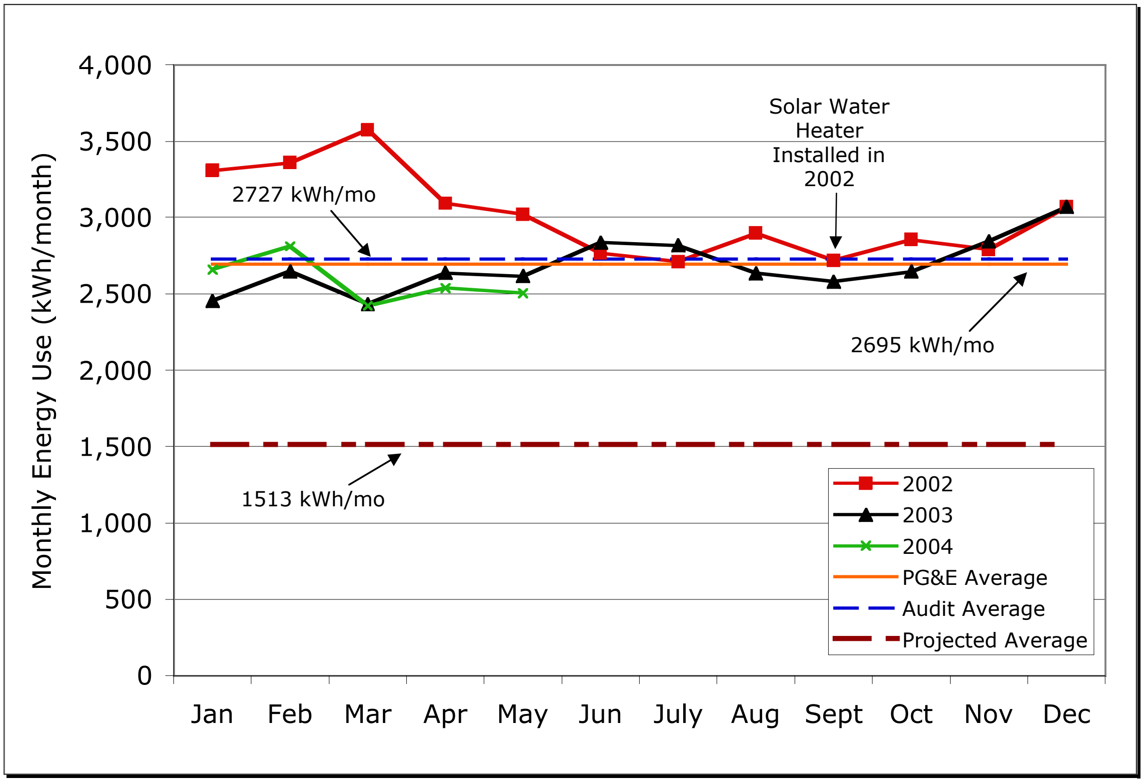


Figure 5: Comparison of our energy audit results with utility bills and a preview of the projected monthly energy use.

Since indoor and outdoor lighting accounts for 69% of the total electricity use at KVC (Figure 4), the greatest potential energy savings can be achieved through lighting retrofits. Therefore, we focused our research on energy efficient lighting technologies. To insure that our recommendations will provide satisfactory lighting, we specified lamps that met or exceed the minimum light quality standards required by the rebate program sponsored by the local utility company Pacific Gas and Electric (PG&E). To meet these standards, we recommended lamps that had a *color rendering index (CRI)* of 80 or higher, a *color temperature* within the range of 3500 to 4000K, and that each bulb met its minimum lumen and *efficacy* levels. The rebate program is described on the PG&E website (Terms 2004), and the bulb specifications are included in **Appendix C**.

Linda Appanaitis, Executive Director of the Redwood Park Association, voiced concerns about the light quality of energy efficient lamps. In a facsimile correspondence she informed us of the lighting standards set by the American Booksellers Association and the Museum Store Association. The standards state that the “store” should have indirect, full spectrum light of 35-50 footcandles; spot lit displays should have 100 footcandles; and the service desk should have 70 footcandles of light.

The current lighting levels at various locations in main lobby are listed in Table 1. These monitored locations are shown in the floorplan in **Appendix A**. The average lighting level was 31 footcandles, indicating that some areas are under-lit. More careful aiming and placement of the existing lights could improve this under-lit condition. Our goal was to recommend lighting retrofits that could provide lighting comparable or superior to the current levels.

Table 1: Lighting levels at various location in KVC.

Location in Main Lobby	Average Foot Candles (fc)	Target Light Level (fc)
NW Corner (Books)	29	35-50
NE Corner	46	35-50
NW Display Area	26	35-50
SW Display Area	27	35-50
Middle Display Area	21	35-50
Info Desk	32	70
SE Corner	40	35-50
Average	**31**	

We acquired and tested two sample fixtures and bulbs to evaluate the utility of the these retrofits for KVC. In the morning on June 7th, 2004, we tested a 15 watt (W) and a 32W *reflector compact fluorescent lamp (CFL)* at different heights on the suspended track. The lighting levels we measured are listed in Table 2. The background lighting levels, shown in column three, are a result of daylight and reflected light from surrounding lamps.

Table 2: Light level measurements of sample lamps at various heights from the floor.

		Footcandle Reading		
Location in Main Lobby	***Description***	**Background Light**	**15W Fluorescent**	**32W Fluorescent**
SE Track (10 ft to the right of the main door)	*2 feet from the floor*	4	8	25
	3 feet from the floor	3	9	31
	4 feet from the floor	2	11	39

Lighting levels decreased significantly with increasing distance between the source and surface. The planned renovation calls for raising two of the suspended tracks, in which case, these tests should be repeated to insure that the displays under the raised tracks are adequately lit.

The 15W fluorescent lamp did not provide adequate light in the suspended tracks; however, the 32W fluorescent lamp provided adequate general lighting at a surface four feet above the floor.

Next, we investigated whether the 15W fluorescents could provide general lighting on the fixed tracks and if the 32W fluorescents could replace the 150W halogens on the suspended tracks. On June 23rd, accompanied by SERC Research Engineer Michael Winkler, we met with Linda Appanaitis and arranged the lights so that the four of us could compare the light quality of the existing lamps with our sample lamps and fixtures (Table 3). We did a side-by-side comparison of the 15W fluorescent and the existing 50W halogen (Table 4). The group agreed that 15W fluorescent lamp performed well in this application, however more light was preferred. Thus, we are recommending the use of 20W reflector CFLs in the fixed tracks.

Table 3: Light level comparison between the sample 15W CFL and the existing 50W halogen.

		Footcandle Reading		
Location in Main Lobby	***Description***	**Background Light**	**15W Fluorescent**	**50W Halogen**
NE corner of room	*Map on wall*	NA	22	47

Next, we did side-by-side comparisons of the existing 150W *halogen lamps* and the 32W fluorescent lamps on the suspended track (Table 4). The group agreed that the 32W reflector CFLs provided superior light quality and footcandle values, when compared to the 150W halogens.

Table 4: Light level comparison between the sample 32W CFL and the existing 150W halogen.

		Footcandle Reading		
Location in Main Lobby	***Description***	**Background Light**	**32W Fluorescent**	**150W Halogen**
SW Display	*Next to windows*	17	36	22

Energy Audit Recommendations

Our energy audit recommendations will save energy at KVC by reducing power levels through energy efficient lighting technologies and by reducing the operation time of specified lights. The lighting technologies and controls are described in detail in the **Glossary**.

Most of the energy efficient lighting technologies we recommend are manufactured by Osram Sylvania and U.S. Energy Sciences. All the main lobby light fixtures are Lightolier products, matching the brand of the tracks at KVC. Specification sheets and/or part numbers for the recommended products are included in **Appendix C**.

After researching companies that manufacture lighting controls, we chose to incorporate products from The Watt Stopper® Inc. into our designs. We discussed our conservation ideas with Stan Lynch, Sales Representative for The Watt Stopper®, and he helped us choose controls appropriate for KVC. Specification sheets for the lighting controls we recommend, as well as contact information for Stan Lynch, can also be found in **Appendix C**.

Main Lobby

In a preliminary presentation to park staff on July 7th, 2004, we provided a life cycle cost (LCC) analysis of various spot and flood lighting alternatives for the main lobby. This analysis showed which alternatives offered the most savings over a 10-year design horizon. Park staff helped us determine which alternatives were best for KVC, and we incorporated these suggestions into our design. **Appendix D** displays results of our LCC analysis.

Indirect Lighting

Fourteen 150W halogen flood lamps in suspended tracks provide indirect lighting in the main lobby. Although the 32W Lyteflood® Scoop™ fixture, shown in Figure 6, had improved light level and quality, as compared with the 150W halogen lamp (Table 4), we are recommending a 42W CFL to further improve the under-lit condition of the main lobby. This recommendation is consistent with the request made by the park staff at our preliminary presentation. Table 5 displays the savings associated with this recommendation.

Table 5: Economic analysis of the 150W halogen flood light replacement.

Area	Conversion	# of Bulbs	Hrs/day	Savings/mo	Equipment Cost	Rebate	Payback (yrs)
Main Lobby	150W halogen flood --> 42W CFL	14	8	$58	$2,900	$175	3.9

The Lyteflood® Scoop™ is a Lightolier fixture with a reflective coating on the underside where the bulb is located. The reflective coating results in directed flood lighting. Note that the 42W CFLs are not included with the fixture and therefore must be purchased separately.

Figure 6: The 32W Lyteflood® Scoop™ (left) next to a 150W halogen flood (right) on the Lightolier track at KVC.

Spot Lighting

Thirty 50W halogen spotlights provide accent lighting in the main lobby. Seventeen of these are located on fixed tracks in the north end of the lobby, and the remaining thirteen are in the suspended tracks in the center of the lobby. The spots on the fixed tracks are providing general lighting to the book showcase and tourist information area, rather than fulfilling their intended purpose as accent lights.

For the fixed track, we recommend that fifteen of the 50W halogen lamps be replaced with Lightolier Universal Lytespot® fixtures, 20W PAR38 reflector CFLs and *cowls*. These fixtures fit into the Lightolier Lytespan tracks currently in use at KVC (Figure 7). Further, we recommend that the two remaining halogens be upgraded to 35W *Halogen IR* bulbs. These recommendations are consistent with requests made by park staff at our preliminary presentation and will allow for some strategic accent lighting for these areas.

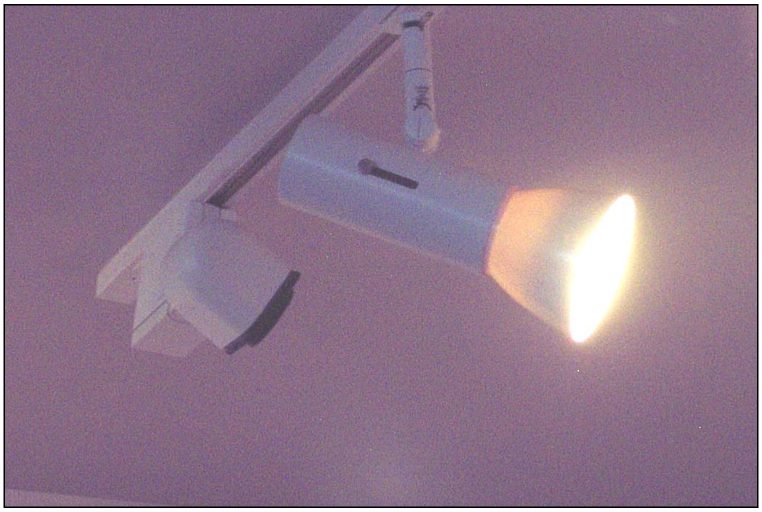


Figure 7: A 50W spot halogen (left) next to the a 15W reflector CFL (right) on the fixed track in KVC.

For the suspended tracks, we recommend that all the halogens be upgraded to 35W Halogen IR bulbs. These bulbs use advanced technology to offer more light output at a reduced power level. The economics associated with these suggestions can be seen in Table 6.

Table 6: Economic analysis of the 50W spot halogen replacement.

Area	Conversion	# of Bulbs	Hrs/day	Savings/ mo	Equipment Cost	Rebate	Payback (yrs)
Main Lobby	50W Spot halogen --> 35W Halogen IR	15	8	$26	$885	$165	2.3
Main Lobby	50W Spot halogen --> 20W CFL	15	8				

Entrance Area and AV Room Lighting

The entrance area and Audio Visual (AV) room contain 13W to 18W CFLs. James Tiffany has been replacing these lamps with 9W CFLs. We recommend that the higher wattage lamps continue to be replaced with 9W CFLs, upon failure.

The upcoming renovations call for replacement of the ceiling mounted fixtures in the AV room with 11 recessed wall washers. At this point, the wattage of these wall washers has not been determined by the designers. Therefore, we assumed the same wattage lamps will be used in the new arrangement. We also learned that the renovation plans call for multiple banks of wall washing fluorescent lights to be added to the suspended track on the east side of the main lobby to light a large mural. The wall washed fluorescents are not accounted for in our audit because the designers had not determined the wattage of these lamps.

On the wall separating the AV room from the Lobby, the Redwood Coast Sign is lit by T12 fluorescent tubes and 18W CFLs. This sign is using a total of 190W of power when in use. James Tiffany suggested replacing these lights with LED lights. Although this recommendation is not included in our economic analysis, using LED lights for this sign will result in significant energy savings and should be pursued.

Employee Areas

The office, mechanical and storage rooms, as well as the employee restroom, use a mix of 34W and 40W T12 fluorescent lamps with *magnetic ballasts*. We recommend that all magnetic ballasts be replaced with *electronic ballasts*. For the fixtures that hold two T12 lamps, we recommend downsizing to one 32W *T8* lamp with a *reflector kit*. For the fixtures that hold four T12 lamps, we recommend they be downsized to hold two 28W *T8* lamps with one reflector kit. Table 7 lists savings associated with the employee area recommendations.

The office lighting data indicate that the lights operate for an average of 8.5 hours per day, while the employee interviews indicate the office is used infrequently throughout the day. Therefore, we recommend an *occupancy sensor* for the office. In particular, we are recommending the WPIR Passive Infrared Sensor with a BZ-100 Power Pack, both made by The Wattstopper® Inc.. This device senses body heat, unlike ultrasonic sensors that detect motion, which will work well for the office at KVC where the occupants are engaging in low movement activities, such as working at a desk or eating lunch (Lynch 2004). We assumed two hours per day of office use in our analysis.

The hall of the employee area is lit by two fixtures, each with two T12 U-shaped fluorescents (34W and/or 40W). We recommend that each of these U-tubes be replaced with 17W 2-ft linear T8 fluorescents, and that each fixture receive a reflector kit and an electronic ballast (Table 7).

Table 7: Economic analysis of the employee area recommendations.

Area	Conversion	# of Fixtures	Hrs/day	Savings/ mo	Equipment Cost	Rebate	Payback (yrs)
Office	4x40W T12 --> 2x28W T8 & Sensor	4	8.5 --> 2	$14.08	$241	$92	0.9
Hall	34W U-Tube --> 17W linear T8	1	8	$1.30	$25	$0	1.6
Hall	40W U-Tube --> 17W linear T8	1	8	$1.75	$25	$0	1.2
Electric Room	2x40W T12 --> 1x32W T8	3	6	$2.98	$68	$18	1.4
Storage Room	2x40W T12 --> 1x32W T8	2	0.5	$0.23	$45	$12	12.1
Totals				**$20**	**$405**	**$122**	**1.7**

Although the payback period for the storage room retrofits is 12.1 years, we recommend this upgrade for consistency and ease of maintenance.

Outdoor Lighting

General

Outdoor lighting at KVC includes two 400W high pressure sodium lamps (HPS) in the parking lot, two 50W HPS lamps in the kiosk fixtures, sixteen 13W CFLs and fixtures on the main boardwalk, and eight rail-mounted fixtures with 40W incandescent lamps on the front steps and three on the south ramp. Ten of the eleven rail-mounted fixtures are corroded and non-operational. We recommend upgrading the rail-mounted lights with 13W CFLs and new fixtures. The high payback periods and low monthly savings associated with the rail-mounted fixtures results from replacing the non-operational bulbs with operational ones, therefore, more energy is used and the steps are ramps will be properly lit (Table 8).

Table 8: Economic analysis of the outdoor area recommendations.

Area	Conversion	# of Fixtures	Hrs/day Before	Hrs/day After	Savings/ mo	Equipment Cost	Rebate	Payback (yrs)
South Ramp	13W CFL fixture/ Astrotimer & Sensor	3	12.0	4.1	-$0.74	$384	$33	NA
Steps	13W CFL fixture/ Astrotimer & Sensor	8	12.0	4.1	$0.26	$448	$88	117.4
Outside Restroom	40W U-Tube--> 17W T8 Astrotimer & Sensor	2	11.0	4.1	$7.10	$51	$0	0.6
Covered Deck	13W CFL --> 9W & Astrotimer & Sensor	16	12.0	4.1	$44.82	$650	$36	1.1
Kiosk	50W HPS --> Astrotimer	2	12.0	4.0				
Parking Lot	400W HPS --> Astrotimer	2	12.0	4.0				
Covered Deck	Sign: 2x40W T12 --> 1x28W T8	1	12.0	4.0	$4.04	$23	$6	0.3
Totals					**$51.43**	**$1,533**	**$157**	**2.5**

Two fixtures, each with two U-shaped T12 lamps, provide lighting for the breezeway in front of the public restrooms. We recommend replacing each of these U-tubes with a 2-ft linear fluorescent T8 lamp and that each fixture receive a reflector kit and an electronic ballast.

With the exception of the U-tubes, all of the outdoor lights are controlled by one timer set to operate from 7PM to 7AM year-round. Interviews with park personnel indicate that while some evening lighting is necessary for safety and security, continuous overnight operation of these lights is not necessary. We recommend that all the outdoor lighting, with the exception of the public restroom lights, be placed on an *astronomical timer* to provide seasonal lighting for 2 hours in the morning for the service personnel and for 2 hours in the evenings for closing after sunset. Table 8 displays the potential savings associated with this upgrade.

Additional methods of control are necessary to address the park's security and safety concerns. To address these concerns, we are recommending a four-relay version of The

Watt Stopper® Inc.'s LP8 Lighting Control Peanut Panel. This panel has a built in astronomical timer and can control four lighting circuits. This panel will be ideal for KVC because three modes of control can be used in concert for the outdoor lights. All lights on this panel will be inactive when there is adequate sun light. One relay will control the parking lot and kiosk lights via the astronomical timer function during the two hour intervals for both the morning and evening lighting periods.

A second relay will use the same astronomical timer schedule to control the boardwalk CFLs, rail-mounted CFL's, and the 2-ft by 2-ft fluorescent fixtures outside of the public restrooms. The second relay will also be subject to a control signal from a network of three ultrasonic *motion sensor*s mounted strategically along the main boardwalk. These sensors will activate lights if someone visits in the middle of the night.

Each relay will also be subject to an "overide" control signal from a button on the panel. The button will allow for night-time lighting outside of the normal control schedule when community meetings or other events take place and outdoor lighting is necessary for safety. Currently, such meetings take place five or six times per year. The above measures will minimize the operation hours of the outdoor lights and provide substantial energy savings, as shown in Table 8.

Public Restrooms

Life cycle cost analyses were performed for various lighting control alternatives for the public restrooms **(Appendix D)**. Park staff chose their desired alternative and the following section incorporates their choice.

The restroom lighting consists of two 32W T8 lamps per fixture, with 4 fixtures in each restroom. We recommend the fixtures be downsized to contain one bulb with a reflector kit.

We estimated daily occupancy rates using data collected from the hand-dryers. We used this data to predict the potential energy savings from occupancy sensors (Table 9).

Table 9: Economic analysis of the public restroom recommendations.

Conversion	# of Fixtures	Hrs/day Before	Hrs/day After	Savings/ mo	Equipment Cost	Rebate	Payback (yrs)
2x32W T8 lamps --> 1xT8 lamp&motion sensor	8	11	6	$19.53	$340	$44	1.3

The potential monthly savings are significant, therefore we recommend the use of a WT-600 Ultrasonic *occupancy sensor* with a BZ-100 dual voltage power pack. Both of these components are made by The Watt Stopper® Inc. and have been identified as appropriate for use in the public restrooms at KVC (Lynch, 2004).

Phantom Loads

The use of timers on the most significant phantom loads of the facility will minimize the energy loss during time periods set by the park staff (Table 10). During the set hours, the devices that are connected to the timer would be shut off from all power. Note, each day any clock displays on these devices will be reset.

Table 10: Economic analysis of the phantom load recommendation.

Phantom Loads	Watts	Hrs/day Before	Hrs/day After	Savings/ mo	Cost of Timers
HP 2100 Laserjet Printer HP DeskJet 940C Printer Scanner	9.3	16	0	$0.71	$23.30
Sharp AR-205 Copier	40	23.75	7.75	$3.00	$23.30
Microwave	2	23.65	7.65	$0.15	$23.30
TV, VCR, HD Receiver	14	16	0	$1.07	$23.30
Audio Educational Tool	21	16	0	$1.40	$23.30
Optimus SCT High Speed Tape Deck	6.5	14	0	$0.43	$23.30
Totals				**$6.76**	**$139.80**

In Table 10, the column titled 'Hrs/day Before' represents the number of hours per day in which the devices are not being used by the park staff, but are still drawing power. The column titled 'Hrs/day After' displays the expected operation hours of the phantom loads, after installation of the timers.

Projected Load Profile

Implementation of the recommendations described above will reduce the total energy use at KVC from the estimated 2727 kWh/month to 1513 kWh/month, a reduction of 1214 kWh/mo or 45% (Figure 8).

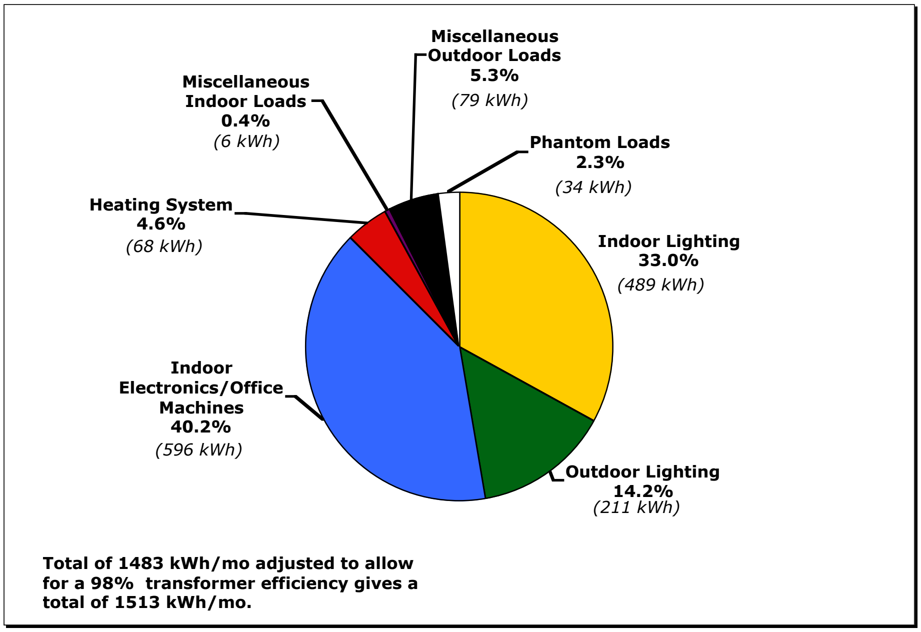


Figure 8: Projected load profile.

Note, the electronics and office machines, communication equipment, heating system, and miscellaneous loads use the same amount of energy as before, although now they represent a higher percentage of the total bill. All the equipment in these categories is modern and necessary for park operations; therefore, no energy saving recommendations were made. Figure 9 shows the percent reduction in monthly electricity charges for each category.

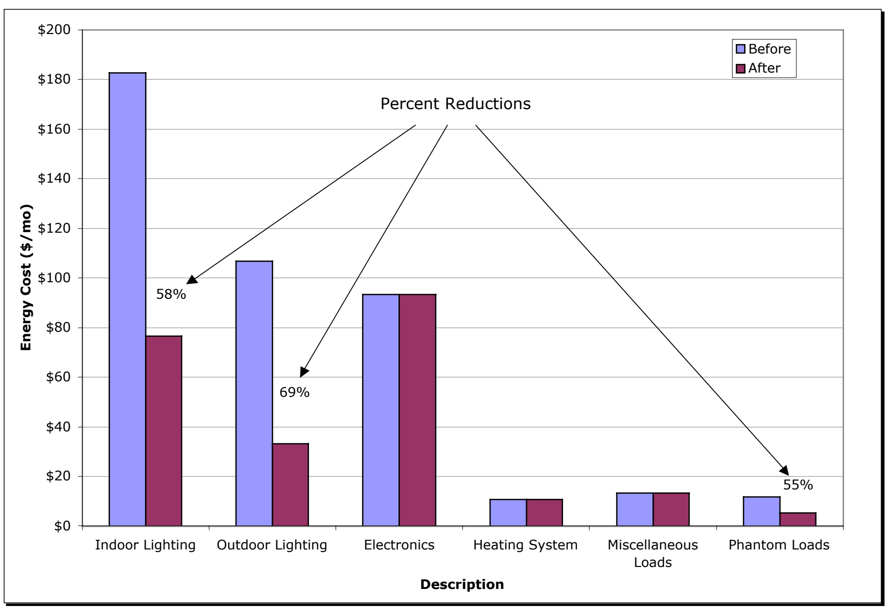


Figure 9: Electricity charges before and after the projected energy efficiency and conservation measures.

After completing our recommended energy efficiency and conservation measures we began our photovoltaic design process.

Renewable Energy System Design

Solar Electric Systems

Solar electric (or photovoltaic or PV) systems are classified as stand alone or grid-connected. In a stand alone system, batteries provide storage of electrical energy for use when the sun is not shining. In a grid-connected system, the utility grid is used as the storage medium. When the sun is shining, excess solar electricity flows into the grid and the utility meter spins backward. When the system is not generating enough electricity to meet the facility's demand, power is drawn from the utility grid, and the meter spins forward. This type of relationship with the utility grid is called "net metering". At the end of a year, the facility will have paid only for electricity use that is in excess of the amount generated by the PV system. Supply and demand profiles will vary seasonally and grid-connected systems are ideally designed to net the annual electricity bill to a minimum charge. This minimum charge is the cost required by the utility to maintain the grid connection, typically \$100-\$200 per year for a nonresidential account.

With net metering, the cost of electricity for a given rate schedule applies regardless of the direction the meter is spinning. Therefore, the *time-of-use* (*TOU*) rate schedule may be advantageous because the highest electricity rates occur when the output from the solar array is at its peak. The potential benefits depend on the daily load profile of the facility and the PV system's ability to generate excess power during peak rate periods. We analyzed the effects of a TOU rate schedule on the economics of the PV systems proposed for KVC.

Resource Data Collection

The relevant data for designing a renewable energy system are the existing load (demand) and the renewable energy resources available at the site (supply). The energy audit provided us with the demand side data. For the supply side data, we analyzed the energy potential of both the solar and wind resources at the site. Although the original scope of work called for a solar electric system, we include a discussion of wind generation in this report because park personnel inquired about the feasibility of a wind energy conversion system.

Insolation Data

Standard design practices for PV systems use average daily *insolation* values for each month to estimate the energy output of a given system. Multiple years of data for the design location is preferred; however, such records are generally not available.

The National Solar Radiation Database (NSRDB) contains insolation data files from 1961 to 1990 for many locations throughout the United States. The NSRDB is maintained by the U.S. Department of Energy and is made up of measured data and modeled data. The NSRDB contains modeled data-files for Arcata, California.

Multiple studies have compared this NSRDB data with measured data from SERC for Trinidad, California (Zoellick 2004, Carter 2004). The Trinidad monitoring station is approximately midway between Arcata and the KVC site. The studies conclude that the NSRDB data for Arcata are in close agreement with actual data for Trinidad, California. Therefore, we based our designs on the NSRDB data.

As a check, we installed a *pyranometer* and measured insolation at KVC from May 26th to July 21st, 2004. We compared this site specific data to the NSRDB data. These two data sets agreed to within 0.042% for June and 4.2% for July **(Appendix E)**.

Shading

Shading will reduce the energy output of a PV array. We used the Solar Pathfinder™ shown in Figure 10 to assess the impacts of shading at KVC. This device displays all obstructions to the solar window throughout the entire year and indicates the degree to which these obstructions will decrease energy availability. Labels on the latitude-specific sunpath diagram allow you to determine the percentage by which shading in each half-hour segment of the day will decrease the total daily insolation during each month of the year.

Figure 10: Solar Pathfinder™ showing shading at Wolf Creek Outdoor School.

Two areas on the southernmost east-facing roof experience some degree of shading. A small tree at the southeast corner of the building will shade the adjacent roof from sunrise to 8 am., August to October. While this shading does not have a significant impact on the system designs, the tree will need to be pruned periodically to minimize power losses from shading.

The northwestern corner of this roof experiences shade from 2:30 p.m. to sunset, June through February. To avoid power losses from shading in this location, the modules should be positioned below the 5 ft. by 5 ft. corner of the roof. The sunpath diagrams, as well as a plan view of the roof showing the shaded locations, can be found in **Appendix F**.

Wind Data

KVC has an *anemometer* that allows the public to observe the instantaneous wind speed; however, the wind speed data are not being recorded. SERC Research Engineer David Scott Rommel helped us design a system to record wind speed data from the anemometer at 30-second intervals. Our measurements began June 15th and ended July 21st, 2004. We calibrated our data using information supplied by the manufacturer of the anemometer. The maximum recorded wind speed was 25 mph and the average speed was 3.9 mph, which is insufficient for a wind energy conversion system. This result is consistent with the findings in The Renewable Energy Atlas of the West, which rates northern Humboldt County, California as poor for wind energy conversion potential (Nielson, et al 2002).

Solar Electric System Alternatives

Park staff requested multiple design alternatives with various array sizes and orientations. The optimum orientation in the northern hemisphere is due south, but the roof of KVC is oriented due east and west. Therefore we developed a preliminary design for a south facing array to be mounted on a picnic structure to be constructed with architecture matching KVC. This alternative was ruled out by park staff at the preliminary presentation.

We also developed preliminary designs for three roof-mounted PV systems. At the preliminary presentation, park staff requested complete designs for all three of the east and west-facing systems in our final report.

The methods we used for these designs are part of the Environmental Resources Engineering curriculum at Humboldt State University and are outlined in **Appendix G**.

Alternative A

6kW- As shown in Figure 11, this system will be mounted on the southern east-facing roof above the covered deck. This system will meet 36% of the facility's annual post-retrofit electrical use. The capital costs are approximately $21,985, after rebates from the California Energy Commission (CEC).

A **B**

Figure 11: PV Design Alternatives

Alternative B

9kW-As shown in Figure 11, this system will be mounted on the central, west-facing roof. This system will meet 55% of the facility's annual post-retrofit electrical use. The capital costs are approximately $30,572, after rebates from the CEC.

Alternative C

15 kW-This system will be a combination of alternatives A&B. This system will meet 91% of the facility's annual post-retrofit electrical use. The capital costs are approximately $45,035, after rebates from the CEC.

The estimates of the percent of the load covered for each design are based on the projected load profile shown in Figure 8. The cost estimates of these designs are discussed in more detail in the economics section below.

A listing of the PV system components, a discussion of the current and voltage characteristics for each system, and a diagram showing the orientation of the panels and wire runs on the facility for all three alternatives are included in **Appendix G**.

Project Economics

The recommended efficiency and conservation measures greatly enhance the economics of the entire project. Table 11 displays a summary of the economics associated with the load reduction measures.

Table 11: Summary of the load reduction economics.

Current monthly load (kWh)	2727
Projected monthly load (kWh)	1513
Projected energy savings (kWh)	1214
Percent energy savings	45%
Projected monthly savings	$190
Capital costs for retrofits	$6,407
Rebates from PG&E	$676
Net cost for retrofits	$5,731
Simple payback (years)	2.51

These load reduction measures are a cost-effective and necessary first step in designing a renewable energy system. Reducing the load results in a smaller PV system that can still provide the same benefits. Figure 12 shows how installing the efficiency retrofits and the PV system at the same time can significantly improve the payback periods for the PV systems.

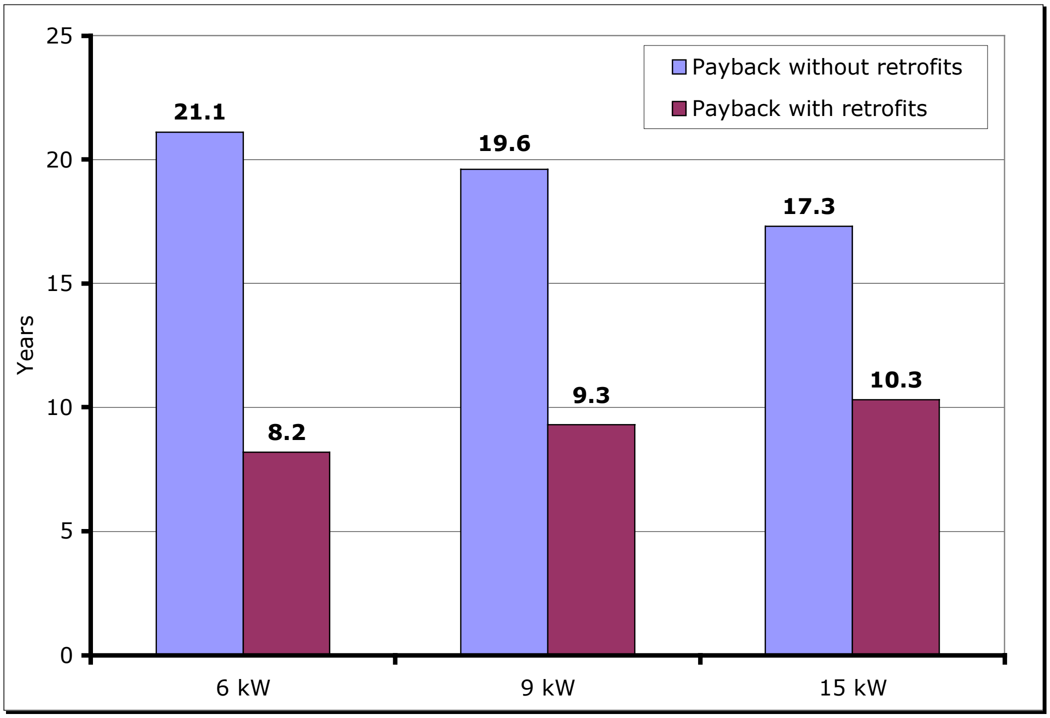


Figure 12: Effects of efficiency upgrades on Payback periods of PV systems

Combining the efficiency retrofits and the PV system in one package also enhances the fraction of KVC's electricity bill that will be covered by the PV systems (Figure 13).

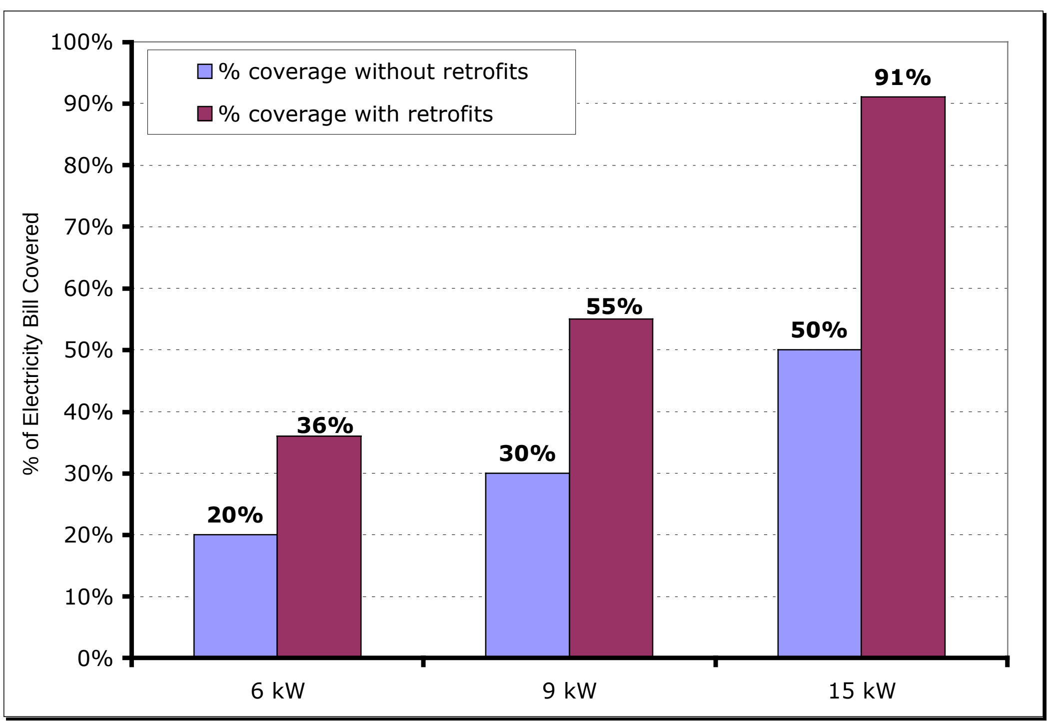


Figure 13: Effects of retrofits on the fraction of the electricity bill covered by the PV systems.

Table 12 shows a summary of the PV system economics. The Lifecycle Cost (LCC) analysis of the PV system incorporates the present value of money over a 30 year design life and includes inverter replacements at years 10 and 20.

Table 12: Summary of the economics for KVC solar electric systems.

Criterion	6 kW	9 kW	15 kW
Capital Costs	$ 31,677	$ 46,357	$ 73,007
Installation	$ 5,657	$ 7,238	$10,400
CEC Rebate ($3/Watt)	$ 15,349	$ 23,023	$ 38,372
Net Cost	**$ 21,985**	**$ 30,572**	**$ 45,035**
LCC	$ 30,727	$ 41,964	$ 61,436
Levelized cost ($/kWh)	**$ 0.17**	**$ 0.15**	**$ 0.13**
$/Watt_DC	$ 3.66	$ 3.39	$ 3.00

The discount rate we used for the lifecycle costs was 2% (Zoellick 2004). The levelized cost of electricity (LCE) incorporates the LCC of the PV system and is equivalent to a **fixed** rate ($/kWh) that the facility will pay for electricity over the 30 year design life of the PV system. The LCE for each system only applies to the fraction of the facility's electricity use that is produced by the PV system. The current rates at KVC are $0.128 from November 1st through April 30th, and $0.194 from May 1st through October 31st. The LCE indicates that the 15-kW system can provide 91% of the facility's electricity at a fixed rate of $0.13/ kWh for 30 years.

Although we performed an extensive, in-depth economic analysis, the cost of the PV system will fluctuate with the market value of equipment and the installation contractor's labor rate. An itemized list of the components and estimated costs for each system is included in **Appendix G**. The installation costs for all three systems are based on local contractors' estimates for the 15-kW system (Table 13).

Table 13: Estimates for the 15 kW system from local contractors.

15 kW system		
Contractor	Installation costs	Total cost before rebate
Solarwinds Northern Lights	$7,200	$76,841
"Roger"	$9000 - $15,000 *	$80,000 **
UNPEPP interns	$10,400	$83,407
Six Rivers Solar	No breakdown provided	$114,750

* Low estimate is contingent upon two helpers from park staff
** Estimate is based on high estimate for installation costs

Contact information for these contractors is also included in **Appendix G**. Note, in our analysis we assumed the current CEC rebate of $3.00/Watt; however, the CEC rebates are decreasing $0.20 per watt every six months. The next scheduled decrease is January 1, 2005.

Comparison of the A6 Time Of Use and A1 General Service rate schedules

We performed a detailed analysis of the potential benefits of switching from the current A1 General Services (GS) rate schedule to the A6 Time of Use (TOU) rate schedule. The A6 rate schedule would increase in the fraction of the annual electricity bill covered by the 15 kW system from 91% with the current rate schedule to 94%. With the A6 rate schedule the maximum coverage a PV system can provide for KVC is 94% because the minimum charge required by PG&E is $168. With the A1 rate schedule, 95% coverage is possible because the minimum charge is slightly less at $144.

With the A6 rate schedule the 15 kW system will net the annual electricity bill to approximately $1. The annual bill will be approximately $168 because the net bill is below the minimum charge. Therefore, KVC could use an additional $167 worth of electricity during the year and still have a bill of $168 at the end of the year. However, if this surplus is not used, KVC would be supplying an extra $167 worth of electricity to the PG&E grid each year.

With the A1 rate schedule the 15kW system will net the annual electricity bill to approximately $255. The net bill is greater than $144; therefore, the minimum charge is applied directly to KVC's electricity bill. The minimum charge is only an additional charge if KVC generates over 94-95% of its electricity (depending on the rate schedule). Below the 94-95% level, the minimum charge is applied to actual energy used by KVC. The fractions of the post-retrofit electricity bill that will be covered, the estimated time to pay back the PV system, and the annual savings to be gained from each system are shown in Figure 14. Note that the data shown in Figure 14 are contingent upon the completion of the efficiency retrofits.

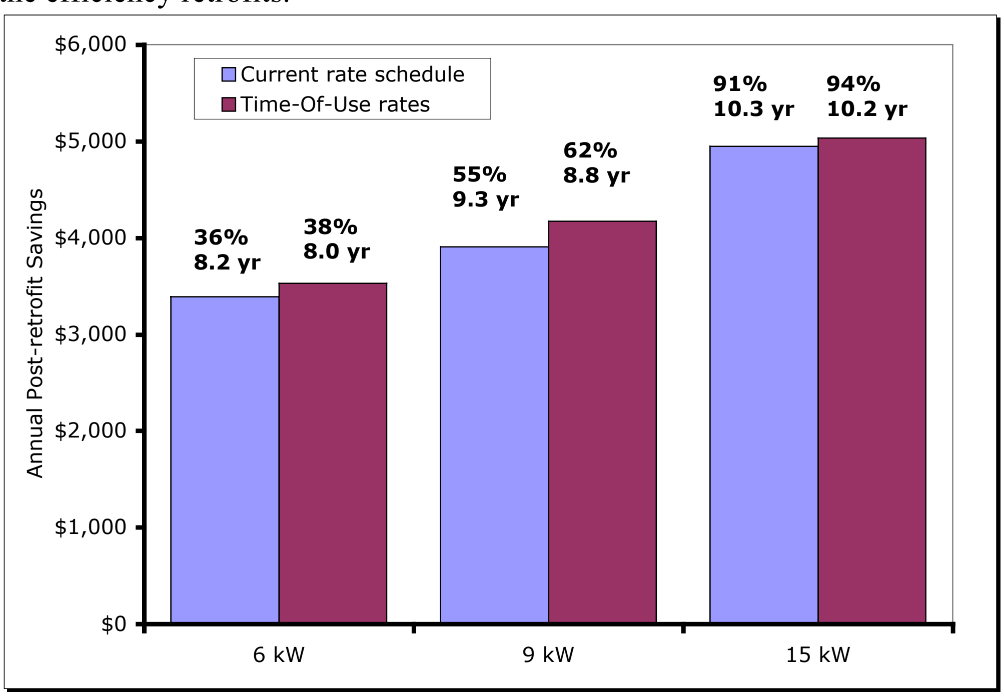


Figure 14: Comparison of A1 versus A6 rate schedules for all three systems.

This shows that a small advantage can be gained by switching to the A6 TOU rate schedule. For the 15 kW system, this advantage is limited by the minimum charge. For the smaller systems, the advantage decreases as the system size decreases. For any solar electric system at KVC, the risks of switching rate schedules may outweigh the benefits due to uncertainty regarding the upcoming remodel, scheduled for January 2005.

In light of these concerns, we recommend that the Park stay with the A1 rate schedule until the expected changes in the load profile for KVC can be confirmed.

Conclusions

Our results show that a combination of load reduction measures and a PV system at KVC would result in annual savings ranging from approximately $3,300 to $5,000 depending on the size of the PV system. We are hopeful that this project will be funded and that KVC will become a model for efficient and renewable energy technologies. The following list summarizes the results of our project.

Efficiency and Conservation Measures

- By implementing the efficiency and conservation recommendations in this report the electricity energy use at KVC can be reduced by 45% from 2727 kWh per month to 1513 kWh per month.
- The retrofit package is estimated to cost $5,731 (excluding labor) after a rebate of $676 from Pacific Gas and Electric (PG&E).
- The retrofit package offers an estimated monthly savings of $190 and a simple payback period of 2.5 years.
- Since 69% of the electricity use at KVC is for lighting, most of the projected savings are a result of lighting efficiency measures.

PV Design Alternatives

- A 6 kW_DC system mounted on the southern east-facing roof candesign can provide 36% of KVC's reduced electrical demand at a cost of $0.17 per kWh for a thirty year lifecycle.
    - This system would cost approximately $21,985 after a rebate of $15,349 from the California Energy Commission (CEC).
    - We estimated the combined payback period for the load reduction measures and the 6 kW_DC system to be 8.2 years.

- A 9 kW_DC system mounted on the central, west-facing roof can provide 55% of KVC's reduced electrical demand at a cost of $0.15 per kWh for a thirty year lifecycle.
    - This system would cost approximately $30,572 after a rebate of $23,023 from the CEC.
    - We estimated the combined payback period for the load reduction measures and the 9kW_DC system to be 9.3 years.

- A 15 kW_DC system (a combination of our first two designs) can provide 91% of KVC's reduced electrical demand at a cost of $0.13 per kWh for a thirty year lifecycle.

- The system would cost approximately $45,035 after a rebate of $38,372 from the CEC.
- We estimated the combined payback period for the load reduction measures and the 15 kW_DC system to be 10.3 years.

- We investigated the potential benefits of switching from the current A1 General Services (GS) rate schedule to the A6 Time of Use (TOU) rate schedule and found that only a small advantage can be gained by switching KVC to the A6 TOU rate schedule. There could be economic risks in this switch due to changes in the load profile that are expected in the upcoming remodel. In light of these risks, we recommend that the Park stay with the A1 rate schedule until the expected changes in the load profile for KVC can be confirmed.

This summer's project provided us with a valuable opportunity to use skills we gained in the classroom on a real world problem. We are pleased to have been able to develop recommendations for efficiency and conservation measures that offer significant energy savings for the park. It is satisfying to see how the load reduction measures enhance the economics of the PV systems. Thank you for giving us the opportunity to participate in this project.

References

1) Carter, David (2004). “Comparative Analysis of Two Sources of Insolation Data for Arcata Ca..” Requirement for Engineering 324, Environmental Resources Engineering Department, Humboldt State University.
2) “Compact Fluorescent (CFL).” (2004). <http://www.gelighting.com/na/faq/cfl_what.html> (July 22, 2004).
3) “DOI/DOE Memorandum of understanding.” (2001). <http://www.nps.gov/renew/mou.htm> (August 9, 2004).
4) Duffie, J.A., and Beckman, W.A. (1991). *Solar Engineering of Thermal Processes.* John Wiley & Sons, Inc. New York, N.Y.
5) “GE Lighting North America – Quality of Light.” (2004). <http://www.gelighting.com/na/institute/quality.html> (July 19, 2004).
6) “Halogen Lighting: How-To Article.” (1997). <http://www.electrical-online.com/howtoarticles/Lighting/*Halogen*.htm> (July 16, 2004).
7) “Light Bulb and *Ballast* Information: What is Color Temperature?” (2002). <http://www.goodmart.com/facts/light_bulbs/lightinfo_default.aspx> (July 19, 2004). <http://www.goodmart.com/facts/light_bulbs/glossary.aspx>
8) “Natural Lighting – Basic *Ballast* Information.” (2004). <http://www.naturallighting.com/articles/basic_*ballast*_information.htm> (July 23, 2004).
9) Nielsen J., Innis S., Kaas L., Rhoads-Weaver H., and Shutak A. (2002) "Renewable Energy Atlas Of The West". Land and Water Fund of the Rockies, Boulder Co..
10) NREL National Solar Radiation Users Manual. (2004). <http://rredc.nrel.gov/solar/pubs/NSRDB/history.html>, (March 5, 2004).
11) Quiring, Reg (2001). “Advances in Lighting.” *The Conviron Edge*, Vol. 1, October, 2001.
12) “Redwood National and State Parks.” (2004). <http://www.nps.gov/redw/index.htm> (January 2004).
13) “About SERC.” (2004). <http://www.humboldt.edu/~serc/about.html> (August 7, 2004).

14) "Terms." (2004).
<http://www.pge.com/biz/rebates/express_efficiency/eligibility/index.html>
(August 13, 2004).
15) "The Beam Post-Mount Spotlights." (2004). <http://www.bisho.com/unity.html>
(July 16, 2004).
16) "University-National Park Energy Partnership Program." (2004).
<www.nbc.gov/facilities/presentations/ PresentationforFAMC043004.pdf>
(August 7, 2004)
17) Zoellick, Jim (2004), Personal Communication. July 27, 2004, Arcata, Ca..

Glossary

Anemometer: device that measures the speed and direction of wind.

Astronomical timer: lighting control device that incorporates seasonal changes in day length and daylight savings time, allowing for outdoor lighting to be switched at dusk and dawn for a specified time period. An astronomical timer can provide significant energy savings when used to replace conventional lighting control timers.

Ballast: device that regulates voltage and current to electric-discharge light sources such as fluorescent or HID lamps (http://www.lrc.rpi.edu/researchTopics/technologies/ballasts.asp). All fluorescent lights require a ballast. Ballasts allow lamps to start reliably and operate efficiently.

Ballast (electronic): Electronic ballasts have several advantages over magnetic ballasts. They increase lamp efficacy, decrease power consumption, provide light output close to the rated lumens, provide quiet and cooler operation, and increase lamp life. Most of these benefits are attributed to the electronic ballast's ability to "bump up" the current frequency to 20-40 kHz.

Fluorescent lamps operate more efficiently at higher frequency with an electronic ballast; therefore, a 40W T12 lamp operates at 34 Watts, and a two-lamp fixture with ballast consumes only 68-71 watts (Natural Lighting 2004).

Ballast (magnetic): Magnetic ballasts operate at line current with a frequency of 60Hz. A magnetic ballast reduces the lamp's rated lumen output by 7.5% and consumes an extra 8 to 10 Watts of power when the lamp is operating. In addition, when the lamps are removed and the light switch is on, the ballasts will still operate at a power level of 4 watts (Natural Lighting 2004).

Candlepower (cp): luminous intensity expressed in candelas that describes the characteristics of spot lighting. Candlepower ratings describe how much light a bulb produces, measured at the bulb.

Color rendering index (CRI): lamp specification that describes a light source's ability to render colors as compared with daylight. CRI ranges from 1-100, where a value of 100 represents a light source that creates the same color characteristics as daylight. Low CRI bulbs make colors look washed out, while high CRI bulbs produce colors that look natural and vibrant (GoodMart.com 2002).

Color temperature: lamp specification that describes the degree of visual warmth or coolness that a light source emits (GE Lighting@ 2004). A color temperature between 3000 and 4000K is neutral, representing a complete depiction of the visible spectrum. Color temperatures from 2000-3000K correspond to a cooler, more blue light output, while color temperatures greater than 4000K correspond to a warmer, reddish light output (GoodMart.com 2002).

Compact fluorescent lamp (CFL): fluorescent lamp designed to replace incandescent bulbs. Fluorescent bulbs use approximately 65 to 80% less electricity than regular incandescent bulbs and may last up to 13 times longer. They produce warm white tones that closely duplicate incandescent light, with comparable lumen ratings (GE Lighting, 2004).

Cowl: protective covering used around the base of a bulb that provides aesthetic qualities.

Efficacy: measure of the amount of lumens per watt coming out of a bulb. Higher efficacy implies an improvement in lighting efficiency because the lamp uses less power to produce more light (GoodMart.com 2002).

Electronic ballast: See Ballast (electronic)

Footcandle (fc): unit of measure of the intensity of light falling on a surface, equal to one lumen per square foot and originally defined with reference to a standardized candle burning at one foot from a given surface (Bartleby.com).

Fluorescent lamp: lamp that produces visible light by fluorescence, especially a glass tube whose inner wall is coated with a material that fluoresces when an electrical current causes a vapor within the tube to discharge electrons (Bartleby.com).

Fluorescent tube: tube-shaped fluorescent lamp as designated by the letter ‘T’ in the lamp name. The number after the ‘T’ is multiplied by 1/8” to determine the tube diameter. Thus the T12 lamp has a diameter of 1.5”. T8 lamps are replacing the former T12 lamps as the new technology because T8 lamps with electronic ballasts are nearly twice as efficient as T12 lamps that use magnetic inductive ballasts (Quiring, 2001).

Linear fluorescent tubes come in various lengths, including 2, 4, and 8 feet. Fluorescent T12 tubes also come in a U-bent shape designed so that two can fit into a 2’ x 2’ fixture.

Halogen IR bulb: lamp containing multiple thin layers of a unique coating on the outside of the glass covering. This coating provides a filter that is transparent to visible light but reflects the infrared light back onto the filament, making the bulb more efficient (http://www.electrical-online.com/howtoarticles/Lighting/Halogen.htm).

Halogen IR bulbs convert 21% of their energy to visible light, while regular halogens convert only 15% of their energy to visible light (http://www.bisho.com/unity.html). In addition, a Halogen IR bulb rated at 35W produces 2,200 candlepower (cp), whereas a halogen rated at 50W produces 2,000 cp.

Halogen lamp: advanced type of incandescent light bulb.

Halogen bulbs have a longer life span than regular incandescents and have a higher efficacy. The shorter life span of incandescent bulbs is a result of the evaporation of the tungsten filament. To minimize this problem, halogen bulbs contain trace amounts of halogen gas, which at high temperatures react with the evaporating tungsten gas and deposit it back on the filament. The high temperatures required for this reaction result in a hotter filament. Hotter filaments produce whiter light and are more efficient, although they increase the costs of the lamp components.

Halogen lamps are commonly used in high quality retail lighting. Halogen floods provide indirect, general purpose lighting, and halogen spots draw attention to specific displays.

Insolation: rate of delivery of solar radiation per unit of horizontal surface (Bartleby.com).

Light meter: device that measures the amount of light, in footcandles, at a specific location.

Lumen:SI unit of measure of the amount of light flux exiting a bulb.

Magnetic ballast: See Ballast (magnetic)

Motion sensor: control device that activates lighting when movement is detected. Motion sensors utilize either ultrasonic or infrared technology. Ultrasonic occupancy sensors use Doppler technology to sense movement in a room. When movement is detected, the unit switches the lights on via a dual voltage power pack. After the space is vacated and an adjustable time period has elapsed, the lights are switched off.

Passive infrared occupancy sensors detect a change in the infrared heat radiated within the controlled room. This type of sensor is most suitable when occupants are not moving yet still require task light.

Phantom load: power a device uses when plugged in but not in use.

Pyranometer: device that measures isolation. Most insolation data is measured using thermopile pyranometers (Duffie and Beckman, 1991). The detectors on these instruments must have a response that is independent of wavelength. The most commonly used pyranometers in the United States are made by Eppley Laboratories. These instruments utilize highly absorbent and highly reflective materials side by side to develop a thermal gradient that is proportional to the amount of solar radiation incident upon the instrument. A well maintained Eppley pyranometer is able to generate insolation data that is accurate to within plus or minus 1.5% (Duffie and Beckman, 1991).

Reflector CFL: compact fluorescent lamp with a reflective coating that allows for directed flood lighting. The reflective coating is a great evolution in the fluorescent lighting technology, which is usually only applicable to general area lighting.

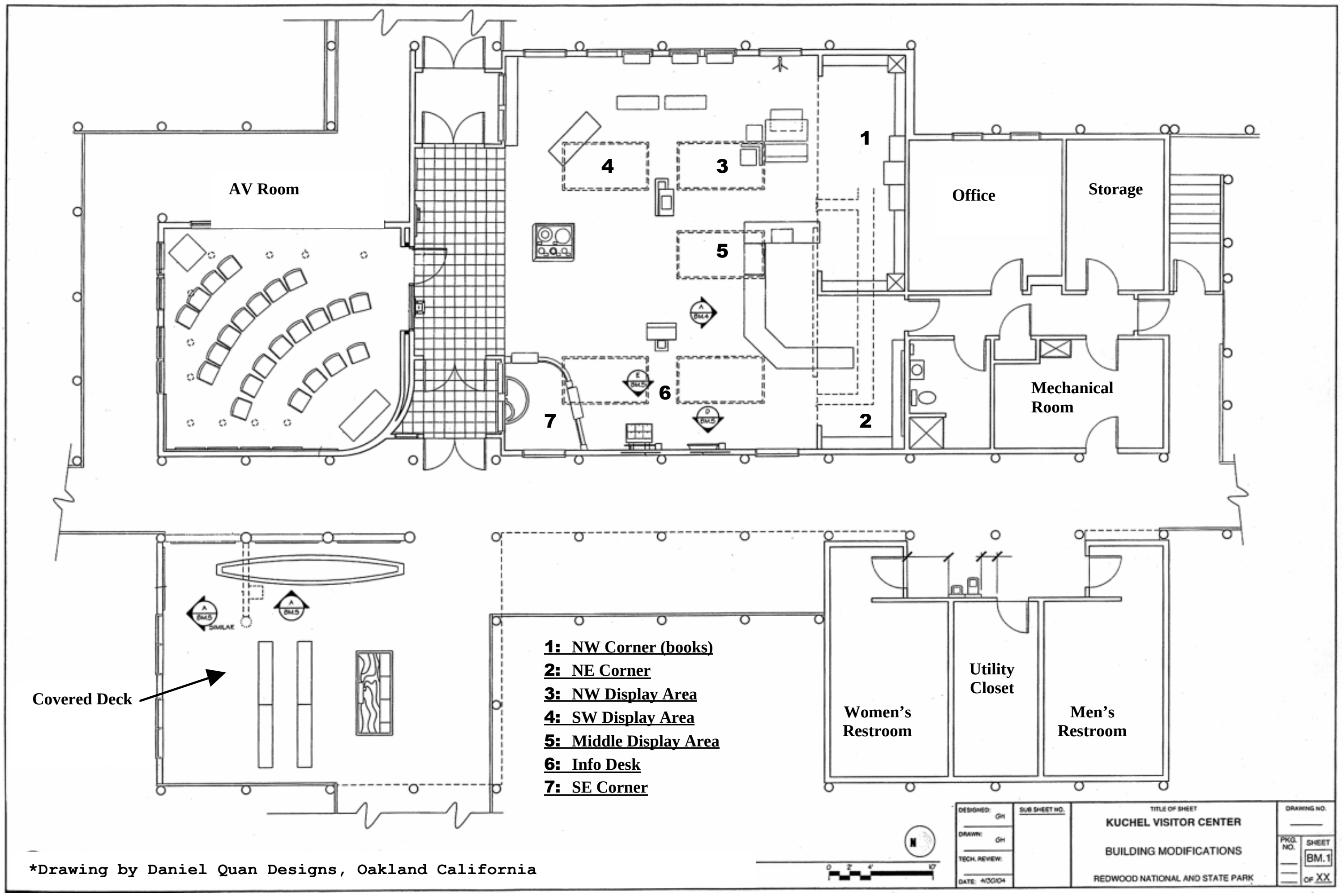
Reflector kit: retrofit equipment that decreases the power consumption of a fluorescent tube fixture without decreasing the amount of light that reaches the work or display surface. Reflector kits include the reflector and the hardware necessary to reconfigure the lamp placement within the fixture. A typical reflector kit upgrade involves removing four 4-ft T12 tubes from a 4’ x 2’ fixture and installing two T8 tubes with the reflector. The final step in the upgrade is to replace the magnetic ballast with an electronic equivalent. Most fluorescent tube fixtures can be upgraded using reflector kits, including those containing U-shaped T12 lamps.

T8 lamp: See Fluorescent tube

T12 lamp: See Fluorescent tube

Time-of-use (TOU): utility electricity rate schedule that varies by season, day of the week, holiday, and hour. TOU rates were designed to reduce summer cooling loads; therefore, the highest electricity rates occur during the summer afternoons. TOU rates are available for both residents and businesses.

Appendix A: Floor Plan of KVC



Appendix B : Itemized List of Loads

Table B1: Itemized list of all loads included in the energy audit

Audit Results and Recommendations: Kuchel Visitor Center (May-August 2004)

Public area lighting alternatives (Indoor)				Watts		# of Bulbs per fixture		Hours per day		kWh per month		$ per month					
Area	**Action**	**Device Name**	**# of fixtures**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Savings/ mo**	**Equipment Cost**	**Rebate**	**Payback**
Main room	Alt. 1	50W Spot halogen --> 15W CFL	30	50	15	1	1	8.00	8.00	365	110	$57.22	$17.17	$40.05	$1,644.30	$330.00	2.73
	Alt. 2	50W Spot halogen --> 20W CFL	30	50	20	1	1	8.00	8.00	365	146	$57.22	$22.89	$34.33	$1,499.70	$330.00	2.84
	Alt. 3	50W Spot halogen --> 35W Halogen IR	30	50	35	1	1	8.00	8.00	365	256	$57.22	$40.05	$17.17	$269.70	$0.00	1.31
	Chosen Alt.	50W Spot halogen --> 35W Halogen IR	15	50	35	1	1	8.00	8.00	365	201	$57.22	$31.47	$25.75	$884.70	$165.00	2.33
		50W Spot halogen --> 20W CFL	15	50	20	1	1	8.00	8.00								
	No Change	Compact fluorescent (CFL) spot	1	26	26	1	1	8.00	8.00	6	6	$0.99	$0.99	$0.00			
	Replace	150W halogen--> 42W CFL	14	150	42	1	1	8.00	8.00	511	143	$80.11	$22.43	$57.68	$2,900.24	$175.00	3.94
	No Change	Jewelry display lights (Halogens)	1	42	42	1	1	8.00	8.00	10	10	$1.60	$1.60	$0.00			
RW sign	No Change	Fluorescent U-tube (190W Total)	4	20	20	1	1	8.00	8.00	19	19	$3.05	$3.05	$0.00			
	R&R @ failure	13W-->9 W CFL	8	13	9	1	1	8.00	8.00	25	18	$3.97	$2.75	$1.22			
Entrance area	No Change	Compact fluorescent	4	9	9	1	1	8.00	8.00	9	9	$1.37	$1.37	$0.00			
AV room	R&R @ failure	18W-->9 W CFL	2	18	9	1	1	8.00	8.00	9	4	$1.37	$0.69	$0.69			
	No Change	Compact fluorescent	3	9	9	1	1	8.00	8.00	7	7	$1.03	$1.03	$0.00			
	R&R @ failure	13W-->9 W CFL	1	13	9	1	1	8.00	8.00	3	2	$0.50	$0.34	$0.15			
	R&R @ failure	14W-->9 W CFL	2	14	9	1	1	8.00	8.00	7	4	$1.07	$0.69	$0.38			
		Subtotal								972	424	$152	$66	$86	$3,784.94	$340.00	3.34

Employee area lighting alternatives (Indoor)				Watts		No. of Bulbs per fixture		Hours per day		kWh per month		$ per month					
Area	**Action**	**Device Name**	**# of fixtures**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Savings/ mo**	**Equipment Cost**	**Rebate**	**Payback**
Hall	Replace	34W U-Tube-->17Wlinear	1	34	17	2	2	8.00	8.00	17	8	$2.59	$1.30	$1.30	$25.49		1.64
Hall	Replace	40W U-Tube-->17Wlinear	1	40	17	2	2	8.00	8.00	19	8	$3.05	$1.30	$1.75	$25.49		1.21
Electric Room	Replace	2 x T12 --> 1 x T8	3	40	32	1.67	1	6.00	6.00	37	18	$5.72	$2.75	$2.98	$67.80	$18.00	1.39
Office	Alt. 1	**4 x T12 -->2 x T8**	4	40	28	2.5	2	8.50	8.50	103	58	$16.21	$9.08	$7.13	$138.92	$48.00	1.06
Office	Chosen Alt.	**4 x T12 -->2 x T8 w/ sensor**	4	40	28	2.5	2	8.50	2.00	103	14	$16.21	$2.14	$14.08	$240.92	$92.00	0.88
Storage Room	Replace	**2 x T12 -->1 x T8**	2	40	32	2	1	0.50	0.50	2	1	$0.38	$0.15	$0.23	$45.20	$12.00	12.09
Misc.	No Change	Exit Sign: LED (2X2.8W)	4	5.6	5.6	1	1	24.00	24.00	16	16	$2.56	$2.56	$0.00			
		Subtotal								195	65	$31	$10	$20	$404.90	$122.00	1.16
		Indoor Lighting Subtotal								1167	489	$183	$77	$106	4190	462	2.93

Outdoor Lighting Alternative				Watts		No. of Bulbs per fixture		Hours per day		kWh per month		$ per month					
Area	**Action**	**Device Name**	**# of fixtures**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Savings/ mo**	**Equipment Cost**	**Rebate**	**Payback**
Bathroom	Alt. 1	2T8 --> 1 T8	8	32	32	2	1	11.00	11.00	171	86	$26.85	$13.43	$13.43	$56.00		0.35
Bathroom	Chosen Alt.	2T8 --> 1 T8 w/ motion sensor	8	32	32	2	1	11.00	6.00	171	47	$26.85	$7.32	$19.53	$340.00	$44.00	1.26
Bathroom	Alt. 2	2T8 --> 1 T8 w/ both sensors	8	32	32	2	1	11.00	2.50	171	19	$26.85	$3.05	$23.80	$508.00	$51.00	1.60
Janitor Closet	Delamp	2T8 --> 1 T8	2	32	28	2	2	2.00	2.00	8	7	$1.22	$1.07	$0.15	$14.00		7.65
Outdoors	Replace	2 U-tubes-> 2 T-8 2ft linear/astro timer	2	40	17	2	2	11.00	4.00	54	8	$8.39	$1.30	$7.10	$50.98		0.60
	Replace	**2 T-12 -->1 T8 4-foot, Astro timer**	1	40	28	2	1	12.00	4.00	29	3	$4.58	$0.53	$4.04	$22.60	$6.00	0.34
	Add	Main Boardwalk CFL + astro timer	16	13	9	1	1	12.00	4.10	76	18						
	Add	Kiosk: HPS + astro timer	2	50	50	1	1	12.00	4.00	37	12	$63.40	$19.98	$43.42	$650.00	$36.00	1.18
	Add	Parking Lot Lighting: HPS + astro timer	2	400	400	1	1	12.00	4.00	292	97						
	No Change	Porch Light (North end)	1	18	18	1	1	1.00	1.00	1	1	$0.09	$0.09	$0.00			
	Repair	South Ramp: 40W --> 13W CFL + astro timer&sensor	3	40	13	0	1	12.00	4.00	0	5	$0.00	$0.74	-$0.74	$384.00	$33.00	-39.32
	Repair	Steps: 40W --> 13W CFL + astro timer&sensor	8	40	13	0.125	1	12.00	4.10	15	13	$2.29	$2.03	$0.26	$448.00	$88.00	117.38
	No Change	Flag Pole: Recessed Incandescent	0	40		0	0	12.00	4.00	0	0	$0.00	$0.00	$0.00			
	No Change	Ground lighting	3	40		0	0	12.00	4.00	0	0	$0.00	$0.00	$0.00			
		Subtotal								682	211	######	$33.07	$74	$2,077.58	$214.00	2.11

	Indoor Electronics/Office Machines					
	Device Name	**Rated watts**	**No. of items**	**Hours per day**	**kWh per month**	**$ per month**
Main Room	Optimus 320W STAV-3670 Audio/Video Receiver	41	1	8.50	11	$1.66
	Royal Alpha 9170 (Cash Register)	23	1	4.00	3	$0.44
	Optimus SCT High Speed Tape Deck	6.5	1	24.00	5	$0.74
	Audio educational tool	21	1	8.00	5	$0.80
	Phone					
	Subtotal				23	$3.65
TV Room	Mitsubishi HD 1080 (Big Screen TV)	200	1	8.00	49	$7.63
	HD 1080 Receiver					
	VCR					
	Subtotal				49	$7.63
Electronic Room	Coast Guard Repeater radio (icom)	25	1	24.00	18	$2.86
	Coast Guard Doppler (DDF 6000)	10	1	24.00	7	$1.14
	Coast Guard Modem	10	1	24.00	7	$1.14
	Triplite BC400 (UPS)	100	1	24.00	73	$11.44
	APC Back-ups Pro 650 (UPS)	100	1	24.00	73	$11.44
	Refrigerator	22	1	8.00	5	$0.84
	Subtotal				184	$28.88

	Indoor Electronics/Office Machines					
	Device Name	Rated watts	No. of items	Hours per day	kWh per month	$ per month
Office	Astron RS-20A (actual: signal out)	350	1	0.75	8	$1.25
	Motorola Radio Charger(40W rating)	10	1	24.00	7	$1.14
	Desktop Computer (w/monitor)	107.7	1	8.00	26	$4.11
	HP 2100 Laserjet Printer (during printing)	225			0	$0.00
	HP DeskJet 940C Printer (during printing	25			0	$0.00
	Scanner				0	$0.00
	Sharp AR-205 Copier (during printing)	1200	1	0.25	9	$1.43
	Laminator	720	1	0.25	5	$0.86
	Microwave	1500	1	0.35	16	$2.50
	Dust Buster	Represented as phantom load				
	Screwdriver battery charger	Represented as phantom load				
	Mr. Coffee (Small Coffee Maker)	625	1	1.00	19	$2.98
	Cadet Wall Heater	1500	1	2.00	91	$14.30
	Phone (actual)	0.8	1	24.00	1	$0.09
	Clock	2	1	24.00	1	$0.23
	Subtotal				184	$28.90
Office/Storage	Satellite modem(includes fax & comp)	150	1	24.00	110	$17.17
	Fax				0	$0.00
	Computer				0	$0.00
	Cadet Wall Heater	1500	1	1.00	46	$7.15
	Subtotal				155	$24.32
	Indoor Electronics Subtotal				596	93

	Heating System					
Attic	Furnace: Lennox Pulse 21 (fan)	750	1	3.00	68	$10.73
	Subtotal				68	$10.73
	Miscellaneous Indoor Loads					
Electronic Room	Security System	15	1	14.00	6	$1.00
	Transformer: Sylvania		1	24.00	0	$0.00
	Subtotal				6	$1.00
	Miscellaneous Outdoor Loads					
Restroom	Restroom hand dryer(30 sec cycle)	2288	1	0.97	68	$10.59
Outdoors	QB-4 Ultrasonic Bird Repeller	10	1	24.00	7	$1.14
Electronic Room	Sludge pump (Wet Pump #1)	3730	1	0.00	0	$0.00
	Wet Pump #2	3730	1	0.03	4	$0.59
	Subtotal				79	$12.33
	Phantom Loads				34	$5.28
	Total @ 120V				1,479.1	231.8
	Total @ 480V	7460	2	0	4	$0.59
	Grand Total				1513	$237.11

	Phantom Loads		**Hours per day**		**kWh per month**		**$ per month**		
Area	**Device Name**	**Watts**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Savings**
Office	HP 2100 Laserjet Printer	Included with Scanner							
	HP DeskJet 940C Printer	Included with Scanner							
	Scanner	9.3	16.00	8.00	5	2	$0.71	$0.35	$0.35
	Sharp AR-205 Copier (stand-by)	40	23.75	8.00	29	10	$4.53	$1.53	$3.00
	Astron RS-20A (receiving)	25.7	23.25	8.00	18	6	$2.85	$0.98	$1.87
	Microwave	2	23.65	7.65	1	0	$0.23	$0.07	$0.15
	Dust Buster	0.5	24	24.00	0	0	$0.06	$0.06	$0.00
	Screwdriver battery charger	0.2	24	24.00	0	0	$0.02	$0.02	$0.00
	Coffee Maker	0.4	23.00	23.00	0	0	$0.04	$0.04	$0.00
Main Room	Royal Alpha 9170 (Cash Register)	6.5	20.00	20.00	4	4	$0.62	$0.62	$0.00
	Audio educaional tool	21	16.00	16	10	10	$1.60	$1.60	$0.00
AV Room	TV, VCR, HD Reciever	14	16.00	0.00	7	0	$1.07	$0.00	$1.07
	Subtotal				74.8	33.7	$11.73	$5.28	$6.45

Cost per timer	$23.30	http://www.rewci.com/insedaydiprt.html
Cost of timers	$139.80	
Payback on timers (years)	1.81	

Total retrofit cost without labor	
Equipment cost	$6,407.22
Rebates	$676.00
Net cost	$ 5,731.22
Composite payback (years)	2.51

Red Letters	Estimations
	These values were monitored for a period of time
	Actual value from Watt-meter
	Alternatives that were not chosen
	The chosen alternative, which is incorporated into the subtotals and economics

Appendix C: Specification Sheets

Stan Lynch of The Wattstopper™ Inc. can be reached at 1-800-879-8585

P o w e r P a c k s

BZ-100 Dual Voltage Power Pack

Product Overview

Description

The BZ-100 is a full-featured power pack, providing 24 VDC operating voltage to The Watt Stopper's low voltage occupancy sensors. In addition, the BZ enables special hold-ON, hold-OFF and load shed applications when used with lighting control panels or building management systems.

Operation

The BZ consists of a transformer and a high-current relay. The transformer has a primary high voltage input of 120 or 277 VAC. The secondary output, which provides the operating power for Watt Stopper occupancy sensors, is 24 VDC, 150 mA. This 150 mA output is available with the power pack's relay connected. The power packs receive input from occupancy sensors or light level sensors and switch lighting on and off. For example, when an occupancy sensor detects motion, it electrically closes an internal circuit which sends 24 VDC to the power pack. This closes the power pack relay and turns the lights on.

Plenum rated

The BZ is UL 2043 plenum rated with teflon coated low voltage leads and plenum rated plastic. This means that the power packs do not need to be installed in the junction box, but can be installed in the plenum. They are housed in ABS, UL-rated 94V-0 plastic enclosures.

Applications

BZ power packs can control lighting circuits, self-contained air conditioners, pumps, fans, motors, VAV systems, motorized damper controls and setback thermostats. The hold-OFF input can be used to perform load shedding. During a power alert or during peak demand, a signal from a BMS or utility meter triggers the BZ to shed non-critical lighting loads. The hold-OFF function also works with a security system to hold some lights off during a security walk-through. The hold-ON input is ideal for retail and commercial facilities that want to hold certain lighting ON during normal business hours. After-hours, a time clock signals the BZ to no longer hold lights ON, allowing occupancy sensors to resume control.

Features

- Self-contained transformer relay system
- Primary high voltage input of 120 or 277 VAC
- LED indicates status of relay or if there is an overcurrent
- Hold-ON and hold-OFF inputs integrate with lighting control panels, BMS and other building systems
- Hold-OFF input can provide load shedding function
- Hold-ON input enables method to override occupancy sensor and hold lighting ON
- Zero crossing circuitry for reliability and increased product life
- UL 2043 plenum rated plastic
- Can be installed directly in plenum for cost-effective installation
- 1/2 inch snap-in nipple attaches to standard electrical enclosures through 1/2 inch knockouts

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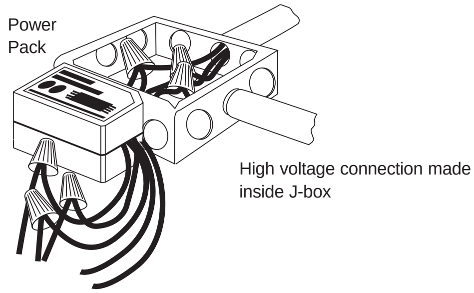
BZ Technical Information

Specifications

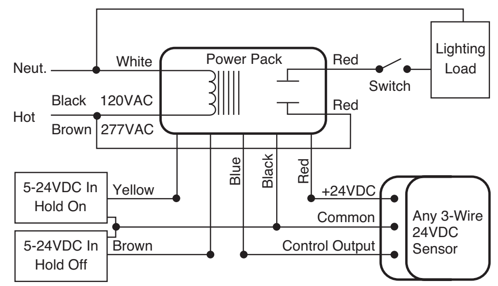
- 120/277 VAC voltage input
- Secondary voltage of 24 VDC
- Secondary output of 150 mA (with relay connected)
- Low voltage leads are rated for 300 volts
- Hold-ON and hold-OFF inputs for integration with lighting control panels, BMS, and other building systems (5-24 VDC)
- UL-rated 94V-0 plastic enclosure; units are grey
- UL 2043 plenum rated plastic and wiring
- Dimensions: 1.6" x 2.75" x 1.6" (41mm x 70mm x 41mm) with a 1/2 inch snap-in nipple
- UL and CUL listed; Five year warranty

Wiring & Installation

Installation Diagram

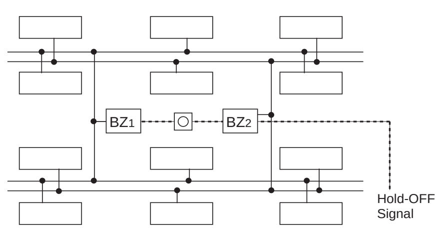


Wiring with Occupancy Sensor

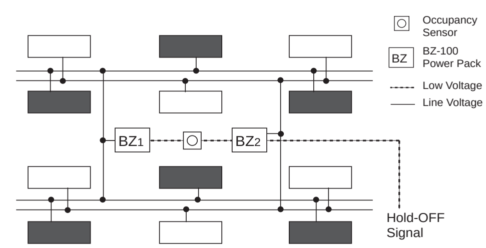


Hold-OFF & Hold-ON Applications

Load Shed (Hold-OFF) Application for Open Office Spaces

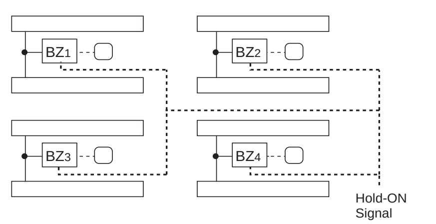


The occupancy sensor, connected to each BZ, keeps all lights on when the space is occupied.

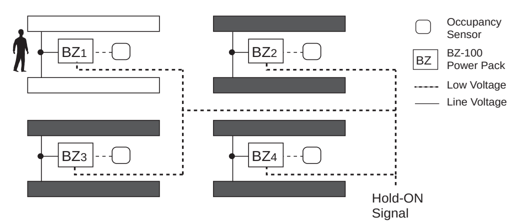


When the load shed command is given (by utility meter, BMS, etc.), lights connected to the BZ2 are held off. Remaining lights, (BZ1) are controlled by occupancy sensor.

Hold-ON Retail Application



During store hours, a signal from a time clock to the BZ holds lights on, regardless of occupancy.



After hours, the clock schedule cancels the hold on and occupancy sensor control takes over.

Ordering Information

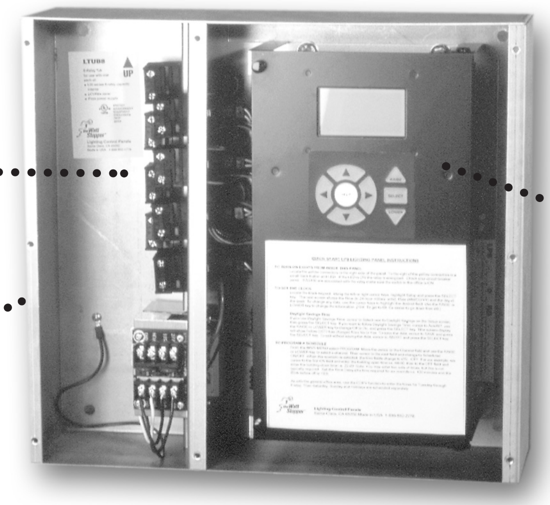
Catalog No.	Description/Type	Input Voltage	Load Ratings Ballast (A)	Incan (A)	Motor (HP)	Output
BZ-100	Power Pack	120/277 VAC; 60 Hz	20	20	1*	24 VDC; 150 mA**

* 1 Hp rated at 120/250 VAC. ** Output is 150 mA with relay connected.

Installation Notes

1. All Watt Stopper power packs should be installed in accordance with state, local, and national electrical codes and requirements.
2. Power packs are designed to attach to existing or new electrical enclosures with 1/2 inch knockouts. (Check electrical codes in your area.)
3. Most applications require UL listed, 18-22 AWG, 3-conductor, Class 2 cable for low voltage wiring. For plenum return ceilings use UL listed plenum-approved cables.

LP8 Lighting Control Peanut Panel



Product Overview

Description

The Watt Stopper LP8 Peanut panel provides simple, yet effective control for exterior and interior lighting in small applications. The panel combines relays with a system time clock in a pre-assembled, easy-to-install package.

Operation

The LP8 consist of relays, a system time clock, an interior housing panel intelligence, power supply and a tub enclosure and cover. The LP8 can control up to 8 channels or zones of lighting. The relays respond to control signals from the system time clock (or other signalling devices such as low voltage switches and occupancy sensors), to turn lighting on and off. When controlling exterior lighting, users can utilize the clock for astronomic control (based on sunrise and sunset) or add the optional photocell for exterior light level control. For interior lighting control, users can implement AS Automatic Control Switches or low voltage switches to automate after hours lighting shut-off while providing manual override control.

System Time Clock

The system clock provides automation for the LP8 panel. With an easy to navigate keypad, a backlit LED and user-friendly help menus, set-up and programming is simple. Included are the following pre-programmed control scenarios: scheduled on/off, manual on/scheduled off, manual on/sweep off with automatic switch, astronomic or photocell on/off, and astronomic or photocell with schedule on/off. The clock features 7 day format with holiday scheduling.

Applications

The LP8 panels are ideal for exterior applications such as parking lot lighting, site night lighting, and sign lighting. Their use promotes energy savings by turning off outside lighting when not needed, as well as providing a secure illuminated environment when occupants might be present. For interior lighting, LP8 panels integrate with a wide range of control devices such as switches and occupancy sensors to create a flexible lighting shut-off strategy.

Features

- Fully assembled with no component ordering necessary; greatly simplifies design and installation
- System clock: 8 channels, pre-programmed control scenarios, 7 day scheduling with holiday, astronomic control, automatic daylight savings, retains time during power outage, non-volatile program memory
- Override push buttons for manual override of each relay
- LED for visual indication of relay status
- 8 universal switch inputs for low voltage switches, occupancy sensors, photocells or other devices to directly control each relay
- For user flexibility, accepts most types of switch inputs
- Accessory power of 800mA VDC/AC for powering external devices
- Separately accessed high voltage section for user protection

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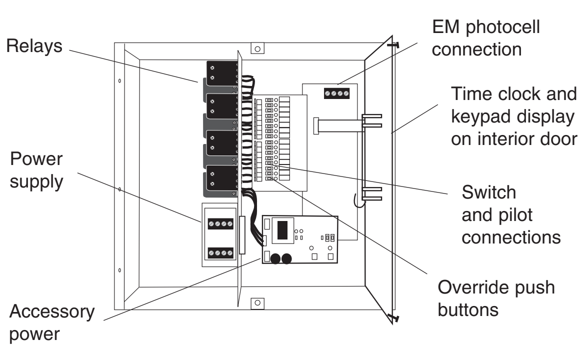
LP8 Technical Information

Specifications

- Multiple power supplies to choose from: 115/277 VAC, 220-240 VAC, 115/347 VAC; 50/60 Hz
- Relay Ratings
  @120 VAC 50/60 Hz 20A tungsten or ballast
  @347 VAC 50/60 Hz 20A ballast
  @250 VAC, single phase 1 hp
- Accessory power 800 mA at 24 VDC/VAC/VACR
- 8 universal switch inputs; compatible with 3 wire momentary or maintained, 2 wire momentary or maintained, or 24 VDC input
- Ambient temperature 32 to 139°F; 5 to 95% RH non-condensing
- Dimensions: 16.84” x 15.36” x 4.5” (maximum dimensions of tub with cover)
- UL and CUL listed, one year warranty

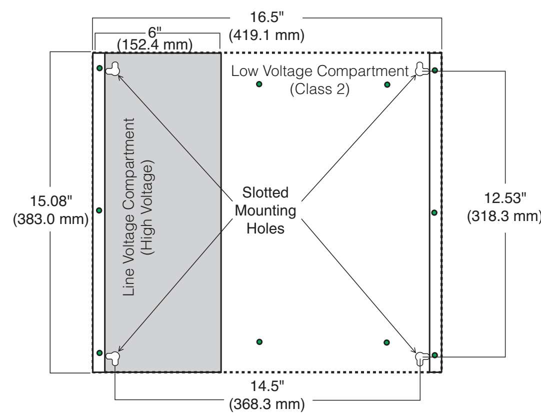
Wiring & Installation

LP8 Panel Layout

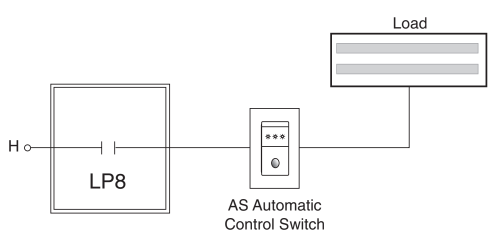


Shown with interior door open

Dimensions

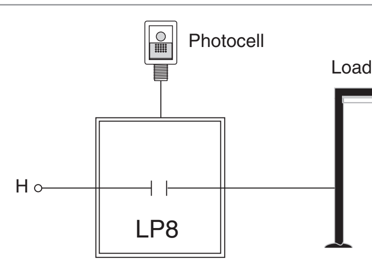


Indoor Application



Indoors, users can add Automatic Control Switches (AS-100) to achieve manual and override control.

Exterior Application



The system clock and photocell enable astronomic or photocell-based exterior lighting control.

Ordering Information

Catalog No.	Description
LP8S-8-115	8 relay lighting control panel; 115/277 VAC
LP8S-8-347	8 relay lighting control panel; 115/347 VAC
LP8S-4-115	4 relay lighting control panel; 115/277 VAC
LP8S-4–347	4 relay lighting control panel; 115/347 VAC
Optional system enhancements:	
EM-24A2	Low voltage exterior photocell
AS-100	Automatic control switch; 120/277 VAC; 50/60 Hz

LP8 S - 8 - 115

Mechanical Options
S
S = surface mount cover (default)
F = flush mount cover
S4 = surface NEMA 4 tub enclosure

Relay Options
8
8 = 8 relays (default)
4 = 4 relays

Voltage Options
115
115 = P115/277 power supply (default)
240 = P240 power supply
277 = P115/277 power supply (default)
347 = P115/347 power supply

WPIR Passive Infrared Occupancy Sensor

Product Overview

Description

The Watt Stopper WPIR is a versatile ceiling mount passive infrared occupancy sensor that turns lights on and off based on occupancy. The WPIR controls lighting in a wide variety of applications, but is especially adept at controlling small spaces with well defined coverage.

Operation

When the WPIR sensor detects a change in the infrared heat radiated within the controlled area, lighting (or HVAC) systems are switched ON through a Watt Stopper power pack. The 24 VDC sensor controls the power pack through low voltage wiring. When occupants leave the area, lighting is switched OFF after the user-adjustable time delay elapses.

Fresnel Lens and Coverage

The WPIR is equipped with a multi-element Fresnel lens that allows the sensor to efficiently collect infrared energy and provides optical gain over a defined field of view. The profile of each groove facet is determined by computer simulation to produce the sharpest images possible from a distant object. The use of a 30 segment lens allows overlapping coverage within the defined field of view. The coverage is partially determined by the view available to the sensor. Mounted to a wall, the WPIR will produce a completely different viewing pattern. Zone 4 and 5 (see diagram on back) are then capable of sensing up to 45 feet.

Applications

The WPIR can effectively cover small offices, utility areas, or computer rooms. Additional applications include racquetball courts, garage areas, library aisle ways, and storage rooms.

Features

- ASIC technology enhances reliability; provides immunity to RFI & EMI
- Uses passive infrared (PIR) technology to reliably control lighting in a variety of applications
- User-adjustable time delay of 30 seconds to 30 minutes
- A "daylight" filter ensures that the device will be insensitive to short-wavelength infrared waves such as those emitted by the sun
- A multi-element Fresnel lens allows the sensor to efficiently collect infrared energy and provides optical gain over a defined field of view
- Alternate viewing patterns depending on mounting choice
- Optional ON override through logic key/ON bypass
- LED indicates occupancy detection

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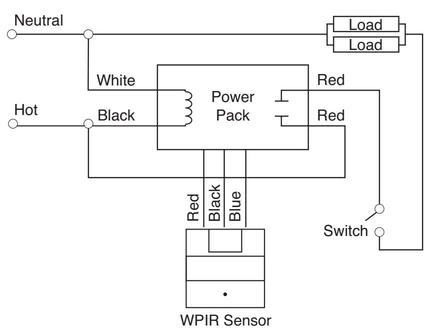
WPIR Technical Information

Specifications

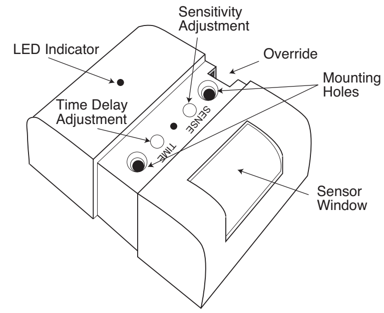
- Dual-element, temperature compensated pyroelectric sensor
- Time delay adjustment from 30 seconds to 30 minutes
- Poly IR4 lens, optical filter material
- Control output – 100mA maximum
- Units per power pack: up to 8 (B); up to 10 (BZ)
- Dimensions: 2.5" x 2.5" x 1.14" (64mm x 64mm x 29mm) (W x L x D)
- UL and CUL listed; five year warranty

Wiring & Controls

Wiring Diagram



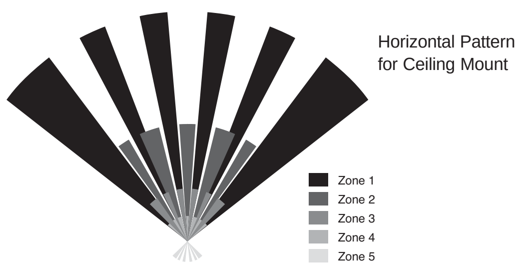
Product Controls

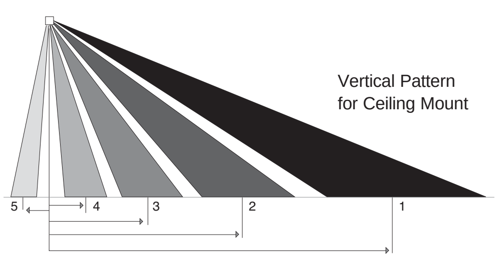


Factory settings: 30 min. time delay, maximum sensitivity

Coverage & Placement

Coverage



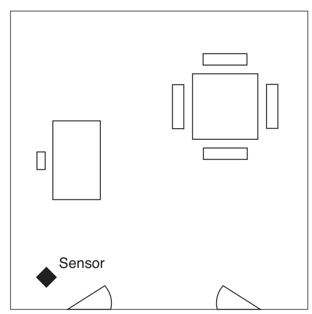


Detection Zones

Ceiling Height	Zone 5	Zone 4	Zone 3	Zone 2	Zone 1
8'	-1	1	4	8	15
10'	-1.5	1.5	5	10	19
12'	-2	2	6	12	23
15'	-2.5	2.5	8	15	29
20'	-3	3	10	18	36
25'	-4	4	12	23	45
*8'	50	40	25	15	5

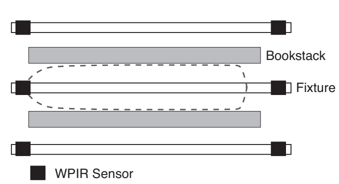
* Wall mounted Horizontally

Typical Office Placement



For an enclosed office, the WPIR should be placed in the corner of the room so that it will detect occupants as they enter the room. For the aisle way between bookstacks, the WPIR should be placed at the end of each bookstack to detect occupancy upon entrance to the aisle way from either direction. For longer bookstacks, 2 or more WPIRs can be used.

Aisleway Library Bookstack Placement



Ordering Information

Catalog No.	Description	Voltage	Current	Coverage
WPIR	Passive infrared ceiling sensor	24 VDC	14 mA	300 sq ft

All units are white and use Watt Stopper power packs.

WT Ultrasonic Occupancy Sensor

Product Overview

Description

The Watt Stopper WT sensors are advanced ultrasonic occupancy sensors with a 32 KHz frequency. The sensors are available in several models to control lighting in a wide variety of applications.

Operation

The 24 VDC ultrasonic sensors utilize advanced, omni-directional, Doppler technology. When an ultrasonic sensor detects movement in a controlled area, it switches lighting on through a Watt Stopper power or auxiliary pack. The sensor controls the power pack through low voltage wiring. Once the area is vacated and the time delay has elapsed, lighting systems automatically switch off.

Advanced Signal Processing

The sensors use The Watt Stopper's Advanced Signal Processing (ASP). ASP filters out moving air noise by checking for small cyclical changes found in turbulent air. This helps to eliminate false ON problems found in sensors without ASP.

Applications

WT sensors offer excellent control of lighting for many areas of a building. The sensors are designed to effectively control offices, restrooms, storage areas, and open office areas and can control large partitioned office spaces when configured in zone patterns. The WT can be used with Watt Stopper AS-100 Automatic Control Switches to achieve manual-on/auto-off function when auto-on is not desired. The WT sensors' superior performance and ease of installation will provide fast paybacks and many years of energy savings.

Features

- Advanced Signal Processing Circuitry helps to eliminate false ONs
- Utilizes advanced, omni-directional, Doppler technology for reliable occupancy detection
- Angled transmitter and receiver pairs help optimize sensitivity while eliminating unwanted detection from ceiling air movement
- Coverage ranges from 600 to 2200 square feet and 90 linear feet (for hallways)
- Isolated relay can interface with HVAC, EMS, or with an additional lighting load
- DIP switch adjustable time delay and sensitivity
- LED indicates occupancy detection

the Watt Stopper®
www.wattstopper.com
800.879.8585

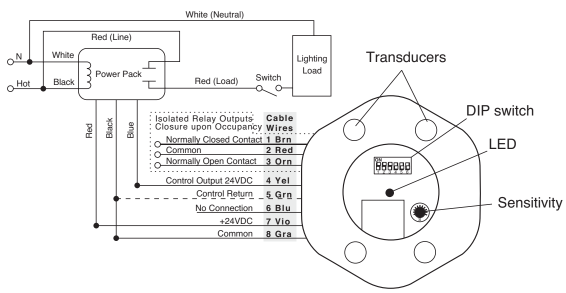
WT Technical Information

Specifications

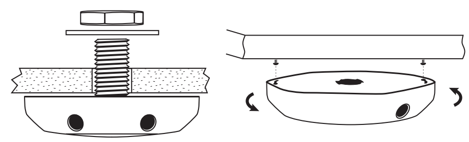
- Solid state, crystal-controlled (32.768 kHz ± 0.002%)
- Omni-directional transmission (360° coverage)
- Temperature and humidity resistant 32 kHz receivers
- Digital DIP switch time delay (15 seconds to 30 minutes)
- Isolated relay with N/O and N/C outputs; rated for 1 Amp @ 30 VDC/VAC
- Units per power pack: WT-605: up to 4 (B), up to 5 (BZ). WT-600: up to 3 (B), up to 4 (BZ). WT-1105, WT-2205, WT-2255: up to 3 (B), up to 5 (BZ). WT-1100, WT-2200, WT-2250: up to 2 (B), up to 3 (BZ).
- Dimensions: 4.8" diameter x 1.5" (122mm x 38mm)
- UL and CUL listed; Five year warranty

Wiring, Installation & Placement

Wiring & Controls

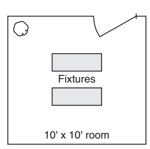


Installation

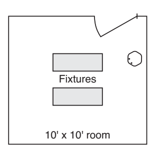


Attached to a vibration-free surface. Mount the sensors with the receivers facing the area of coverage. Note: Place 4' away from supply ducts, 6' from horizontal discharge ducts, and 6" from power packs.

Enclosed Office Placement



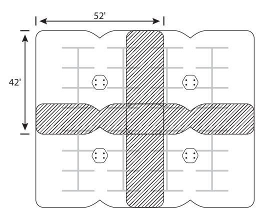
Correct



Incorrect

For enclosed spaces, place sensors as in Figure A. Sensors placed as in Figure B may see out the door and cause false triggers.

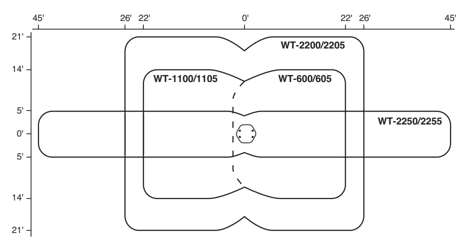
Open Office Placement



For open office spaces, the WT-2200 is typically used because of its 360° coverage and capability to bounce ultrasound off of partitions, walls, floors and other reflecting objects. A typical layout place the sensors so they control the area in zones that overlap.

Coverage & Settings

Coverage



Coverages shown represent half-step walking motion. Actual coverages can vary for each application depending on the shape and use of space and the obstacles present.

DIP Switch Settings

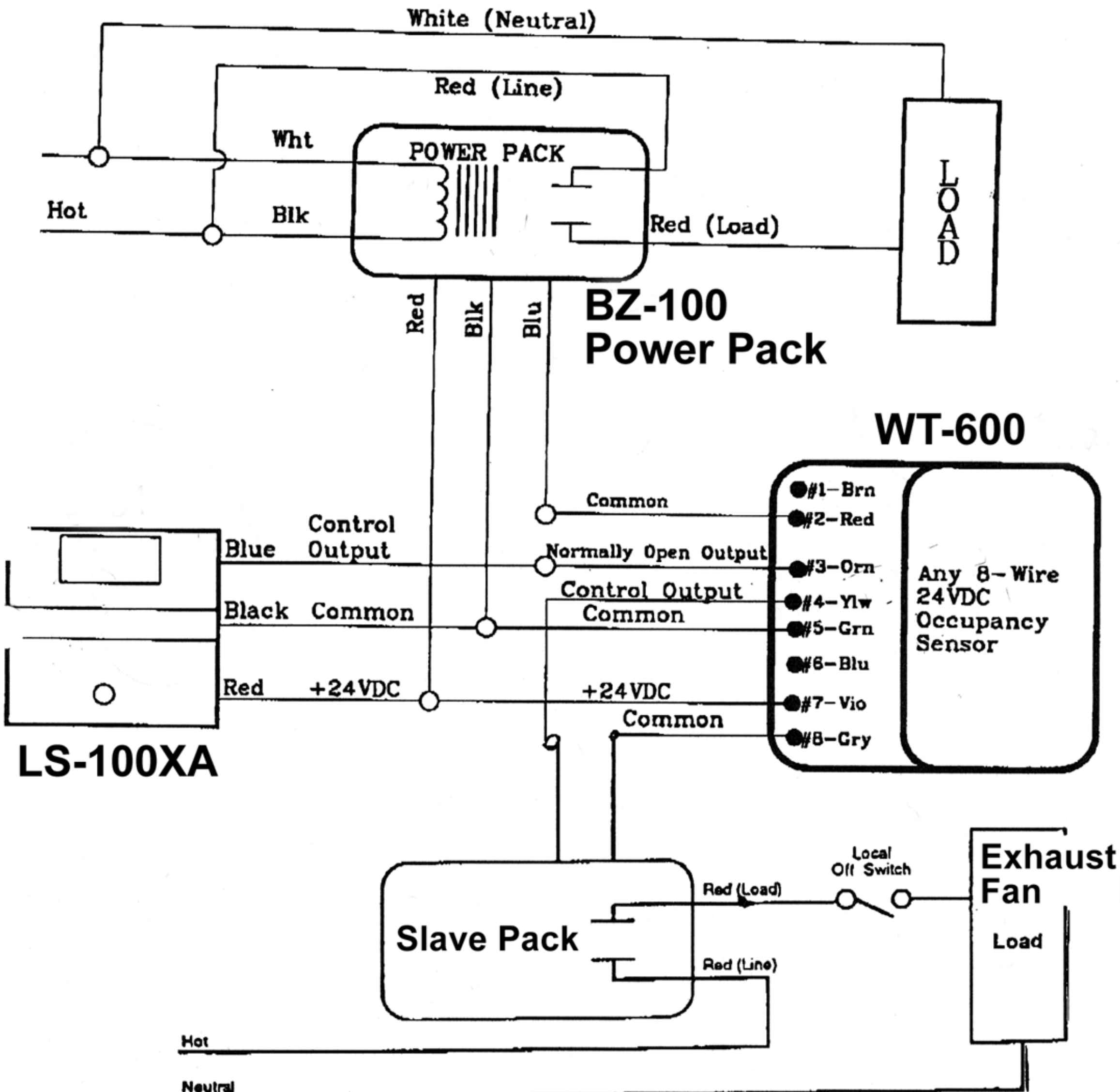
♦ = factory preset
●=ON –=OFF

Time Delay	DIP Switch # 1	2	3	4	5	6	
15 seconds	●	–	–	–	–	–	
2 minutes	–	●	–	–	–	–	
4 minutes	–	–	●	–	–	–	
6 minutes	–	●	●	–	–	–	
8 minutes	–	–	–	●	–	–	
10 minutes	–	●	–	●	–	–	
12 minutes	–	–	●	●	–	–	
14 minutes	–	●	●	●	–	–	
16 minutes	–	–	–	–	●	–	♦
18 minutes	–	●	–	–	●	–	
20 minutes	–	–	●	–	●	–	
22 minutes	–	●	●	–	●	–	
24 minutes	–	–	–	●	●	–	
26 minutes	–	●	–	●	●	–	
28 minutes	–	–	●	●	●	–	
30 minutes	–	●	●	●	●	–	
Output Disable	–	–	–	–	–	–	
Override						●	

Ordering Information

Catalog No.	Description	Voltage	Current	Coverage
WT-605	Ultrasonic ceiling sensor	24 VDC	27 mA	600 sq ft; 360°
WT-600	Ultrasonic ceiling sensor w/ isolated relay	24 VDC	37 mA	600 sq ft; 360°
WT-1105	Ultrasonic ceiling sensor	24 VDC	30 mA	1100 sq ft; 360°
WT-1100	Ultrasonic ceiling sensor w/ isolated relay	24 VDC	40 mA	1100 sq ft; 360°
WT-2205	Ultrasonic ceiling sensor	24 VDC	30 mA	2200 sq ft; 360°
WT-2200	Ultrasonic ceiling sensor w/ isolated relay	24 VDC	40 mA	2200 sq ft; 360°
WT-2255	Ultrasonic hallway sensor	24 VDC	30 mA	90 linear ft; 360°
WT-2250	Ultrasonic hallway sensor w/ isolated relay	24 VDC	40 mA	90 linear ft; 360°

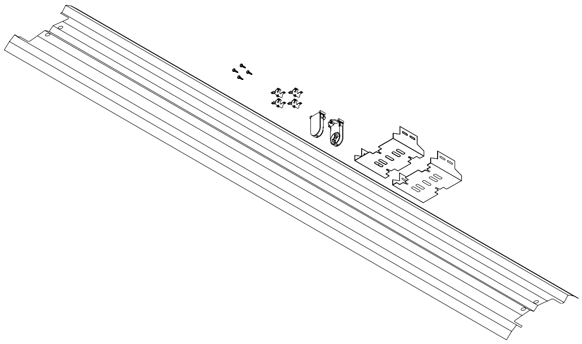
All units are white and use Watt Stopper power packs. Current consumption can be slightly higher when only one sensor per power pack is used.

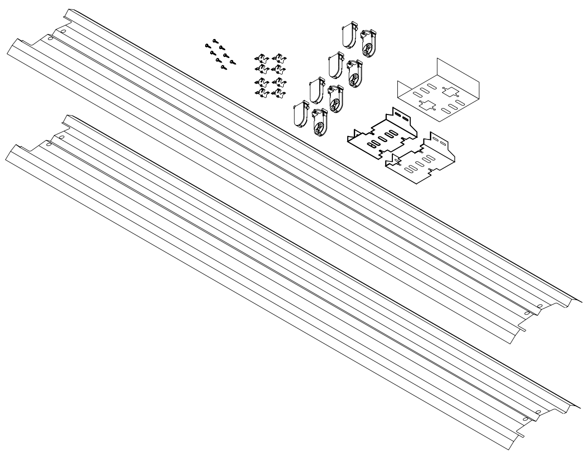


On Low Voltage Wiring
Red is 24VDC
Black is Common
Blue is 24VDC Control Output

THE WATT STOPPER 800-879-8585			
Title: Custom			
Scale	Drawing#	Date	Rev.
NONE	Custom	10/7/98	

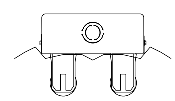
SKSS Series Reflector Kit





Application

The SKSS reflector kits are designed to convert standard two lamp T-12 strip luminaires to highly efficient one or two lamp T-8 luminaires. The SKSS configuration provides optimum performance with heights between 8 feet and 10 feet. Conversion maximizes fixture efficiency and provides uniform light distribution. The reflector can be easily removed for maintenance without tools. Kit contains reflector, mounting brackets, fasteners and shunted sockets.



Construction

Reflectors are aluminum with a wide range of finish options to meet a full array of lighting needs. Brackets are constructed from die formed code gauge steel. All painted metal parts are pre-treated with a phosphate bonding process and painted with electrostatically applied high temperature baked white enamel for superior quality and durability. Material form, fit and thickness meet UL 1598 standards. Components are Underwriters Laboratories Inc. classified for use in retrofit applications. Computer assisted design results in maximum light output uniform light distribution, rigid strength and ballast access without the use of tools.

Installation

Installation of the retrofit kit is simple and easy. The process involves removing the existing lamps and sockets and then installing the new brackets and sockets. The reflector is then easily attached to the brackets with quarter turn fasteners. The reflector will serve as the ballast cover. Universal end brackets as shown can be used with either one or two lamp conversions.

Features

Highly efficient fixture – OVER 96% - greatest light output per watt input

Lower maintenance costs because of fewer lamps and ballast

Increased lamp and ballast life with lower operating temperature

25 year efficiency longevity with anodized aluminum reflectors

Computer designed reflector creates maximum light output and even light distribution for heights of 12 to 20 feet

25 year warranty on reflector

314 Highway 17 North
Palatka, FL 32177
800.537.1629
Fax: 386.328.1580
www.reflect-a-light.com

u.s.energysciences,inc.
reflecting technology

Photometric Data

All photometry reports and IES files are provided by independent testing laboratories and are available either as a download from U.S. Energy Sciences web site http://www.reflect-a-light.com/ies.asp or from the CD-ROM Catalog.

Catalog Number: SKSS4/SA/4-1BE or SKSS4/SA/8-2BE
Luminaire: Formed steel housing, formed aluminum specular reflector.
Lamps: 4-1BE - One F32T8/841 rated 2900 lumens each.
8-2BE - Two F32T8/841 rated 2900 lumens each.
Ballast: Electronic QT1X32/120IS or QT2X32/120IS

Coefficients of Utilization - Zonal Cavity Method
Effective Floor Cavity Reflectance 0.20

RC	80%				70%				50%		
RW	70%	50%	30%	10%	70%	50%	30%	10%	50%	30%	10%
0	111	111	111	111	107	107	107	107	101	101	101
1	99	94	89	85	96	91	86	83	85	82	79
2	89	81	74	68	86	78	72	66	74	68	64
3	81	71	62	56	78	69	61	55	65	58	53
4	74	62	53	47	71	60	52	46	57	50	44
5	67	54	45	39	65	53	44	38	50	43	37
6	61	48	39	33	59	47	38	32	44	37	31
7	56	43	34	28	54	42	33	27	40	32	27
8	52	38	29	24	50	67	29	23	35	28	23
9	47	34	26	20	46	33	25	20	31	24	19
10	44	31	23	17	42	30	22	17	28	22	17

	0-DEG	90-DEG
Plane:	0-DEG	90-DEG
Spacing Criteria:	1.2	1.7

Luminaire Efficiency: 94.2%

Photometrics Certified by: Luminaire Testing Laboratory
SKSS4/SA/4-1BE Report No. 1656A
SKSS4/SA/8-2BE Report No. 1656B

Catalog Number: SKSS4/SA/4-2BE or SKSS4/SA/8-4BE
Luminaire: Formed steel housing, formed aluminum specular reflector.
Lamps: 4-2BE - Two F32T8/841 rated 2900 lumens each.
8-4BE - Four F32T8/841 rated 2900 lumens each
Ballast: Electronic QT2X32/120IS or QT4X32/120IS

Coefficients of Utilization - Zonal Cavity Method
Effective Floor Cavity Reflectance 0.20

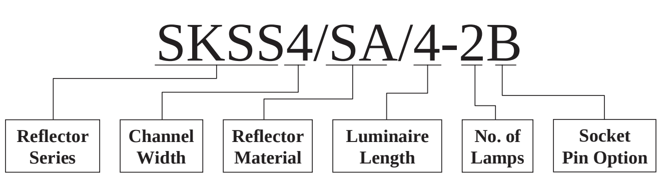
RC	80%				70%				50%		
RW	70%	50%	30%	10%	70%	50%	30%	10%	50%	30%	10%
0	103	103	103	103	101	101	101	101	96	96	96
1	93	88	84	80	90	86	82	79	82	79	76
2	84	76	69	64	81	74	68	63	71	66	62
3	76	66	59	53	74	65	58	52	62	56	51
4	70	59	50	44	68	57	50	44	55	49	43
5	63	51	43	37	61	50	43	37	48	42	36
6	58	46	38	32	56	45	37	31	43	36	31
7	53	41	33	27	52	40	33	27	39	32	27
8	49	37	29	23	48	36	28	23	35	28	23
9	45	33	25	20	44	32	25	20	31	24	20
10	42	30	22	17	41	29	22	17	28	22	17

	0-DEG	90-DEG
Plane:	0-DEG	90-DEG
Spacing Criteria:	1.2	1.7

Luminaire Efficiency: 86.8%

Photometrics Certified by: Luminaire Testing Laboratory
SKSS4/SA/4-2BE Report No. 1657A
SKSS4/SA/8-4BE Report No. 1657B

Ordering Guide



Reflector Series
SKSS = Reflector Kit w/ sockets
KSS = Reflector Kit w/o sockets

Channel Width
4 = 4.25 inch width
5 = 5 inch width
(*Specify if other width*)

Reflector Material
SA = Specular Aluminum
EA = Enhanced Aluminum
WP = White Paint

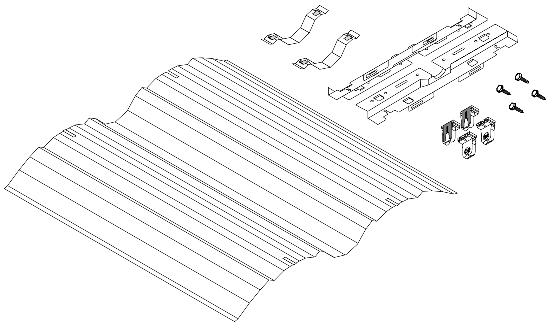
Luminaire Length
4 = 4 feet or 48 Inches
6 = 6 feet or 72 Inches
8 = 8 feet or 96 Inches

Number of Lamps
1 = One Lamp *(4 ft. Only)*
2 = Two Lamps *(4 ft. & 8 ft.)*
4 = Four Lamps *(8 ft. Only)*

Socket Pin Option
B = T-8 Bi-pin Socket
C = T-5 Bi-pin Socket
S = Slimline Socket

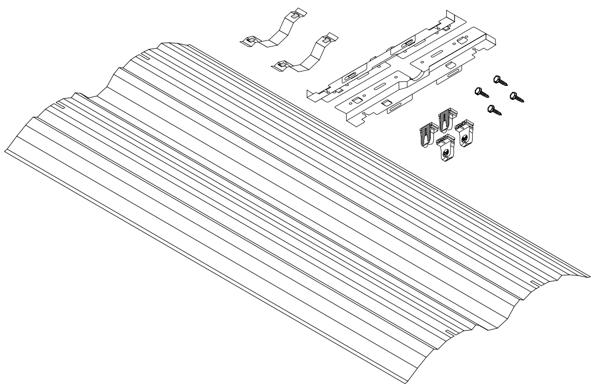
u.s.energysciences,inc.
reflecting technology
314 Highway 17 North
Palatka, FL 32177
Telephone: 386.329.4062
Fax: 386.328.1580
www.reflect-a-light.com

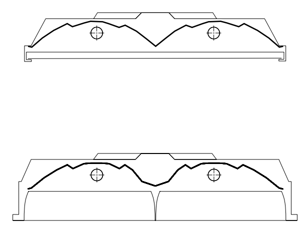
SKLF1 Series Reflector Kit



Application

Full coverage reflectors for 2x4 and 2x2 luminaires being converted to a 2-lamp configuration. Maximizes fixture efficiency, providing uniform light distribution. The reflector becomes the new ballast cover and easily snaps in and out for ballast maintenance. Kit contains reflector, mounting brackets, wire guards, fasteners and shunted sockets.





Construction

Reflectors are aluminum with a wide range of finish options to meet a full array of lighting needs. Brackets are constructed from die formed code gauge steel, embossed for strength and uniformity. All painted metal parts are pre-treated with a phosphate bonding process and painted with electrostatically applied high temperature baked white enamel for superior quality and durability. Material form, fit and thickness meet or exceed UL 1598 standards. Components are Underwriters Laboratories Inc. classified for use in retrofit applications. Computer assisted design results in maximum light output, uniform light distribution, rigid strength and ballast access without the use of tools.

Installation

Installation of the retrofit kit is simple and easy. The process involves removing the existing lamps, sockets and ballast cover then installing the new brackets and sockets. Wireway guards and reflector is then easily snapped onto brackets.

Features

Increases fixture efficiency to over 80%

Maintenance costs are reduced because fewer lamps and ballast

25 year warranty on anodized aluminum reflectors.

Computer designed for maximum light output

Kit includes all parts needed for labor saving conversion

314 Highway 17 North
Palatka, FL 32177
800.537.1629
Fax: 386.328.1580
www.reflect-a-light.com

u.s.energysciences,inc.
reflecting technology

SKLF1 Series Reflector Kit

Photometric Data

All photometry reports and IES files are provided by independent testing laboratories and are available either as a download from U.S. Energy Sciences web site http://www.reflect-a-light.com/ies.asp or from the CD-ROM Catalog.

Catalog Number: SKLF1T-A/SA/4
Luminaire: Formed steel housing, formed aluminum specular reflector, .125 clear prismatic lens.
Lamps: Two F32T8/CW rated 2900 lumens each.
Ballast: Electronic QT2X32/277IS

Coefficients of Utilization - Zonal Cavity Method Effective Floor Cavity Reflectance 0.20											
RC	80%				70%				50%		
RW	70%	50%	30%	10%	70%	50%	30%	10%	50%	30%	10%
0	96	96	96	96	94	94	94	94	89	89	89
1	89	86	84	81	87	85	82	80	81	79	77
2	83	78	73	70	81	76	72	69	74	70	67
3	77	70	65	61	75	69	64	60	67	63	59
4	72	64	58	53	70	63	57	53	61	56	52
5	66	58	51	47	65	57	51	47	55	50	46
6	62	53	46	42	60	52	46	42	50	45	41
7	58	48	42	37	56	47	41	37	46	41	37
8	53	43	37	33	52	43	37	33	42	36	33
9	49	39	33	29	48	39	33	29	38	33	29
10	46	36	30	26	45	36	30	26	35	30	26

Plane:	0-DEG	90-DEG
Spacing Criteria:	1.1	0.9

Luminaire Efficiency: 80.5%

Photometrics Certified by: Luminaire Testing Laboratory
Report No. 1311

Catalog Number: SKLF1T-A/WP/4
Luminaire: Formed steel housing, formed aluminum specular reflector, .125 clear prismatic lens.
Lamps: Two F32T8/TL741 rated 2900 lumens each.
Ballast: Electronic QT2X32/277IS

Coefficients of Utilization - Zonal Cavity Method Effective Floor Cavity Reflectance 0.20											
RC	80%				70%				50%		
RW	70%	50%	30%	10%	70%	50%	30%	10%	50%	30%	10%
0	97	97	97	97	95	95	95	95	90	90	90
1	90	87	84	81	88	85	82	80	81	79	77
2	83	77	73	69	81	76	72	68	73	70	66
3	77	70	64	59	75	63	63	59	66	61	58
4	71	63	56	51	69	62	56	51	60	54	50
5	65	56	49	45	64	55	49	44	54	48	44
6	61	51	44	39	59	50	44	39	49	43	39
7	56	46	39	34	55	45	39	34	44	38	34
8	52	41	35	30	50	41	34	30	40	34	30
9	48	37	31	26	46	37	30	26	36	30	26
10	44	34	27	23	43	33	27	23	32	27	23

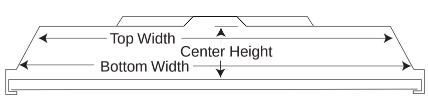
Plane:	0-DEG	90-DEG
Spacing Criteria:	1.2	1.3

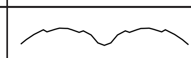
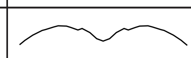
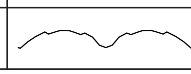
Luminaire Efficiency: 81.4%

Photometrics Certified by: Luminaire Testing Laboratory
Report No. 2825

Dimensional Guide

SKLF1T Series is available in many different profiles. Profile is determined by luminaire's internal body dimensions. While the C style reflector will fit most applications, it is recommended that dimension sheets be completed and faxed to the factory for correct sizing. In lieu of this procedure, reflector dimensions are available in the table to the immediate right.



Profile & Dimensions				
Part Number	Profile	Top Width	Bottom Width	Center Height
SKLF1-A		14.000	21.125	1.875
SKLF1-C		14.000	19.500	1.875
SKLF1-D		12.500	20.500	1.875
SKLF1-H		14.000	20.500	1.875

Ordering Guide

SKLF1T-A/SA/4

Reflector Series | Reflector Style | Reflector Material | Luminaire Length

Reflector Series
See dimension specifications for correct application and reflector nomenclature

SKLF1T = Socketed Kit includes jumpered sockets, one piece reflector, brackets and self-tapping screws.

KLF1T = Non-socketed kit includes one piece reflector, brackets and self-tapping screws.

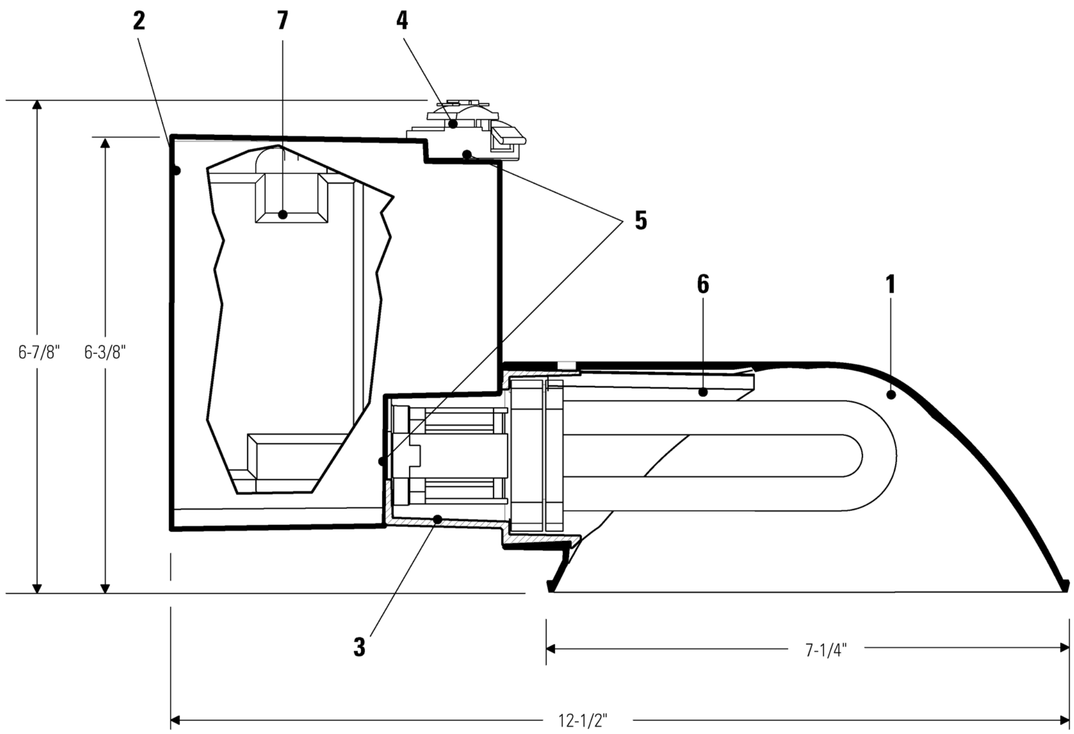
RLF1 = One piece reflector only.

Kit/Reflector Style
SKLF1T-A or KLF1T-A or RLF1-A
SKLF1T-C or KLF1T-C or RLF1-C
SKLF1T-D or KLF1T-D or RLF1-D
SKLF1T-H or KLF1T-H or RLF1-H

Reflector Material
SA = Specular Aluminum
EA = Enhanced Aluminum
WP = White Paint

Luminaire Length
2 = 2 ft.
4 = 4 ft.

u.s.energysciences,inc.
reflecting technology
314 Highway 17 North
Palatka, FL 32177
Telephone: 386.329.4062
Fax: 386.328.1580
www.reflect-a-light.com



Ordering Information

Catalog No.	Finishes	Mountings	Ballast	Lamps
8284WH **8284BK**	Matte White Matte Black	All Lytespan Track Systems	HPF (E)	42W Triple Tube Compact Fluorescent (4-pin) PLT Philips Dulux T/E/IN Osram Sylvania

Features

1. **Reflector:** Hi-temperature polycarbonate with a vacuum metalized dual finish reflector.
2. **Housing and Cover:** Hi-temperature impact resistant polycarbonate.
3. **Socket Housing:** Hi-temperature impact resistant polycarbonate.
4. **Track Adaptor:** Molded hi-temperature impact resistant polycarbonate adaptor in die-cast housing.
5. **Tension Pivots:** 180° Vertical rotation. 245° horizontal rotation.
6. **Heat Shield:** .020" thick specular aluminum.
7. **Ballast:** Pre-heat, high power factor, electronic ballast, housed in hi-temperature polycarbonate.

Electrical

Electronic Ballast

120V Input
Input Wattage: 45W
Power Factor: >0.98
Starting Temp.: 0°F
Total Harmonic Distortion: <10%
Ballast Factor: 0.87 to 1.0
Crest Factor: <1.55

Accessories

3/4" Cube Cell Louver
82LVRBK--Black Louver
82LVRWH--White Louver
NOTE: Multiply performance data by .66 when using the white louver and by .5 when using the black louver.

Labels

UL

Job Information	**Type:**
Job Name:	
Cat. No.:	
Lamp(s):	
Notes:	

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LIGHTOLIER®

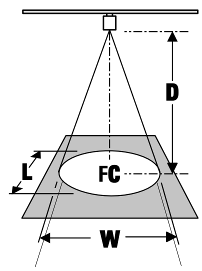
Lighting Data

Aiming Angle:

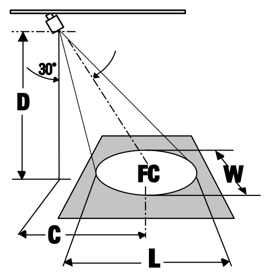
L Beam length
W Beam width
C Distance to center of beam
D Distance
FC Footcandles

L and **W** are the outer points where the candlepower drops to 50% of the maximum. **FC** are the initial footcandles at the center of the beam.

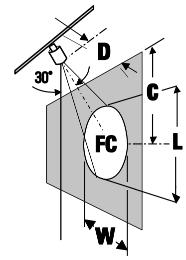
0°



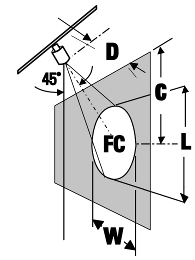
30° Horizontal



30° Vertical



45° Vertical



LAMP

LAMP	Beam Spread 50% Max CP	Beam Center C.P. Candelas	Rated Life-Hrs
42W Triple Tube (GX24q-4	60°	1652	10000

0°

D	FC	L	W
4'	103	4.6'	4.6'
6'	46	6.9'	6.9'
8'	26	9.2'	9.2'
10'	17	11.5'	11.5'

30° Horizontal

D	C	FC	L	W
3'	1.7'	119	5.2'	4.0'
5'	2.9'	43	8.7'	6.7'
7'	4.0'	22	12.1'	9.3'
9'	5.2'	13	15.6'	12.0'

30° Vertical

D	C	FC	L	W
1'	1.7'	207	*	2.3'
2'	3.5'	52	*	4.6'
3'	5.2'	23	*	6.9'
4'	6.9'	13	*	9.2'

45° Vertical

D	C	FC	L	W
3'	3.0'	65	10.4'	4.9'
4'	4.0'	37	13.9'	6.5'
5'	5.0'	23	17.3'	8.2'
6'	6.0'	16	20.6'	9.8'

* Exceeds usable limits.

NOTE: Multiply footcandles by .66 when using the white louver and by .5 when using the black louver.

Job Information	Type:

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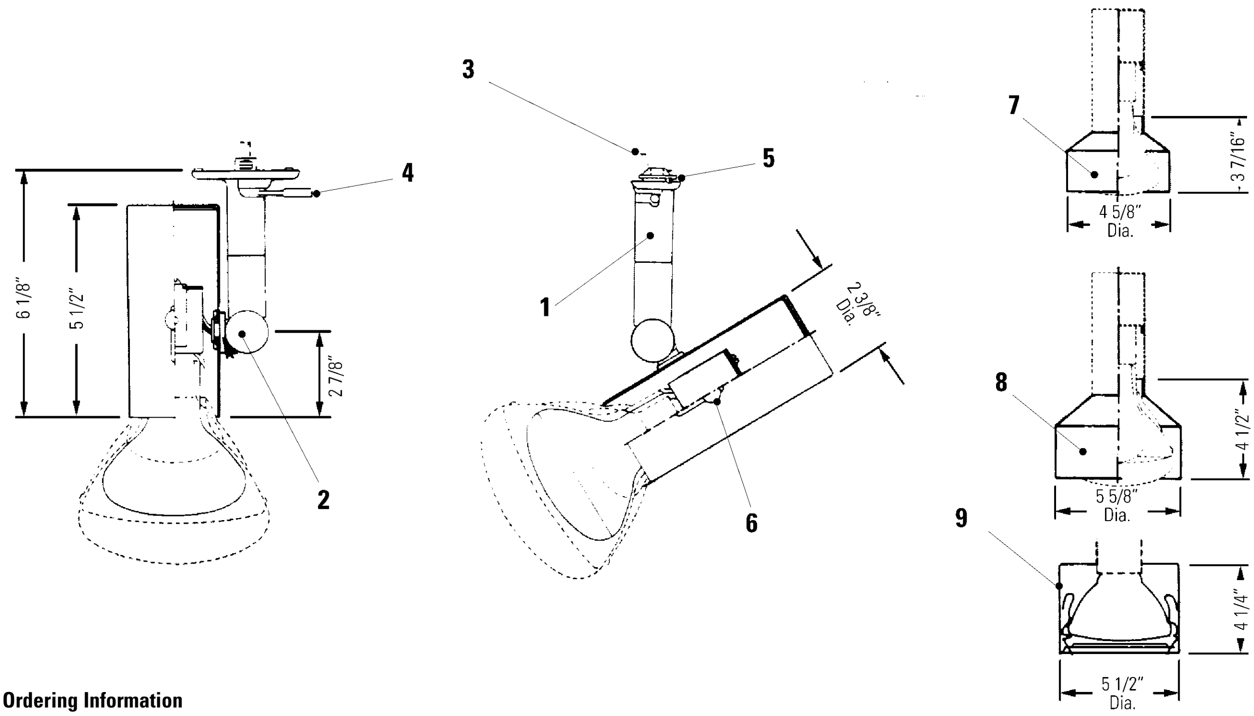
Universal Lytespot®



Ordering Information

Catalog No.	Description of Lamps	Finish	Mountings
6320 **6322**	Housing Only = 75W R20; 75W-100W R30; 250W PAR38; 150W PAR38 Cool Beam; 75W PAR16, 50W PAR20, 75W PAR30	Matte White Matte Black	All Lytespan Track Systems
6325 **6337**	Cowl* Only for 75W A19	Matte White Outside† Matte Black	
6326 **6338**	Cowl* Only 75W ER30, 150W PAR38, 150W A21	Matte White Outside† Matte Black	
7587 **7627**	Cowl* Only 250W PAR38	Matte Black Matte White	

† Matte Black Textured Surface Inside.

* NOTE: Universal Cowls Limit Choice of Lamps.

Features

1. **Lytespan Attachment Fitting:** die-cast zinc alloy.
2. **Pivot Mounting:** tensioned with built-in stop, provides 90° vertical adjustment.
3. **Movable Brass Contact:** extends for connection to 2nd circuit in Advent Lytespan Track.
4. **Lever:** energizes unit.
5. **Polarity Keyway**
6. **Thumbscrew:** for lampholder adjustment.
7. **6325, 6337 Cowl:** textured anodized aluminum with matte black band to control brightness.
8. **6326, 6338 Cowl:** textured anodized aluminum with matte black band to control brightness.
9. **7587, 7627 Cowl:** clips onto PAR38 lamp only.

Electrical

Porcelain socket, medium base, nickel plated screw shell.
No. 18 braided SF-1 leads.

Finish

All painted finishes baked enamel.

Labels

UL, I.B.E.W.

US Patent Nos. 3,496, 518; 3,894,781. Foreign patents granted.

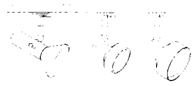
Job Information	**Type:**
Job Name:	
Cat. No.:	
Lamp(s):	
Volts/Ballast:	

Lightolier a Genlyte Thomas Company www.lightolier.com
Technical Information: (978) 657-7600 • Fax (978) 658-0595
631 Airport Road, Fall River, MA 02720 • (508) 679-8131 • Fax (508) 674-4710

We reserve the right to change details of design, materials and finish.

A0902

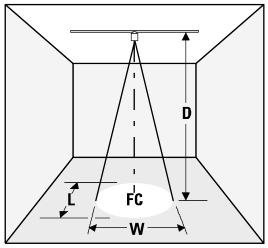
LIGHTOLIER®

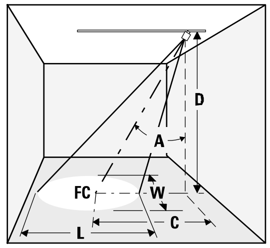


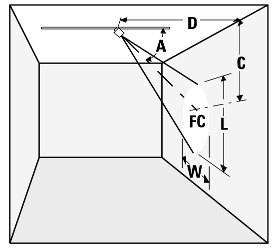
Lighting Data

L Beam length
W Beam Width
C Distance to center beam
D Distance
A Aiming angle
FC Footcandles

L and **W** are the outer points where the candle power drops to 50% of the maximum. **FC** are the intial foot-candles at the center of the beam.







Lamp	Beam Spread 50% Max. CP	Beam Center C.P. Candelas	Rated Life-Hrs	D	FC	L	W	D	C	FC	L	W	D	C	FC	L	W	D	C	FC	L	W
75W PAR30 NSP (Halogen)	9°	14,000	2,500	8"	219	1.3"	1.3"	7"	4.0"	186	1.5"	1.3"	5"	5.0"	198	1.6"	1.1"	3"	5.2"	194	1.9"	0.9"
				12"	97	1.9"	1.9"	10"	5.8"	91	2.1"	1.8"	7"	7.0"	101	2.2"	1.6"	4"	6.9"	109	2.6"	1.3"
				16"	55	2.5"	2.5"	13"	7.5"	54	2.7"	2.4"	9"	9.0"	61	2.9"	2.0"	5"	8.7"	70	3.2"	1.6"
				20"	35	3.1"	3.1"	16"	9.2"	36	3.4"	2.9"	11"	11.0"	41	3.5"	2.4"	6"	10.4"	49	3.8"	1.9"
75W PAR30 NFL (Halogen)	30°	3.200	2,500	6"	89	3.2"	3.2"	5"	2.9"	83	3.7"	3.1"	3"	3.0"	126	3.5"	2.3"	2"	3.5"	100	5.5"	2.1"
				8"	50	4.3"	4.3"	7"	4.0"	42	5.1"	4.3"	5"	5.0"	45	5.8"	3.8"	3"	5.2"	44	8.2"	3.2"
				10"	32	5.4"	5.4"	9"	5.2"	26	6.6"	5.6"	7"	7.0"	23	8.1"	5.3"	4"	6.9"	25	10.9"	4.3"
				12"	22	6.4"	6.4"	11"	6.4"	17	8.1"	6.8"	9"	9.0"	114	10.4"	6.8"	5"	8.7"	16	13.7"	5.4"
90W PAR38 NSP (Halogen)	9°	19.500	2,500	10"	195	1.6"	1.6"	8"	4.6"	198	1.7"	1.5"	6"	6.0"	192	1.9"	1.3"	4"	6.9"	152	2.6"	1.3"
				15"	87	2.4"	2.4"	12"	6.9"	88	2.5"	2.2"	9"	9.0"	85	2.9"	2.0"	6"	10.4"	68	3.8"	1.9"
				20"	49	3.1"	3.1"	16"	9.2"	49	3.4"	2.9"	12"	12.0"	48	3.8"	2.7"	8"	13.9"	38	5.1"	2.5"
				25"	31	3.9"	3.9"	20"	11.5"	32	4.2"	3.8"	15"	15.0"	31	4.8"	3.3"	10"	17.3"	24	8.4"	3.1"
90W PAR38 SP (Halogen)	12°	14.500	2,500	8"	227	1.7"	1.7"	7"	4.0"	192	2.0"	1.7"	5"	5.0"	205	2.1"	1.5"	3"	5.2"	201	2.6"	1.3"
				12"	101	2.5"	2.5"	10"	5.8"	94	2.8"	2.4"	7"	7.0"	105	3.0"	2.1"	4"	6.9"	113	3.5"	1.7"
				16"	57	3.4"	3.4"	13"	7.5"	56	3.7"	3.2"	9"	9.0"	63	3.8"	2.7"	5"	8.7"	73	4.3"	2.1"
				20"	36	4.2"	4.2"	16"	9.2"	37	4.5"	3.9"	11"	11.0"	42	4.7"	3.3"	6"	10.4"	50	5.2"	2.5"
90W PAR38 FL (Halogen)	28°	4,500	2,500	6"	125	3.0"	3.0"	5"	2.9"	117	3.4"	2.9"	3"	3.0"	177	3.2"	2.1"	2"	3.5"	141	4.9"	2.0"
				8"	70	4.0"	4.0"	7"	4.0"	60	4.8"	4.0"	5"	5.0"	64	5.3"	3.5"	3"	5.2"	63	7.4"	3.0"
				10"	45	5.0"	5.0"	9"	5.2"	36	6.1"	5.2"	7"	7.0"	32	7.4"	4.9"	4"	6.9"	35	9.8"	4.0"
				12"	31	6.0"	6.0"	11"	6.4"	24	7.5"	6.3"	9"	9.0"	20	9.6"	8.3"	5"	8.7"	23	12.3"	5.0"
100W PAR38 SP (Halogen)	10°	29,000	3,000	10"	290	1.7"	1.7"	8"	4.6"	294	1.9"	1.6"	6"	6.0"	285	2.1"	1.5"	4"	6.9	227	2.9"	1.4"
				15"	120	2.6"	2.6"	12"	6.9"	131	2.8"	2.4"	9"	9.0"	127	3.2"	2.2"	6"	10.4"	101	4.3"	2.1"
				20"	73	3.5"	3.5"	16"	9.2"	74	3.7"	3.2"	12"	12.0"	71	4.2"	3.0"	8"	13.9"	57	5.7"	2.8"
				25"	46	4.4"	4.4"	20"	11.5"	47	4.7"	4.0"	15"	15.0"	46	5.3"	3.7"	10"	17.3"	36	7.2"	3.5"
100W PAR38 NFL (Halogen)	27°	7,500	3,000	7"	153	3.4"	3.4"	6"	3.5"	135	3.9"	3.3"	4"	4.0"	168	4.1"	2.7"	2"	3.5"	234	4.8"	1.9"
				10"	75	4.8"	4.8"	9"	5.2"	60	5.9"	5.0"	6"	6.0"	74	6.1"	4.1"	3"	5.2"	104	7.4"	2.9"
				13"	44	8.2"	6.2"	12"	6.9"	34	7.8"	6.7"	8"	8.0"	41	8.2"	5.4"	4"	6.9"	59	9.3"	3.8"
				16"	29	7.7"	7.7"	15"	8.7"	22	9.8"	8.3"	10"	10.0"	27	10.2"	6.8"	5"	8.7"	38	11.6"	4.8"
100W PAR38 FL (HIR)	40°	3,400	3,000	6"	94	4.4"	4.4"	5"	2.9"	88	5.1"	4.2"	3"	3.0"	134	5.0"	3.1"	2"	3.5"	106	9.7"	2.9"
				8"	53	5.8"	5.8"	7"	4.0"	45	7.1"	5.9"	5"	5.0"	48	8.4"	5.1"	3"	5.2"	47	14.5"	4.4"
				10"	34	7.3"	7.3"	9"	5.2"	27	9.1"	7.6"	7"	7.0"	25	11.7"	7.2"	4"	6.9"	27	19.3"	5.8"
				12"	24	8.7"	8.7"	11"	6.4"	18	11.2"	9.2"	9"	9.0"	15	15.1"	8.3"	5"	8.7"	17	24.2"	7.3"
120W PAR38 NSP (Halogen)	10°	25,000	3.000	10"	250	1.7"	1.7"	8"	4.6"	254	1.9"	1.6"	6"	6.0"	246	2.1"	1.5"	4"	6.9"	195	2.9"	1.4"
				15"	111	2.6"	2.6"	12"	6.9"	113	2.8"	2.4"	9"	9.0"	109	3.2"	2.2"	6"	10.4"	87	4.3"	2.1"
				20"	63	3.5"	3.5"	16"	9.2"	63	37"	3.2"	12"	12.0"	61	4.2"	3.0"	8"	13.9"	49	5,7"	2.8"
				25"	40	4.4"	4.4"	20"	11.5"	41	4.7"	4.0"	15"	15.0"	39	5.3"	3.7"	10"	17.3"	31	7.2"	3.5"
120W PAR38 FL (Halogen)	30°	5,000	3,000	6"	139	3.2"	3.2"	5"	2.9"	130	3.7"	3.1"	3"	3.0"	196	3.5"	2.3"	2"	3.5"	156	5.5"	2.1"
				8"	78	4.3"	4.3"	7"	4.0"	66	5.1"	4.3"	5"	5.0"	71	5.8"	3.8"	3"	5.2"	69	8.2"	3.2"
				10"	50	5.4"	5.4"	9"	5.2"	40	6.8"	5.6"	7"	7.0"	36	8.1"	5.3"	4"	6.9"	39	10.9"	4.3"
				12"	35	6.4"	6.4"	11"	6.4"	27	8.1"	6.8"	9"	9.0"	22	10.4"	6.8"	5"	8.7"	25	13.7"	5.4"
250W PAR38 SP (Halogen)	11°	40,000	4,200	15"	178	2.9"	2.9"	10"	5.8"	260	2.6"	2.2"	8"	8.0"	221	3.1"	2.2"	5"	8.7"	200	4.0"	1.9"
				20"	100	3.9"	3.9"	15"	8.7"	115	3.9"	3.3"	12"	12.0"	98	4.7"	3.3"	8"	13.9"	78	6.3"	3.1"
				25"	64	4.8"	4.8"	20"	11.5"	65	5.2"	4.4"	18"	18.0"	55	6.2"	4.4"	11"	19.1"	41	8.7"	4.2"
				30"	44	5.8"	5.8"	25"	14.4"	42	6.4"	5.6"	20"	20.0"	35	7.8"	5.4"	14"	24.2"	26	11.1"	5.4"
250W PAR38 FL (Halogen)	32°	8,000	4,200	7"	163	4.0"	4.0"	6"	3.5"	144	4.7"	4.0"	4"	4.0"	177	5.0"	3.2"	2"	3.5"	250	6.1"	2.3"
				10"	80	5.7"	5.7"	9"	5.2"	64	7.1"	6.0"	6"	6.0"	79	7.5"	4.9"	3"	5.2"	111	9.1"	3.4"
				13"	47	7.5"	7.5"	12"	6.9"	36	9.4"	7.9"	8"	8.0"	44	10.0"	6.5"	4"	6.9"	63	12.2"	4.6"
				16"	31	9.2"	9.2"	15"	8.7"	23	11.8"	9.9"	10"	10.0"	28	12.5"	9.1"	5"	8.7"	40	15.2"	5.7"

Job Information	Type:

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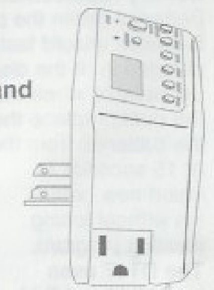
LIGHTOLIER®

INTERMATIC®

DT17 Digital Timer Installation and Operating Instructions

Thank you for purchasing the DT17 Digital Timer.

Features of this timer include



Features

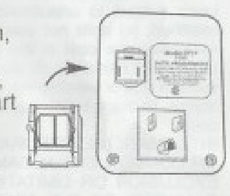
- Automatic or manual operation. Push ON/OFF to switch the plugged in light(s) on or off any time.
- Program up to 14 on/off time pairs per day (maximum 98 automatic switch settings).
- Minimum setting interval 1 minute.
- A setting can be for a particular day of the week, every day, only weekdays, only weekends, or every day but Sunday.
- Random feature adjusts the ON/OFF times within 15 minutes of each programmed setting.
- Batteries (replaceable) save the time and program settings when the unit is unplugged or there is a power outage.

Please read the instructions before programming your timer.

Battery Installation

Using a small flat screwdriver or coin, pry the battery holder open. Position the 2 batteries, supplied with the timer, so the flat part of the batteries are facing the + terminal. When the batteries are in place, press the battery holder back into its original position.

NOTE: For battery replacement use SR44 or LR44



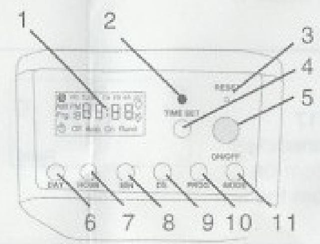
Notes:

(1) WARNING DO NOT USE THE TIMER TO TURN OFF POWER FOR MAINTENANCE (repairs, removing broken bulbs, etc.). ALWAYS TURN POWER OFF AT THE SERVICE PANEL BY REMOVING A FUSE OR CIRCUIT BREAKER BEFORE DOING ANY CIRCUIT REPAIRS.

(2) In case of a conflict (for example you have programmed the timer to be on at 4 pm every day of the week and also programmed the timer to be off at 4 pm on saturdays) the higher program number is followed. In case of a conflict within a program number Off is followed rather than On.

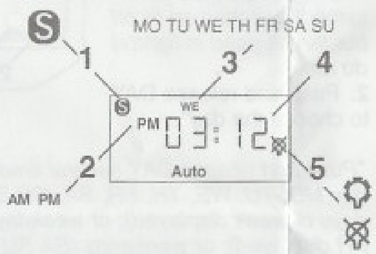
Familiarize yourself with the timer controls and displays.

Timer Controls

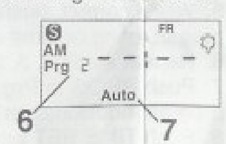


1 **Display** - LCD display (reset display shown).
2 **On light** - red LED is lit when the DT17 is in operation.
3 **RESET button** - push the RESET button with a ball point pen to clear all programming and the clock.
4 **TIME SET button** - push and hold to set the clock.
5 **ON/OFF button** - push and release to manually switch on or off at any time.
6 **Day button** - use during time set to set the day of the week. Use during programming to set individual days, weekdays, weekends or the entire week.
7 **HOUR button** - use during time set or programming to set the hour.
8 **MIN button** - use during time set or programming to set the minute.
9 **DS button** - push and hold for a couple of seconds to switch to or from daylight savings time.
10 **PROG button** - push and release to set or change programmed on and off times.
11 **MODE button** - push and release to choose ON/Off, Auto, Random or Countdown timer modes.

Displays

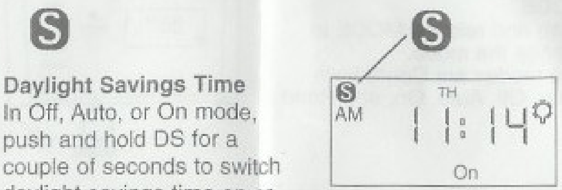


1. Daylight savings symbol indicates daylight savings time when on.
2. AM/PM
3. MO TU... Day of the week.
4. 03:12 - Time.
5. On/Off display
On display. Usually displayed when On light is lit and timer is on, during programming indicates an on time is being programmed.
Off display (Usually displayed when On light is off and timer is off, during programming indicates an off time is being programmed.)



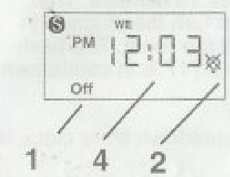
6. Program number - (1-14)
7. Mode - Countdown Timer, Off, Auto, On, or Rand. See Modes, next page, for specific mode displays.

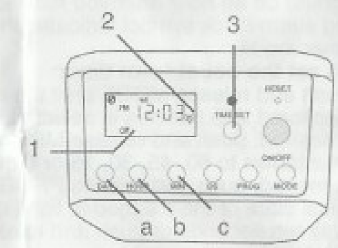
Daylight Savings Time



In Off, Auto, or On mode, push and hold DS for a couple of seconds to switch daylight savings time on or off. The daylight savings (S) symbol switches on or off and the time switches one hour in the appropriate direction.

Setting The Clock





How to set the clock:

1. The mode must be On, Auto, or Off.
2. If it is daylight savings time, push and hold DS for a couple of seconds so the daylight savings symbol appears.
   If it is not daylight savings time, push and hold DS for a couple of seconds so the daylight savings symbol is off.
3. Push and hold TIME SET.
4. The blinking colon stays on (stops blinking).

While holding TIME SET:

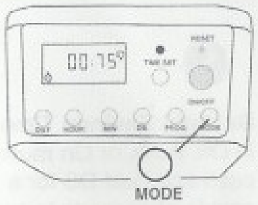
a. Push and release DAY to change the day of week.
b. Push and release HOUR to change the hour and AM/PM.
c. Push and release MIN to change the minute.

Notes:
If you push and hold DAY, HOUR or MIN the display changes quickly.
Seconds are set at 0 when the TIME SET button is released if either the HOUR or MIN have been set.

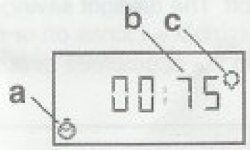
Timer Modes

MODE

Push and release MODE to change the mode.
The modes are Countdown timer, Off, Auto, On, and Rand.

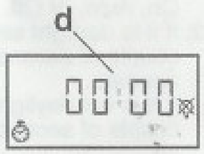


Countdown timer mode



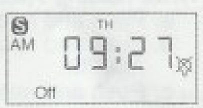
In countdown timer mode the clock symbol is displayed **(a)**.
When countdown timer mode is entered the countdown time is set to 75 minutes **(b)**.
And the plugged in light(s) are turned on **(c)**.
The countdown timer can be set to turn the plugged in light(s) on or off after 75, 60, 45, 30 or 15 minutes. That lets you, for example, set the timer to turn the plugged in light(s) off an hour after you have left the room. The flashing alarm clock symbol indicates the DT17 is in countdown timer mode.

To set the countdown timer:
Push and release MODE until the countdown timer clock is displayed. (75 minutes is selected.)
If desired, push and release MIN to switch change the countdown to 60, 45, 30, 15 or 0 minutes.
If desired, push and release PROG ON/OFF to switch the initial state of the plugged in light(s).
Wait ten seconds or push and release TIME SET to start the countdown.
While counting down the countdown timer clock symbol flashes, and you can push TIME SET to switch between the countdown the current time.
When the countdown reaches 00:00 the connected light(s) are switched and the clock display remains 00:00 **(d)**.



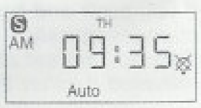
Off Mode

In the Off mode the plugged in light(s) are off. You can push PROG ON/OFF to switch to ON mode and turn the plugged in light(s) on.



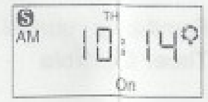
Auto Mode

In auto mode the programmed on and off times automatically switch the plugged in light(s) on and off. See how to program the timer, below for how to enter or change the automatic program times.
You can push PROG ON/OFF while in Auto mode to manually override the program and turn the plugged in light(s) on or off. The programmed switching times remain. The timer stays in auto mode.



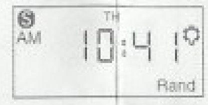
On Mode

In the On mode the plugged in light(s) are on. Push PROG ON/OFF to turn the plugged in light(s) off and switch the mode to Off.



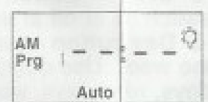
Rand Mode

In Random mode the DT17 randomly switches the connected light(s) on and off. A random on period is ± 15 minutes from the programmed times.

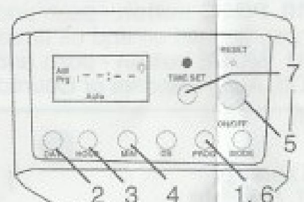


How to program the timer:

You can program the timer in Auto, ON or Off modes. The program is followed in Auto mode.



1. Push and release PROG to start the programming.
Prg 1 is displayed and the display shows --:-- or the programmed time for Prg 1. timer on (lit light bulb symbol on).
--:-- display means there is nothing programmed for that Prg number and on/off time.
Note: You can push and release ON/OFF to switch between the Prg # on time and the Prg # off time. The light bulb symbol switches on or off but the plugged in light(s) do not.



2. Push and release DAY to choose the day*.

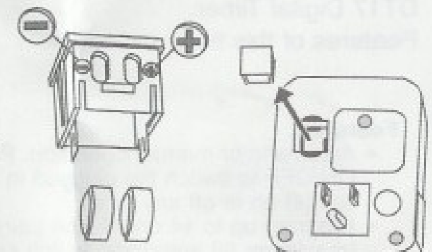
**Push and release DAY several times to set: a single day MO, TU, WE, TH, FR, SA, OR SU; or all week (all days of week displayed); or weekdays (MO TU WE TH FR displayed); or weekends (SA SU displayed); or all days but sunday (MO TU WE TH FR SA displayed).*

3. Push and release HOUR to choose the hour.
4. Push and release MIN to choose the minute.
5. When correct, push ON/OFF to switch between programming on time and off time for that Prg number.
6. Repeat steps 2, 3, and 4 to set the Off program.
7. Push PROG to Prg 2, Prg 3,... up to Prg 14, to program additional on and /or off times.
8. Push TIME SET or wait 15 seconds to exit programming.
After the program is set, turn lamp or appliance ON and plug it into the timer. Plug the timer into a wall receptacle.

ART195B

Battery replacement

Batteries retain the program during power outages. Batteries should last 3 years or more if the timer is left plugged in. If the display is dim, weak or unreadable when the timer is unplugged from the outlet replace the batteries. After removing the batteries from the unit, you have a minimum of 15 seconds to insert new batteries without losing existing program. The DT17 uses two SR44 or LR44 alkaline batteries. Purchase fresh batteries. Unplug the DT17. Follow the directions outlined in Battery Installation.



FULL ONE YEAR WARRANTY
If within one (1) year from the date of purchase, this product fails due to a defect in material or workmanship, Intermatic Incorporated will repair or replace it, at its sole option, free of charge. This warranty is extended to the original household purchaser only and is not transferable. This warranty does not apply to: (a) damage to units caused by accident, dropping or abuse in handling, acts of God or any negligent use; (b) units which have been subject to unauthorized repair, opened, taken apart or otherwise modified; (c) units not used in accordance with instructions; (d) damages exceeding the cost of the product; (e) sealed lamps and/or lamp bulbs, LED's and batteries; (f) the finish on any portion of the product, such as surface and/or weathering, as this is considered normal wear and tear; (g) transit damage,initial installation costs, removal costs, or reinstallation costs.
INTERMATIC INCORPORATED WILL NOT BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES. SOME STATES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES, SO THE ABOVE LIMITATION OR EXCLUSION MAY NOT APPLY TO YOU. THIS WARRANTY IS IN LIEU OF ALL OTHER EXPRESS OR IMPLIED WARRANTIES. ALL IMPLIED WARRANTIES, INCLUDING THE WARRANTY OF MERCHANTABILITY AND THE WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE, ARE HEREBY MODIFIED TO EXIST ONLY AS CONTAINED IN THIS LIMITED WARRANTY, AND SHALL BE OF THE SAME DURATION AS THE WARRANTY PERIOD STATED ABOVE. SOME STATES DO NOT ALLOW LIMITATIONS ON THE DURATION OF AN IMPLIED WARRANTY, SO THE ABOVE LIMITATION MAY NOT APPLY TO YOU.
This warranty gives you specific legal rights and you may also have other rights which vary from state to state. Warranty service is available by mailing postage prepaid to: Intermatic Incorporated/After Sales Service/7777 Winn Rd., Spring Grove, IL 60081-9698/815-675-7000 http://www.intermatic.com Please be sure to wrap the product securely to avoid shipping damage.

Table C1: Specifications, part numbers, and source information for efficiency upgrades.

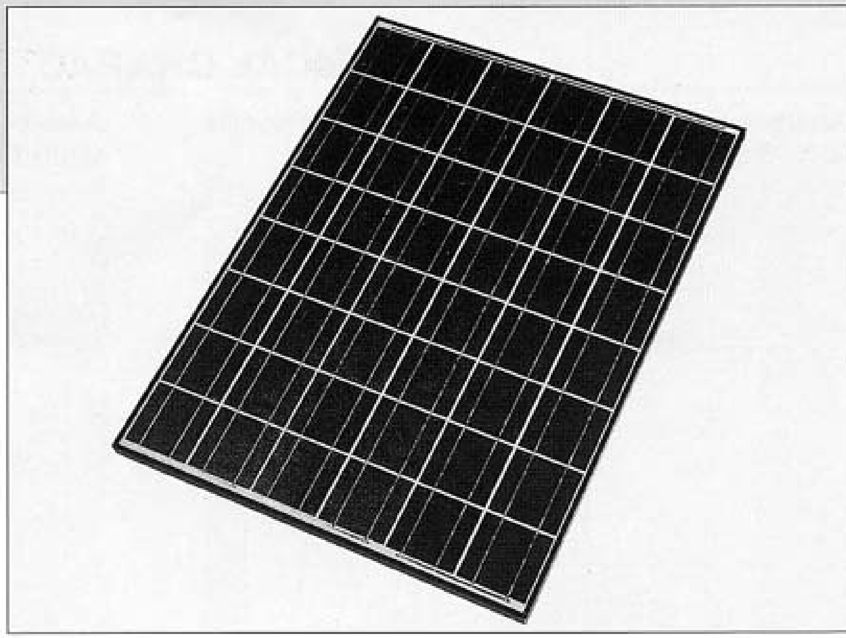
Upgrade	Bulb Life (hrs)	Lumen ouput	CRI	Efficacy	Part Numbers	Source
2 T-12's to 1 T8 (4-foot)	24000	3000	82	93.75	Ballast/QT 2X32/277IS-SC, lamp/FO32/835/XP/ECO, retrofit kit/ SKSS4/SA/4-1BE	http://www.goodmart.com/products/380556.htm , U.S. Energy sciences (www.reflect-a-light.com)
4 T-12's to 2T8 (4-foot)	18000	2725	82	97.321429	Ballast/QHE 2X32T8/UNV ISL-SC, lamp/FO28/835/XP/SS/ECO, retrofit kit/ SKLF 1T-A/SA/4	http://www.goodmart.com/products/380556.htm , U.S. Energy sciences (www.reflect-a-light.com)
2 T-12 U-tubes to 2 T-8 2ft linear	24000	1400	82	82.352941	Ballast/QT 2X32/277IS-SC, lamp/FO17/835/XP/ECO, retrofit kit/ SKLF 1T-C/SA/2	http://www.goodmart.com/products/380556.htm , U.S. Energy sciences (www.reflect-a-light.com)
150W halogen- to 42W CFL	12000	2400	82	57.142857	Lightolier (8284 WH)&(82LVRBK), Sylvania CF42DT/E/IN/835	Fixture/Campton Electric, Bulb/http://bulbs.com/products/product.asp?page=products&class=606
50W halogen to 20W CFL	8000	575	82	28.75	lightolier 6320, Feit electric BPESL23Par38T, Lightolier 7627 cowl	Feit electric/Lightolier
50W halogen to 35W IR	5000	2200 (cp)	100	N/A	35MRC16/IRC/NFL24	Bulbs.com (bulb price for 10-39)
13W CFL to 9W CFL	10000	550	82	61.111111	TCP: 28909-35K	GoodMart.com
2T8 to 1 T8 (4 foot)	N/A	N/A	N/A	N/A	Retrofit kit/ SKSS4/SA/4-1BE	U.S. Energy sciences (www.reflect-a-light.com)

THE NEW VALUE FRONTIER

KYOCERA

KC167G

HIGH EFFICIENCY MULTICRYSTAL PHOTOVOLTAIC MODULE



HIGHLIGHTS OF KYOCERA PHOTOVOLTAIC MODULES

Kyocera's advanced cell processing technology and automated production facilities produce a highly efficient multicrystal photovoltaic module.
The conversion efficiency of the Kyocera solar cell is 15%
These cells are encapsulated between a tempered glass cover and an EVA pottant with back sheet to provide maximum protection from the severest environmental conditions.
The entire laminate is installed in an anodized aluminum frame to provide structural strength and ease of installation.
Equipped with plug-in connectors.

APPLICATIONS

KC167G is ideal for grid tie system applications.

- Residential roof top systems
- Large commercial grid tie systems
- Water Pumping systems
- High Voltage stand alone systems

QUALIFICATIONS

UL1703 certified.

PERFORMANCE WARRANTY

25 year※ limited warranty on power output

SPECIFICATIONS

■ Electrical Specifications

MODEL	KC167G
Maximum Power	167Watts
Maximum Power Voltage	23.2Volts
Maximum Power Current	7.20Amps
Open Circuit Voltage	28.9Volts
Short-Circuit Current	8.00Amps
Length	1290mm (50.8in.)
Width	990mm (39.0in.)
Depth	36mm (1.4in.)
Weight	16.0kg (35.3lbs.)

■ Thermal parameters

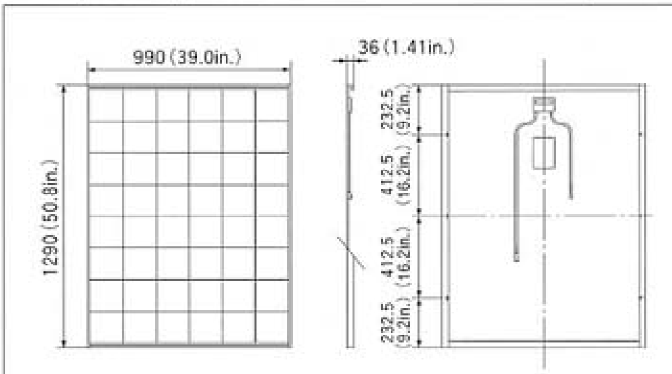
Nominal Operating Cell Temperature	47°C
Isc Current temperature coefficient (A/°C)	(8.60×10^{-3}) A/°C
Voc Voltage temperature coefficient (V/°C)	(-1.12×10^{-1}) V/°C

Note: The electrical specifications are under test conditions of Irradiance of 1kw/m², Spectrum of 1.5 air mass and cell temperature of 25°C

Kyocera reserves the right to modify these specifications without notice

■ Physical Specifications

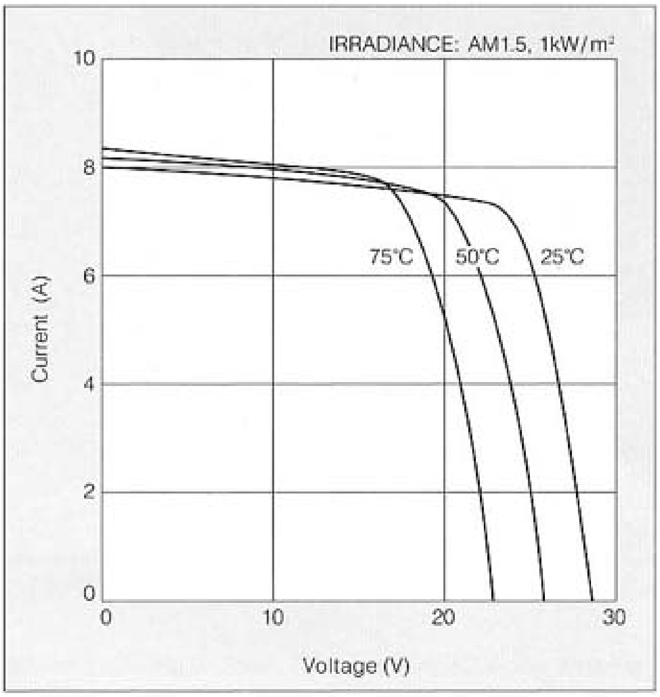
(Unit: mm)



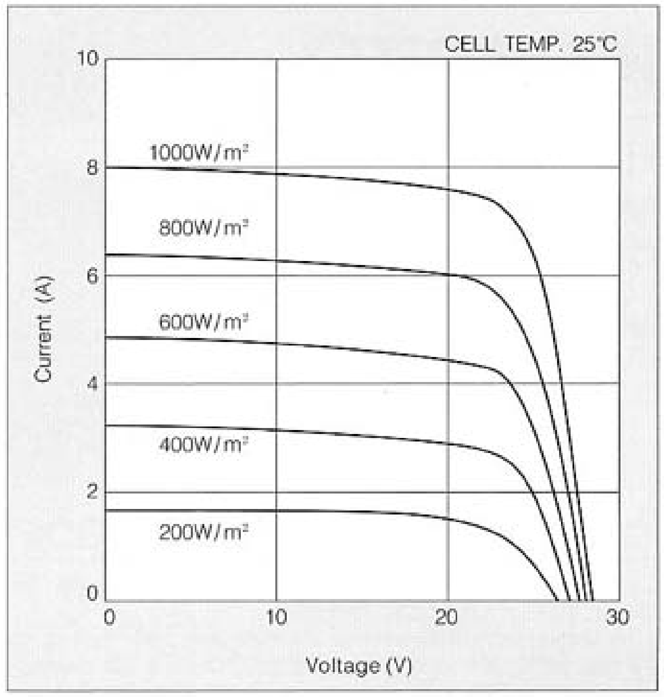
※Power output of the module after 25 years will not be less than 80% of the minimum power specified in the data sheet.

ELECTRICAL CHARACTERISTICS

Current-Voltage characteristics of Photovoltaic Module KC167G at various cell temperatures



Current-Voltage characteristics of Photovoltaic Module KC167G at various irradiance levels



QUALITY ASSURANCE

Kyocera multicrystal photovoltaic modules exceed government specifications for the following tests.

- Thermal cycling test
- Thermal shock test
- Thermal/ Freezing and high humidity cycling test
- Electrical isolation test
- Hail impact test
- Mechanical, wind and twist loading test
- Salt mist test
- Light and water-exposure test
- Field exposure test

Please contact our office to obtain details without hesitation.

KYOCERA Corporation

■ KYOCERA HEAD OFFICE
SOLAR ENERGY DIVISION
6 Takeda Tobadono-cho
Fushimi-ku, Kyoto
612-8501 Japan
Phone:(81)75-604-3476 Telefax:(81)75-604-3475
http://www.kyocera.co.jp

● KYOCERA FINECERAMICS GmbH
Fritz Muller Straße 107, D-73730 Esslingen, F.R.G.
Phone:(49)711-9393417 Telefax:(49)711-9393450

● KYOCERA ASIA PACIFIC PTE. LTD.
298 Tiong Bahru Road, #13-03/04/05
Central Plaza, Singapore 168730
Phone:(65)271-0500 Telefax:(65)271-0600

● KYOCERA ASIA PACIFIC LTD.
Room 803, Tower 1 South Seas Centre, 75 Mody Road,
Tsimshatsui East, Kowloon Hong Kong
Phone:(852)2-7237183 Telefax:(852)2-7244501

● KYOCERA ASIA PACIFIC LTD., TAIPEI BRANCH
Suite 501, Asia Enterprise Center,
No.142-144, Sec. 3, Min Chuan E.Road Taipei, Taiwan
Phone:(886)2-2718-3595 Telefax:(886)2-2718-3587

● Kyocera Solar, Inc.
7812 East Acoma Drive
Scottsdale, AZ 85260
Phone:(480)948-8003 or (800)223-9580 Telefax:(480)483-6431

● Kyocera Solar Pty, Ltd.
Cnr Forbes St & Riverside Drive
West End, QLD, 4102 Australia
Phone:(61)7-3844-6686 Telefax:(61)7-3844-8569

● Kyocera Solar do Brazil Ltda.
R.Mauricio da Costa Faria, 85
Recreio dos Bandeirantes-Rio de Janeiro
Cep:22.790-280
Phone:(55)21-2437-8525 Telefax:(55)21-2437-2338

LIE/I01I0303S3SAGM (Recycled Paper)

PV Inverter

xantrex

High Voltage Commercial Scale Power Conversion Center

LISTED

Utility Interactive Renewable Energy

- Utility interactive, three-phase inverter, with models ranging from 5 kW to 225 kW. Multiple inverters may be paralleled for larger power installations.
- Designed for cost-effectiveness, high performance, easy installation, and reliability.
- Advanced MPPT technology maximizes PV array output (not for use with batteries).
- Revolutionary switching technology utilizes insulated gate bi-polar transistors (IGBT), greatly reducing power losses during the conversion process.
- Meets all applicable UL, IEEE, and NEC codes.
- Automatic operation includes start-up, shut-down, self-diagnosis, and fault detection.

Features

- Efficient design, with over 95% peak efficiency for the inverter, and overall efficiency, including transformer losses, in excess of 93%.
- Digital Signal Processor (DSP) based controls with self-diagnostics and LCD for display of operating status.
- Inverter shut off and reset toggle switch.
- Over- and under-voltage and frequency protection, shutting down the inverter in compliance with UL1741.
- Anti-islanding protection - prevents back-feeding inverter-generated power to the grid in the event of a utility outage.
- User definable power tracking matches the inverter to the array, as well as adjustable delay periods to customize system shut-down sequences.

Options

- Variety of system accessories for ease of system installation, including combiner boxes, isolation transformers, disconnect switches, etc.
- Graphical user interface software for real time communication and control.
- Complete inverter kits, incorporating all required accessories for NEC code compliant installation, are available.

Xantrex Technology Inc.
Headquarters
8999 Nelson Way
Burnaby, British Columbia
Canada V5A 4B5
800 670 0707 Toll Free
604 420 1591 Fax

5916 195th Street NE
Arlington, Washington
USA 98223
800 446 6180 Toll Free
360 925 5144 Fax

P/N 970-0051-01-02 Rev A Printed in USA

www.xantrex.com

PV Inverter

xantrex

High Voltage Commercial Scale Power Conversion Center

Electrical Specifications

Models	PV5	PV10	PV15	PV20	PV30	PV45	PV100	PV225	
Continuous Power Rating	5 kW	10 kW	15 kW	20 kW	30 kW	45 kW	100 kW	225 kW	
Nominal AC Voltage	208 VAC	208 VAC	208 VAC	208 VAC	208 VAC	208 VAC	208 VAC	208 VAC	Three-phase, +10% / -12%
Nominal AC Frequency	60 Hz	60 Hz	60 Hz	60 Hz	60 Hz	60 Hz	60 Hz	60 Hz	+ 0.5 Hz / -0.7 Hz
Line Power Factor	> 0.99	> 0.99	> 0.99	> 0.99	> 0.99	> 0.99	> 0.99	>0.99	Above 20% rated power
Maximum AC Line Current	15.4 amps AC	30.8 amps AC	46.3 amps AC	61.7 amps AC	94 amps AC	143 amps AC	316 amps AC	625 amps AC	
AC Current Distortion	< 5% THD	< 5% THD	< 5% THD	< 5% THD	< 5% THD	< 5% THD	< 5% THD	< 5% THD	At rated power
Max. Open Circuit Voltage	600 VDC	600 VDC	600 VDC	600 VDC	600 VDC	600 VDC	600 VDC	600 VDC	
Power Tracking Window Range	330 to 600 VDC all models								
Max. DC Input Current	15.9 amps DC	31.9 amps DC	47.8 amps DC	63.8 amps DC	100 amps DC	150 amps DC	319 amps DC	710 amps DC	
Max. Ripple Current	< 5%	< 5%	< 5%	< 5%	< 5%	< 5%	< 5%	< 5%	% of rated current
Peak Inverter Efficiency	> 93%	> 95%	> 95%	> 95%	> 95%	> 95%	> 95%	> 95%	
Standby Tare Losses	< 30 watts	< 30 watts	< 30 watts	< 30 watts	< 30 watts	< 30 watts	< 90 watts	< 90 watts	

General Specifications

Temperature Range									
Ambient	-4 °F to 122 °F (-20 °C to 50 °C)								
Storage	-40 °F to 122 °F (-40 °C to 50 °C)								
Enclosure Environmental Rating	NEMA4	NEMA4	NEMA4	NEMA4	NEMA3R	NEMA3R	NEMA3R	NEMA 3R	
Enclosure	Galvaneal folded steel enclosure								
Weight	75 lb	115 lb	160 lb	160 lb	260 lb	260 lb	1140 lb	2150 lb	
	34 kg	52 kg	73 kg	73 kg	118 kg	118 kg	518 kg	977 kg	
Dimensions (H x W x D)	20x16x13″	26x16x12	28x24x15″	28x24x15″	54x36x19″	54x 36x19″	83x76x20″	89x102x27″	
	51x41x33cm	66x41x30cm	71x61x38cm	71x61x38cm	137x91x48cm	137x91x48cm	211x193x51cm	226x259x68cm	
Altitude	6,600′ (2,012 m)								
Relative Humidity	0 to 95%	0 to 95%	0 to 95%	0 to 95%	0 to 95%	0 to 95%	0 to 95%	0 to 95%	non-condensing
Array Configuration	Monopole, negative grounded								

Features & Options

Cooling Method	PV5: natural convection cooling
	PV10 – PV225: forced convection cooling
Protective Functions	AC over / under voltage, AC over / under frequency, ground over current, over temperature, AC and DC over current, DC over voltage
User Display	Standard - LCD, four-line, twenty-characters, with on/off toggle switch (LED status indicators, only, on PV5)
AC Disconnect	Optional - NEMA3R wall mount enclosure, load break rated; Standard and integral to inverter assembly for PV100 and PV225
DC Disconnect	Optional - NEMA3R wall mount enclosure, 600 VDC load break rated; Standard and integral to inverter assembly for PV100 and PV225
Isolation Transformer	Optional - High efficiency, NEMA3R wall or floor mount enclosure
Combiner Enclosures	Optional - 10 or 12 pole, with or without diodes, NEMA3R wall mount enclosure
Communications Software	Optional - Serial communications and control software

Regulatory Approvals

Listed to UL Standard 1741, UL File No. E199356

Appendix D: Life Cycle Cost Analysis

Table D1: LCC for spot lighting alternatives

Option	Lighting Equipment	kWh/ month	Savings/ month	Equip. Cost	Yearly Savings	Rebate	Present Value (10yr)
Base Case	*30 x 50W halogen ($44/mo)*	*365*	*$0*	*$0*	*$0*	*$0*	*$0*
1	50W halogen to 15W CFL	110	$31	$1,644	$368	$330	$769
2	50W halogen to 20W CFL	146	$26	$1,500	$315	$330	$1,381
3	17 x 20W CFL & 13 x 35W halogen IR	194	$21	$967	$247	$187	$915
4	50W halogen to 35W halogen IR	256	$13	$270	$158	$0	$356

Table D2: LCC for Public restroom alternatives

Option	Lighting Equipment	kWh/ month	Savings/ month	Equip. Cost	Yearly Savings	Rebate	Present Value (10yr)
Base Case	*2 x 32W T-8 ($21/mo)*	*171*	*$0*	*$0*	*$0*	*$0*	*$0*
1	2 x 32W T-8 to 1 x 32W T-8 W/reflector	86	$10	$56	$123	$0	$849
2	2 x 32W T-8 to 1 x 32W T-8 W/reflector & occupancy sensor	47	$15	$340	$179	$44	$994
3	2 x 32W T-8 to 1 x 32W T-8 W/reflector &occupancy sensor & photocell	19	$18	$508	$219	$51	$1,095

Appendix E: Insolation Comparison

Figure E1 shows how the data collected at KVC in June and July 2004 compared to the NSRDB data used for the PV designs.

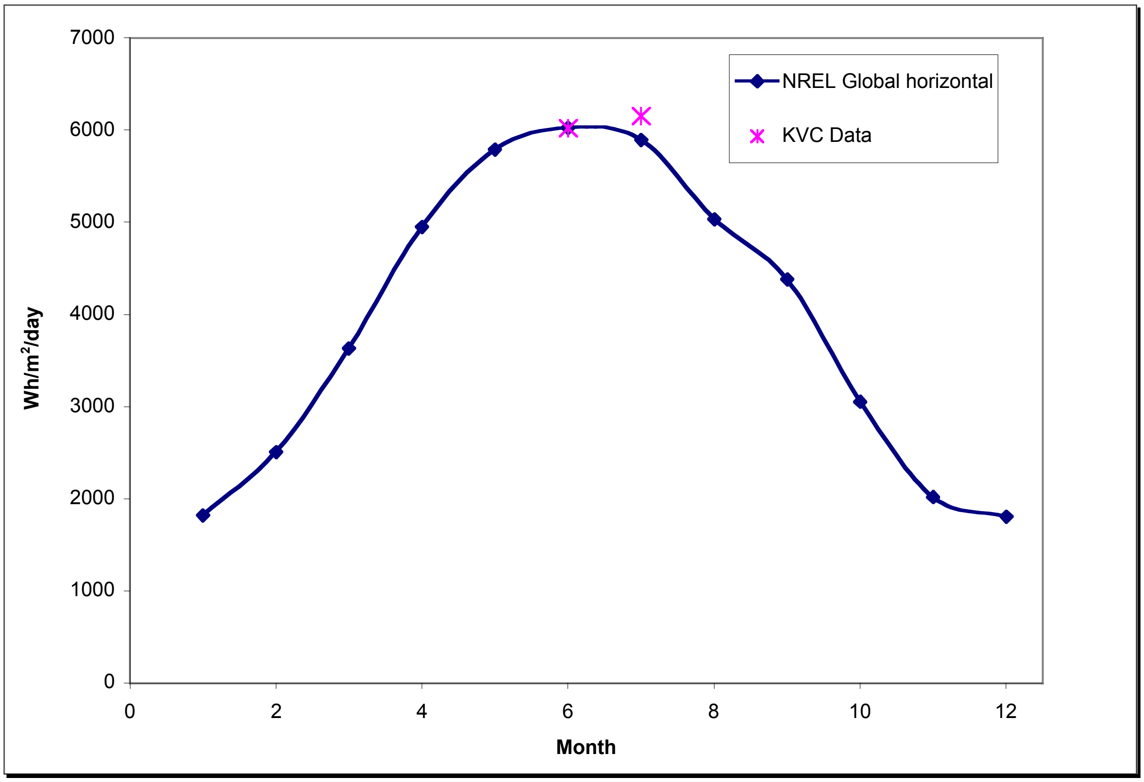


Figure E1: Comparison of KVC and NSRDB insolation data

Appendix F: Impacts of Shading

The shaded areas of the southeastern roof are labeled in Figure F1. The labels correspond to the locations where the white lines were traced on the sunpath diagrams (Figures F2 & F3).

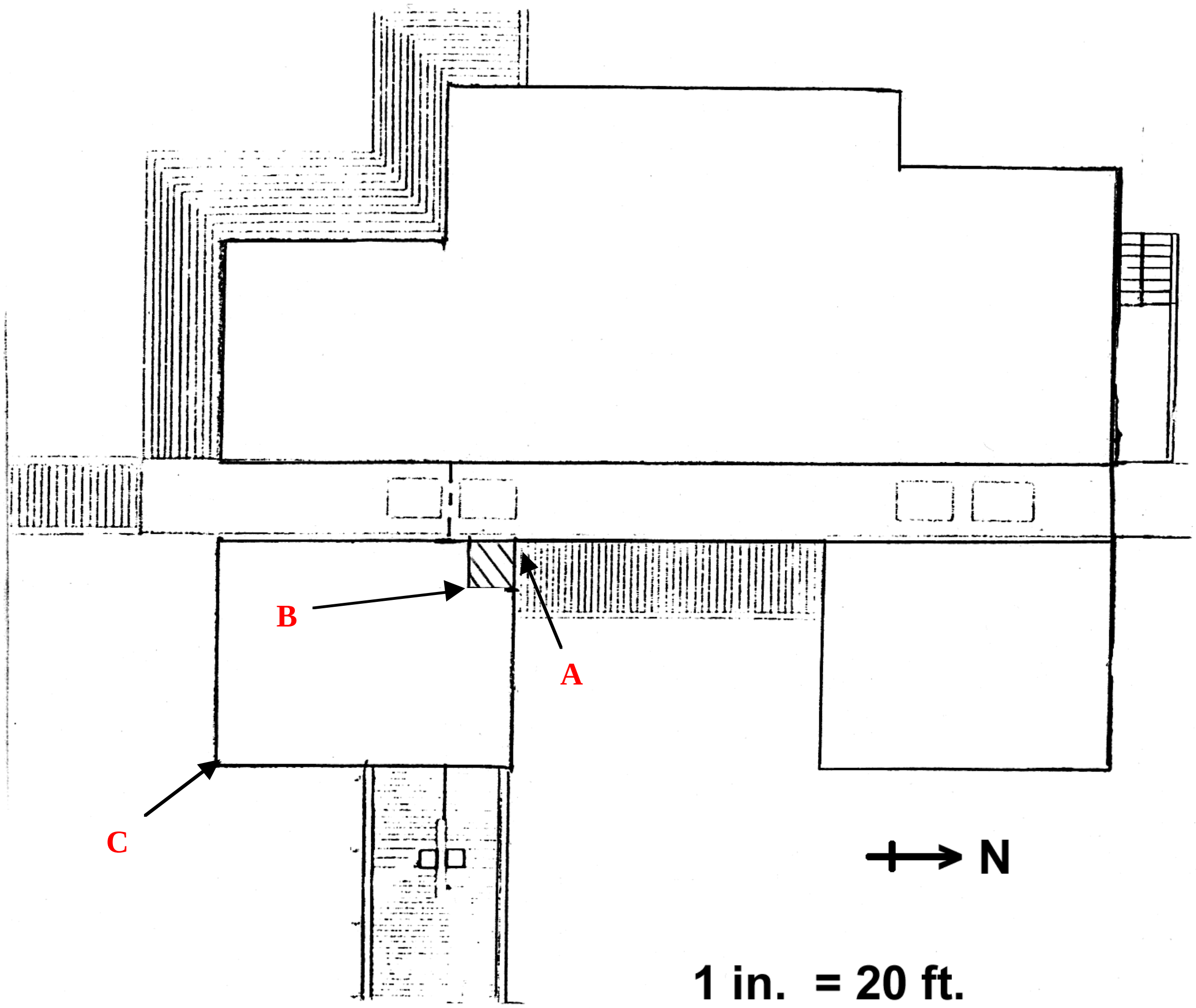


Figure F1: Plan view of KVC roofs showing locations of shading

The cross hatched area in Figure F1 measures 5 ft by 5 ft and should be avoided when panels are being mounted on the roof.

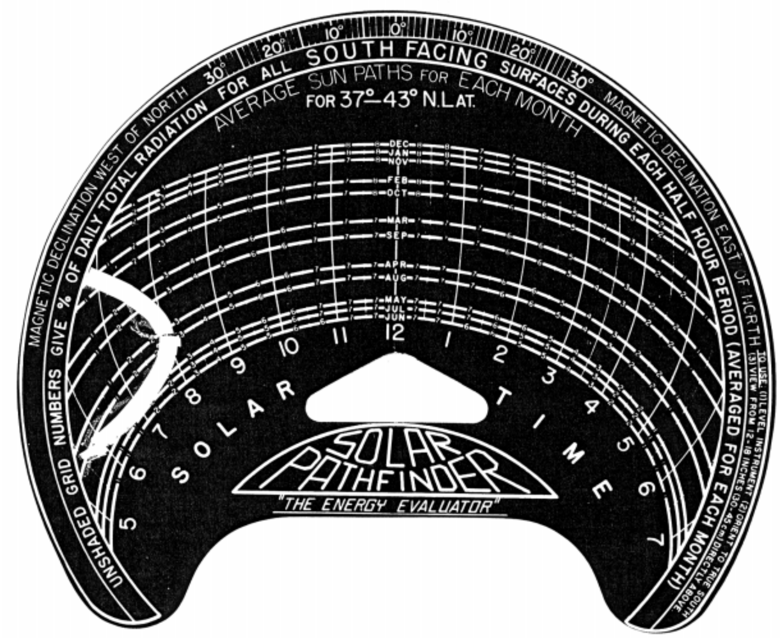


Figure F2: Sunpath diagram showing shading from the tree at the southeastern corner of the building.

The shading shown in Figure F2 corresponds to label **C** in Figure F1.

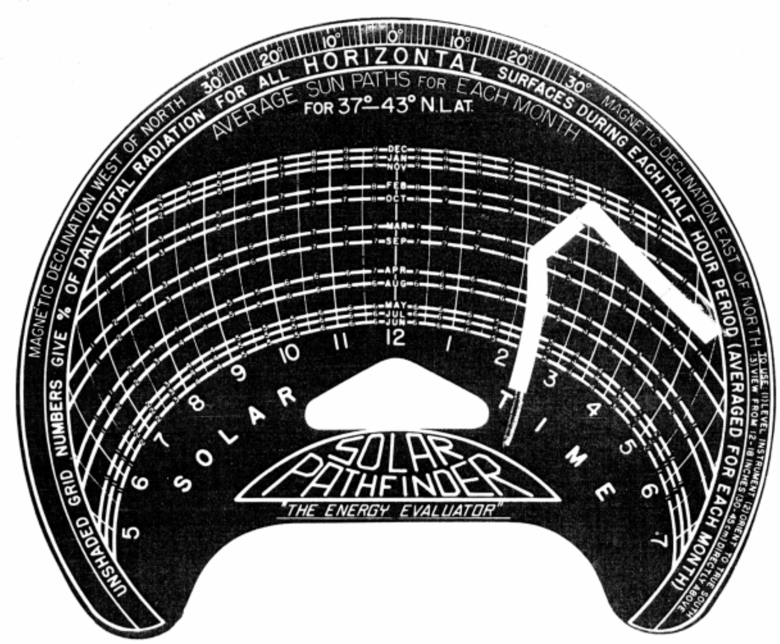


Figure F3:Sunpath diagram showing shading from west facing roof

The shading shown in Figure F3 corresponds to label **A** in Figure F1.

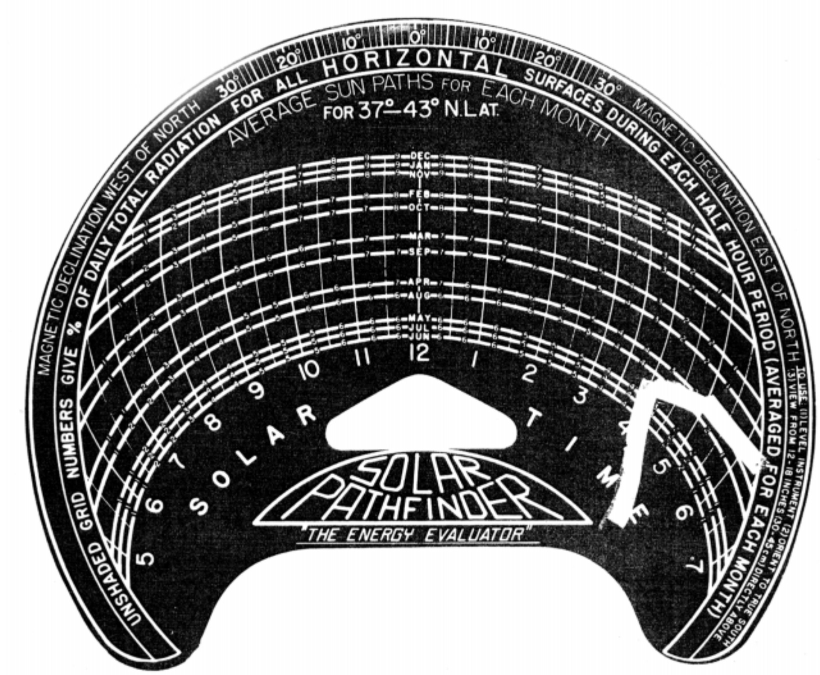


Figure F4: Another sunpath diagram showing shading from west facing roof

The shading shown in Figure F4 corresponds to label **B** in Figure F1.

Appendix G: PV Design Methods

We developed a Microsoft Excel spread sheet tool to determine the kilowatt-hour per month output of a PV array based on global horizontal insolation data from NSRDB for Arcata Ca.. The spreadsheet incorporated the Klein and Theilacker model which allows the global horizontal data to be adjusted for any collector and/or azimuth angle (Duffie and Beckman, 1991). The azimuth angle describes the compass direction that the collector surface faces, with regards to due south.

The slope of KVC's roofs (18 degrees) was used for the east-west roof mount designs. A series of derate factors were incorporated into the spreadsheet to account for power losses within the array due to a variety of factors (Table G1) (Xantrex 2004).

Table G1: Factors used to derate array output

Production tolerance	0.95
High temp losses	0.89
Dirt and dust	0.95
Mismatch losses	0.98
Wiring losses	0.97
Inverter losses	0.95
Total derate factor	0.73

Derate factors range from zero to one so for our designs we assume PV output will be 73% of its rated capacity.

Projected monthly kilowatt-hour usage of the facility was estimated by taking PG&E bills from June 2003 through May 2004 and subtracting the estimated monthly savings gained in efficiency upgrades, from each bill. The result was a reduced kilowatt hour estimate for each month. The annual net electrical energy surplus or deficit was set to the desired percentage of the total annual bill by using Excels solver function to determine the appropriate array size. This process was followed for the three east-west facing design options.

For the south facing array, the area of the picnic structure roof was used to determine the array size and then the percentage of the annual bill covered, was determined. Once the four array sizes were determined, the design focused on the largest array size and proceeded as follows:

- Identify potential PV modules based on eligibility for California Energy Commission (CEC) rebate, cost per watt, efficiency, fill factor and nameplate wattage rating. Fill factor is a measure of how close a module's performance curve matches an ideal performance curve. Six candidate modules were investigated (Table G2).
- Determine the number of modules in the array for each candidate module.

- Determine the maximum power voltage at the manufacturers specified Normal Operating Cell Temperature (NOCT) for each candidate module.
- Determine the maximum power voltage for a series configuration sub-array of modules ranging from 0 to 30 modules, for all candidates.

Table G2: Candidate modules researched for PV designs. Note that prices may change.

Module	Watts	Efficiency	$/watt
ASE -300-DGF/17	300	12.35%	$4.00
ASE -300-DGF/50	300	12.35%	$4.00
BP3160B	160	12.71%	$3.68
Kyocera KC167G	167	13.08%	$3.41
Shell SQ160-PC	160	12.48%	$4.08
BP 5170	170	13.95%	$3.99
Sharp NT-S5E1U	185	14.22%	$3.49

At this point a candidate inverter was chosen from the list of eligible inverters published by the CEC. The Maximum Power Point Tracking (MPPT) range, maximum input voltage and maximum input current were used for the remaining steps in the procedure. These steps proceeded as follows:

- Identify for each candidate module, the interval containing a series of discrete numbers of panels whose cumulative voltages lie within the MPPT range of the candidate inverter.
- For each candidate module's series configuration (within the MPPT range of the inverter), the necessary number of parallel sub-arrays were determined.
- The open circuit voltage of the full array was calculated for each series configuration and those that were above the specified maximum input voltage of the inverter were discarded.
- The short circuit current of the full array was calculated for each parallel configuration and those that were above the specified maximum input current of the inverter were discarded.

In this way an appropriate PV module and inverter were chosen for this application. Using the dimensions of the PV module of choice and the number of modules per sub-array, the actual array area and layout on the facility's roof were determined.
Once these steps were programmed into the spreadsheet tool for the largest array option, the other design options were modeled by changing the input cells and making other minor adjustments.

Kyocera's KC167G, 167 watt modules and Xantrex Technology Inc's PV series inverters were found to be a good match and so they were used in all three designs.

The 15 kW array would consist of five parallel sub-arrays of 18 modules in series. two sub-arrays would be mounted on the southernmost east facing roof and 3 sub-arrays would be mounted on the center, west facing roof. Table G3 shows the Balance of System (BOS) costs associated with this system.

Table G3: BOS costs for 15 kW_DC system

Balance of system costs (15 kW)					
Component	**quantity**	**unit price**	**price**	**model**	**source**
Combiner box	1	$581.00	$581.00	1-151258-01	Xantrex Technology Inc.
Fuses for combiner box	5	$15.70	$78.50	1-151159-01	Xantrex Technology Inc.
10 gauge wire (ft)	1200	$0.40	$480.00	52.9118	Alt. Energy Engineering
1 inch ID conduit (ft)	600	$0.33	$197.40	N/A	Piersons Building Center
Fittings for conduit	20	$1.79	$35.80	N/A	Piersons Building Center
DC disconnect	1	$782.00	$782.00	1-151160-01	Xantrex Technology Inc.
AC disconnect	1	$782.00	$782.00	1-151160-02	Xantrex Technology Inc.
Lockout disconnect switch (60 amp)	1	$186.00	$186.00	D10S2H	Square D
Lightning arrestor (AC side)	1	$40.00	$40.00	LA303R	Alt. Energy Engineering
Racking	4	$271.00	$1,084.00	SMR204	Alt. Energy Engineering
Racking	22	$226.00	$4,972.00	SMR168	Alt. Energy Engineering
Clamps for racking	4	$24.00	$96.00	CT-4C	Alt. Energy Engineering
Clamps for racking	4	$28.00	$112.00	CT-5C	Alt. Energy Engineering
Clamps for racking	18	$20.00	$360.00	CT-3C	Alt. Energy Engineering
Rack rail splice kits	6	$16.00	$96.00	SP2	Alt. Energy Engineering
Total			**$9,882.70**		

At a manufacturers specified Normal Operating Cell Temperature (NOCT) of 47 degrees Celsius in full sun, the sub-arrays would each supply eight amps at approximately 420 V_DC through 10 gauge wire in schedule 40 conduit to the mechanical room of KVC. There, the current from the eight subarrays would be combined in a suitable "combiner box". The 40 amps of combined PV current would then be routed through an appropriate DC disconnect switch and into the PV 15208. The inverter would then deliver 208 V_AC, three phase current at or below 46.3 amps to an appropriate AC disconnect switch. The AC current would then be routed through a lockable AC disconnect that is mounted in a convenient location for PG&E service personnel. Finally the current is wired into the main breaker panel for the facility loads. The installation of a new utility meter with net metering capability would also be required for this system.

Local contractors provided the following estimates for the 15 kW_DC system (Table G4).

Table G4: Estimates for 15kW_DC system from local contractors

Contractor	Estimated installation cos	Estimated total system cost before rebate
Solarwinds Northern Lights	$7,200	**$76,841**
"Roger"	$9000 - $15,000	**$80,000**
UNPEPP interns	$10,400	**$88,007**
Six Rivers Solar	No breakdown provided	**$114,750**

We used these estimates and variations between the BOS for the systems to estimate the installation costs of the 6 and 9 kW_DC systems.

Table G5 shows the contact information for the PV system installation contractors

Table G5: contact information for contractors

Company	**Solarwinds Northern Lights**	**"Roger"**	**Six Rivers Solar**
Phone Number	**(707) 498-2804**	**(707) 826-9901**	**(707) 443-5652**

The 9 kW_DC is otherwise identical to the first design except that the array current is 24 amps_DC under full sun so the DC fuses and switching gear are downsized. Table G5 shows the BOS costs associated with this system.

Table G6: List of components for 9 kW_DC system

Balance of system costs (9 kW)					
Component	**quantity**	**unit price**	**price**	**model**	**source**
Combiner box	1	$581.00	$581.00	1-151258-01	Xantrex Technology Inc.
Fuses for combiner box	3	$15.70	$47.10	1-151159-01	Xantrex Technology Inc.
10 gauge wire (ft)	720	$0.40	$288.00	52.9118	Alt. Energy Engineering
1 inch ID conduit (ft)	360	$0.33	$118.44	N/A	Piersons Building Center
Fittings for conduit	12	$1.79	$21.48	N/A	Piersons Building Center
DC disconnect	1	$782.00	$782.00	1-151160-01	Xantrex Technology Inc.
AC disconnect	1	$782.00	$782.00	1-151160-02	Xantrex Technology Inc.
Lockout disconnect switch (60 amp)	1	$186.00	$186.00	D10S2H	Square D
Lightning arrestor (AC side)	1	$40.00	$40.00	LA303R	Alt. Energy Engineering
Racking	0	$271.00	$0.00	SMR204	Alt. Energy Engineering
Racking	18	$226.00	$4,068.00	SMR168	Alt. Energy Engineering
Clamps for racking	0	$24.00	$0.00	CT-4C	Alt. Energy Engineering
Clamps for racking	0	$28.00	$0.00	CT-5C	Alt. Energy Engineering
Clamps for racking	18	$20.00	$360.00	CT-3C	Alt. Energy Engineering
Rack rail splice kits	6	$16.00	$96.00	SP2	Alt. Energy Engineering
Total			**$7,370.02**		

The third design option is a 6 kW_DC array on the southernmost east facing roof. Again the system design is comparable to that of the 15 kW_DC system except that the array current under full sun would be 16 amps_DC. Table G6 shows the BOS costs associated with this system.

Table G7: List of components for 6 kW_DC system

Balance of system costs (6 kW)					
Component	**quantity**	**unit price**	**price**	**model**	**source**
Combiner box	1	$581.00	$581.00	1-151258-01	Xantrex Technology Inc.
Fuses for combiner box	2	$15.70	$31.40	1-151159-01	Xantrex Technology Inc.
10 gauge wire (ft)	480	$0.40	$192.00	52.9118	Alt. Energy Engineering
1 inch ID conduit (ft)	240	$0.33	$78.96	N/A	Piersons Building Center
Fittings for conduit	8	$1.79	$14.32	N/A	Piersons Building Center
DC disconnect	1	$782.00	$782.00	1-151160-01	Xantrex Technology Inc.
AC disconnect	1	$782.00	$782.00	1-151160-02	Xantrex Technology Inc.
Lockout disconnect switch (60 amp)	1	$186.00	$186.00	D10S2H	Square D
Lightning arrestor (AC side)	1	$40.00	$40.00	LA303R	Alt. Energy Engineering
Racking	4	$271.00	$1,084.00	SMR204	Alt. Energy Engineering
Racking	4	$226.00	$904.00	SMR168	Alt. Energy Engineering
Clamps for racking	4	$24.00	$96.00	CT-4C	Alt. Energy Engineering
Clamps for racking	4	$28.00	$112.00	CT-5C	Alt. Energy Engineering
Clamps for racking	0	$20.00	$0.00	CT-3C	Alt. Energy Engineering
Rack rail splice kits	0	$16.00	$0.00	SP2	Alt. Energy Engineering
Total			**$4,883.68**		

Figure G1 below shows the layout of the panels and wiring on the roof of KVC for all three systems.

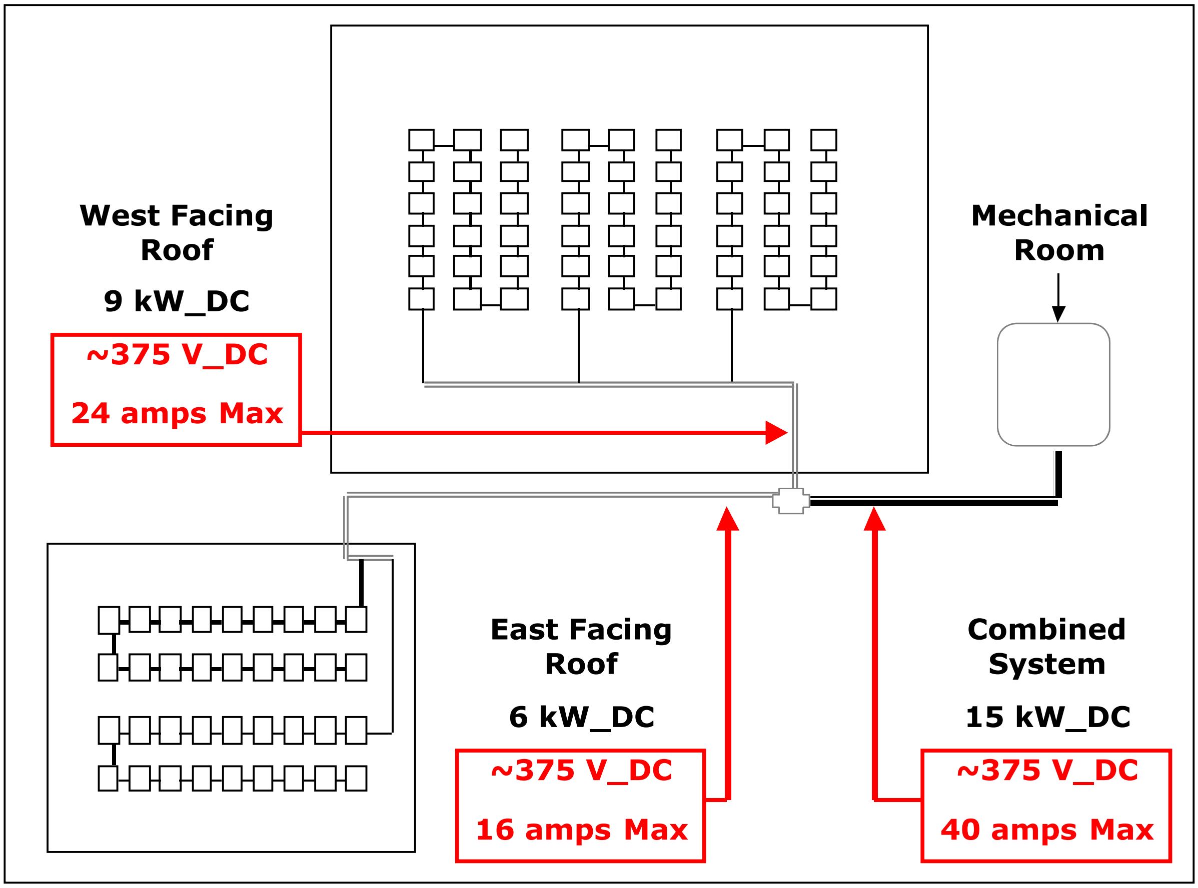


Figure G1: Diagram of PV systems for KVC.

Appendix H: Time-of-Use Rate Analysis

Time-of-Use rate analysis

The following steps were followed to estimate the effects that switching rate schedules would have on the KVC PV designs:

- We contacted PG&E and verified that KVC is eligible for A6 TOU rates.
- We determined the cost of TOU meter and the minimum annual charge under the A6 rate schedule.
- The projected load profile was broken down into hourly kilowatt-hour usage for an average day of the month, for each month of the year.
- The hourly loads were then summed within peak, part-peak, and off-peak rate periods for May 1 through October 31, and part-peak, and off peak rate periods for November 1 through April 30. These dates correspond to summer and winter billing periods.
- Next, we calculated the Percentages of the clear sky radiation falling onto the array surfaces during each hour of the day, for the average day of each month. (Zoellick, 2004)(Duffie and Beckman 1976).
- The annual energy production from both east and west facing arrays was distributed into the five rate periods using the percentages developed in the clear sky calculations.
- The annual totals for both PV production and loads were summed for each rate period and then multiplied by the appropriate PG&E $/kWh rate.
- Then the total annual earnings from PV production, and costs from electricity consumption, were compared to find the annual net bill or credit.