UNPEPP
2008

REDWOOD NATIONAL AND STATE PARKS HEADQUARTERS ENERGY STUDY

REDWOOD
NATIONAL & STATE
PARKS

Schatz Energy Research Center
SERC

HUMBOLDT STATE UNIVERSITY

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Executive Summary

The goals of the 2008 University-National Parks Energy Partnership (UNPEPP) project were as follows: to conduct an energy audit of the Redwood National and State Parks (RNSP) headquarters in Crescent City, CA and recommend energy conservation measures; to design a solar photovoltaic system for the same RNSP facility; and to generate an emissions inventory for the RNSPs.

The energy audit included both an electrical and gas analysis. Recommendations were generated to reduce the RNSP headquarters' annual electricity consumption by 11%, saving $930 annually. These retrofits have an estimated labor and maintenance cost of $2,500, with a simple payback period of 2.6 years. Recommendations to reduce the facility's annual propane consumption were also generated. These recommendations can reduce the facility's propane use by 46%, saving $7,000 annually. The propane retrofits have a labor and maintenance cost of $2000, with a simple payback period of 0.3 years.

Four alternative grid-intertied solar electric systems were developed for the RNSP headquarters facility:

1. A 6.15 kW_DC system expected to meet 9% of the facility's annual electrical demand and cost $44,400, with a combined simple payback period[1] of 24 years.
2. A 9.23 kW_DC system expected to meet 14% of the facility's annual electrical demand and cost $68,100, with a combined simple payback period of 31 years.
3. A 10.7 kW_DC system expected to meet 16% of the facility's annual electrical demand and cost $74,600, with a combined simple payback period of 32 years.
4. A 34.4 kW_DC system expected to meet 52% of the facility's annual electrical demand and cost $227,000, with a combined simple payback period of 46 years.

A combination of PV Alternative 4 (full rooftop utilization) with our recommended electricity conservation measures would result in approximately 50% of site electricity being met with on-site renewable generation. This is the maximum percentage we expect is feasible, based on the building design, internal loads, and rooftop area.

An emissions inventory for RNSPs was produced, analyzing greenhouse gas (GHG) emissions and criteria air pollutants. The RNSP has a gross emission of 2,600 metric tons of carbon equivalent (MTCE) GHGs annually, with the vast majority from mobile combustion (vehicles). The net emission of the RNSPs is -97,000 MTCE GHGs annually, significantly offset by GHGs sequestered by the park forests. The RNSP emits 2,225,000 lbs of criteria air pollutant (CAP) emissions annually, primarily from the National Park and visitors. Future research should be performed to refine estimated values and address areas of insufficient information.

[1] The percentage of demand and combined simple payback period estimates are based on expected PV output in combination with the recommended energy saving retrofits.

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AC	Alternating Current
ASHRAE	American Society of Heating, Refrigerating, and Air-Condition Engineers
°C	Degree Celsius
CAP	Criteria Air Pollutant
CFP	Climate Friendly Parks
CH_4	Methane
CLIP	Climate Leadership In Parks
CO	Carbon monoxide
CO_2	Carbon dioxide
DC	Direct Current
DOE	Department of Energy
EOLA	Equivalent Orifice Leakage Area
EPA	Environmental Protection Agency
eQUEST	Quick Energy Simulation Tool
°F	Degree Fahrenheit
ft^2	Square foot
ft^3	Cubic foot
GHG	Greenhouse Gas
GSA	General Service Administration
HFC	Hydrofluorocarbons
kWh	Kilowatt-hour
MTCE	Metric Tons of Carbon Equivalent
N_2O	Nitrous Oxide
NO_x	Nitrogen Oxides
NSRD	National Solar Radiation Database
OSHA	Occupational Safety and Health Administration
PM_{10}	Large Particulate Matter
$PM_{2.5}$	Small Particulate Matter

PV	Photovoltaic
RNSP	Redwood National and State Parks
SERC	Schatz Energy Research Center
SO_2	Sulfur Dioxide
UNPEPP	University-National Parks Energy Partnership Program
VOC	Volatile Organic Compounds

1 Introduction

This report summarizes work performed at the Redwood National and State Parks (RNSP) during the summer of 2008 by the University National Park Energy Partnership Program (UNPEPP) interns from Humboldt State University.

Established in 1997, UNPEPP provides valuable educational opportunities to students, while employing their knowledge towards the development of energy efficiency and renewable energy projects at Park facilities.

The UNPEPP model showcases the value of sustainable energy use in a myriad of ways; by demonstrating to park visitors the technologies and methods associated with energy efficiency and self generation; by quantifying and publicizing the monetary benefits of their implementation; and by developing student experts in the field of sustainable resources management.

The 2008 UNPEPP project carries on the collaboration between the Schatz Energy Research Center (SERC) and the RNSP. SERC is located at Humboldt State University in Arcata, California, and promotes the incorporation of renewable energy technologies into society through research activities and educational outreach. Since the first collaboration in 2000, SERC interns have conducted energy audits, designed solar hot water systems, designed photovoltaic systems, and compiled efficiency recommendations for numerous park facilities.

The 2008 project was comprised of three parts: an energy audit of the RNSP headquarters facility, a photovoltaic system design for the RNSP headquarters facility, and a greenhouse gas and criteria air pollutant emissions inventory for the entire RNSP system. The emissions inventory was a first for the RNSP system, and was carried out in accordance with the Climate Friendly Parks program (CFP). The CFP project is designed to make national parks leaders in reducing emissions and setting examples for sustainability. The objectives of the 2008 UNPEPP project were as follow:

I. Itemize and quantify the sources of propane and electricity demand within the RNSP headquarters facility.
II. Offer economically viable recommendations to the RNSP for reducing propane and electricity use at the facility.
III. Design a photovoltaic system for the RNSP facility to provide onsite electrical generation.
IV. Conduct a greenhouse gas emissions inventory for the entire RNSP system using the “Climate Leadership in Parks” estimation tools.

1.1 Facility Description

The RNSP headquarters is located at 1111 Second Street in Crescent City, on the Northern Coast of California (Figure 1). The facility serves as a visitor information center and the administrative headquarters for the parks. For a more detailed park map see Appendix 8.

The facility is 11480 square feet and was built in the mid 1970's. The majority of the building space is elevated on concrete pillars for protection from tsunamis (Figure 2). The bottom floor consists of a visitor center, storage areas, offices, and an employee lounge. The second floor consists of offices for the park employees, a conference room, and a large hallway. Each of the four concrete pillars holds a stairwell connecting the first and second floors[1].

Figure 1. Map of the Redwood National and State Parks.
Image from <http://maps.google.com>

[1] See Appendix B: RNSP Headquarters Floor Plan

Figure 2. Redwood National and State Parks Headquarters building.

Energy use at the facility includes electricity and propane consumption. Electric loads include: indoor/outdoor lighting, office appliances, space heaters, and active ventilation systems. Propane is consumed by one gas fireplace and eight high efficiency furnaces.

Pacific Power provides electricity to the facility under rate schedule A-32 for service to buildings requiring over 20 kW of power. Onsite propane storage tanks are filled monthly by Blue Star Gas and billed by the cubic foot.

Energy Intensity is defined as the energy consumed per square foot of building floor space, and provides a common basis for comparing energy use to other facilities of its type (Administration). The energy intensity of the headquarters facility was estimated, based on billing records from 2002 to 2008 as 68 kBTU/ft^2-per year. The energy intensity indexes of similar buildings range between 58-74 kBTU/ft^2-per year (Administration, Commercial Buildings Energy Consumption Survey).

2 Energy Audit

The facility energy audit was performed to characterize the various loads which constitute the facility's total energy consumption. In addition, the audit process investigated the thermal integrity of the building envelope and the performance of the HVAC system. The results of the audit were valuable for identifying the systems which contribute most to the total energy consumption; and thus pose the best opportunities for reduced energy demand.

2.1 Building Energy Analysis Model

The Quick Energy Simulation Tool (eQUEST) was used to aid in the energy audit process. A virtual representation of the RNSP facility was developed to simulate its energy demand as a function of the architecture, construction materials, operating schedules, and local weather patterns (Figure 3). This model was used to predict the effects on energy demand of various facility retrofits including: adding insulation, replacing windows, modifying thermostat settings, and repairing duct systems.

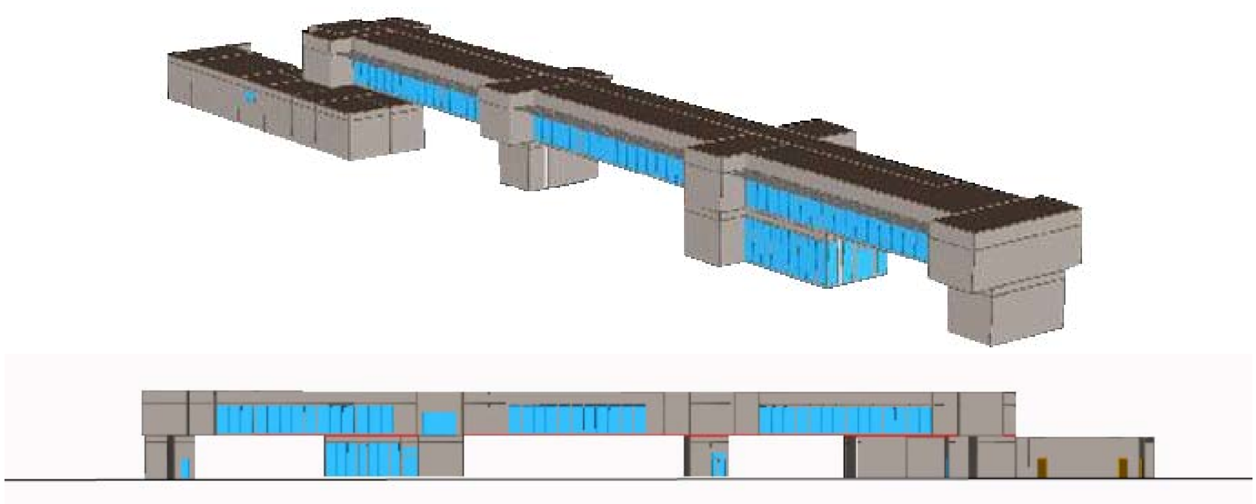

Figure 3. Virtual representation of the headquarters facility in eQuest.

2.2 Electrical Audit Results

The electrical portion of the energy audit was performed over a series of trips to the RNSP facility. Efforts were focused on characterizing three main load categories: lighting, appliances, and HVAC systems. The annual electricity consumed for all categories was estimated through a mixture of field measurements, continuous device monitoring, staff surveys, and estimations based on the judgment of SERC employees.

The annual electricity demand was estimated at 90,200 kWh[1], at an annual cost of $8300[2] (Figure 4). Records of historic electricity consumption were used to validate the results. The audit estimate is within 3% of the average annual consumption during the period of record[3].

Appliances account for 25% of the total facility electricity consumption. The largest loads are printers, computers, the beverage vending machine, and personal electric space heaters (Figure 4). Devices in these categories incur an estimated annual electricity expense of $1200. Appliance conservation measures have been identified to save $570 in annual electricity costs (6200 kWh/year). In addition to these measures we recommend instituting a policy giving purchasing priority to ENERGY STAR appliances, which have lower lifecycle energy costs than alternatives.

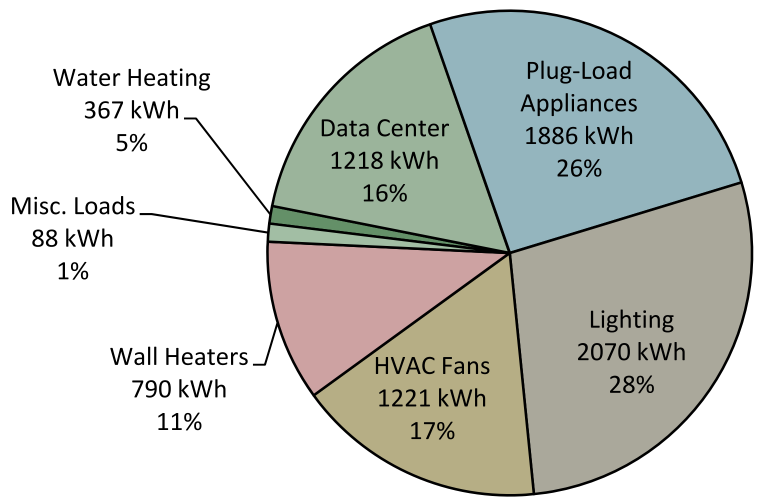

Figure 4. Current average monthly electricity consumption by end-use.

Indoor and outdoor lighting accounts for another 28% of the facility's electricity consumption. The largest lighting loads are overhead fluorescent lights and the metal halide outdoor lights. Park Electrician James Tiffany has retrofitted most of the facility lighting with high-efficiency bulbs and is committed to replacing the remaining halogen, incandescent, and T-12 bulbs with efficient alternatives at the end of their life. Additional savings opportunities remain: some areas of the facility are over-lit and some lack waste-minimizing lighting controls. Lighting reduction measures have been identified to save $360 in annual electricity costs (3900 kWh/yr).

[1] Final estimate is the average between an upper estimate of 91,800 kWh and a lower estimate of 88,200 kWh.
[2] Excluding baseline connection fees and taxes.
[3] Average electricity consumption from 2005 thru 2007: 93,300 kWh per year.

Conservation measures were identified to reduce the electrical consumption of the two largest load categories: Appliances and lighting. We estimate that the electrical consumption of the facility will be reduced by 11% through the following recommendations:

1. Reduce the number of office printers through increased networking.
2. Install a VendingMiser on the vending machine in the employee lounge.
3. Replace personal space heaters with low-wattage footrest heaters.
4. Mitigate phantom loads by switching off appliances via power strips.
5. Reduce office over-lighting by de-lamping fixtures and providing task lights.
6. Install light timers in both visitor center restrooms.

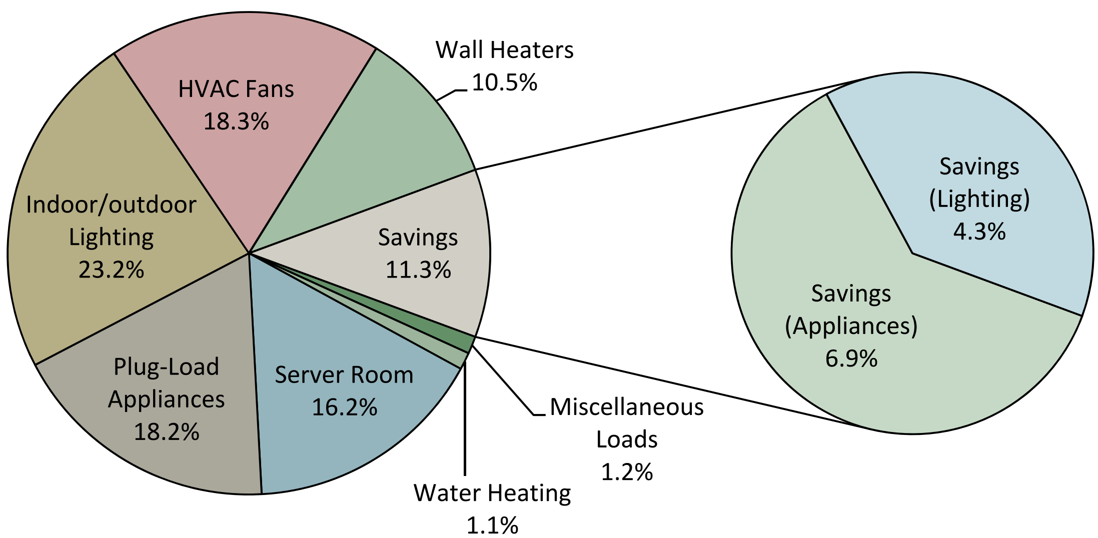

Figure 5. Annual average electricity consumption components after proposed conservation measures.

2.2.1 Recommendation #1: Office Printer Reduction

The facility operates a total of 27 printers which fall into four basic categories: small, medium, large, and print/fax combos (Figure 6). According to staff, most of the printers remain on throughout the workday and are shut off or entered into a power-save mode at the end of the day. Over the course of a year, we estimate that 35% of electricity consumed by a single medium printer is spent printing while the remaining 65% is consumed while idle[1].

[1] Assumptions: (1) Printer is actively printing 15 min. per workday. (2) The remaining day is spent idling, or in power-save mode. (3) Some printers are left in power-save mode through the night.

The number of printers reserved for use by one or two individuals should be minimized. Instead, the networked printers should be expanded so all office printing demands can be shared by a smaller array of machines strategically located. Information Technology specialist Joel Gordon was consulted regarding the idea of an expanded printer network. Mr. Gordon was supportive of the idea on its energy saving merits as well as its potential to substantially reduce the costs of printer maintenance. Mr. Gordon estimated that the entire upstairs printing demand could be met with 5 printers[1].

We recommend that ten medium printers and four small printers be removed from the upstairs offices. In addition, the older printers located in office #17 and the visitor center could be replaced with newer printers no longer needed upstairs. These low-cost measures would reduce the number of printers in the facility from 27 to 13 and save an estimated $140[2] in annual electricity costs.

Small Printer	Medium Printer	Large Printer	Printer/Fax
QTY: 4	QTY: 18	QTY: 1	QTY:4

Figure 6. Types and quantities of printers found at RNSP headquarters.

Images from <www.physics.hku>,<inkjet-laser.com>,<www.pricerunner.com>, <www.pricemin.com>

2.2.2 Recommendation #2: Vending Machine Energy Management

The beverage vending machine, located in the first floor employee lounge, operates regardless of the activity level in the facility even during non-business hours. This electrically demanding task leads to a substantial operating cost of $320 per year.

A cost-effective measure for minimizing vending machine consumption is to install a VendingMiser®[3], which utilizes an infrared sensor to power down the machine when the surrounding area is vacant. The device monitors room temperature and automatically re-powers the refrigerator at intervals to ensure the product maintains an acceptable chill. This measure is estimated to reduce the vending machine energy consumption by 50%, leading to annual savings of $160. A $75 rebate for installing a VendingMiser is available through Pacific Power's FinAnswer Express program.[4]

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[1] Excludes printer/fax combos and printers which are kept private for confidentiality purposes.
[2] Estimate excludes changes in lifetime operation and maintenance costs.
[3] GSA Advantage Item #VM160. See Appendix 10.4.
[4] Visit www.pacificpower.net for Finanswer Express details.

2.2.3 Recommendation #3: Personal Space Heater Replacement

Personal electric heaters are used in various offices to supplement the furnace system and the wall mounted heaters. The power demand of these heaters ranges between 800-1300 watts. Cumulatively, these units incur an estimated annual electricity cost of $185.

An energy efficient option for meeting the comfort needs of employees is to replace the space heaters with low-wattage, heating footrests[1] (Figure 8). These heaters can be used in an office as a footrest, or as a freestanding panel. This method of heating minimizes energy losses to the environment by concentrating energy on the occupant. Eliminating the current space heaters by substitution with low-wattage heaters will save an estimated $170 in annual electricity costs.

Figure 7. VendingMiser with passive infrared sensor. Available through GSA.

Image from <www.austinenergy.com>

Figure 8. Radiant heating footrests. Available through GSA.

Image from < www.healiohealth.com>

2.2.4 Recommendation #4: Phantom Load Management

We estimate that approximately 10% of the annual electricity used by all appliances in this facility is being consumed while they are turned off[2]. These devices are deemed *phantom loads*; and they are found on devices including but not limited to, computer monitors, stereos, and printers (Figure 9). Although these loads are individually small (1 watt – 5 watts), they are widespread, and run for extended periods of time.

We recommend that phantom loads be mitigated by enabling and encouraging employees to disable their office appliances at the end of each day with the aid of a power strip. Conservatively, this low-cost measure will save an estimated $100 in annual electricity costs.

An alternative strategy for mitigating phantom loads is to consider phasing out the current surge protectors for Smart Power Strips (Figure 10). Aside from offering surge protection, these devices allow one appliance to be designated as the "control device", which when shut off, triggers the power strip to disable three other designated devices. For example, if an office computer is designated as the control device; at the end of the day when an employee shuts down the computer it will trigger the power strip to also cut power to the monitor, printer, and desktop

[1] GSA Advantage Item #MCG10604. For product details see Appendix 10.5.
[2] This estimate does not account for the energy use of devices which are inadvertently left on after business hours.

calculator, eliminating their phantom loads before leaving the office. This product is not currently available through GSA though it may be purchased from a variety of internet sources at prices ranging from $25-$40.

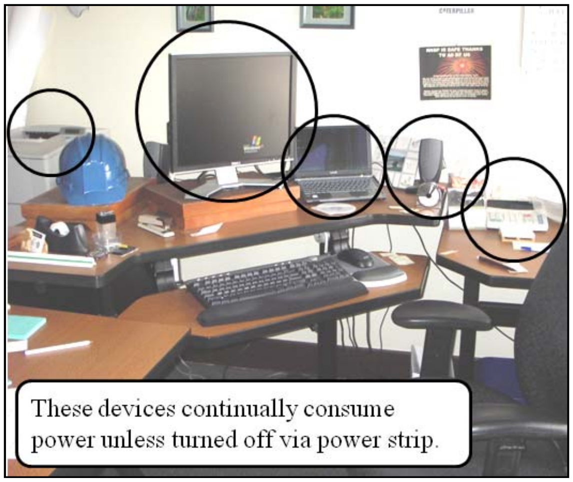

Figure 9. Phantom load harboring appliances commonly found in RNSP offices.

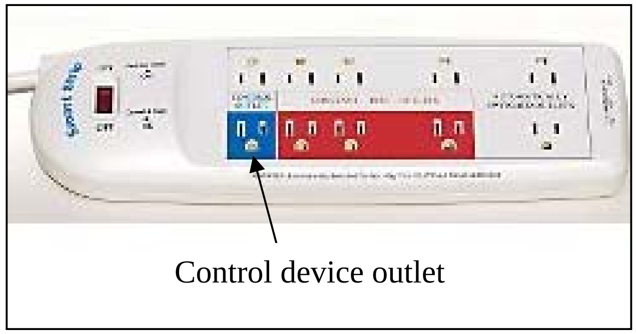

Figure 10. Smart Power Strip for managing phantom loads. *Image from <www.gaiam.com>*

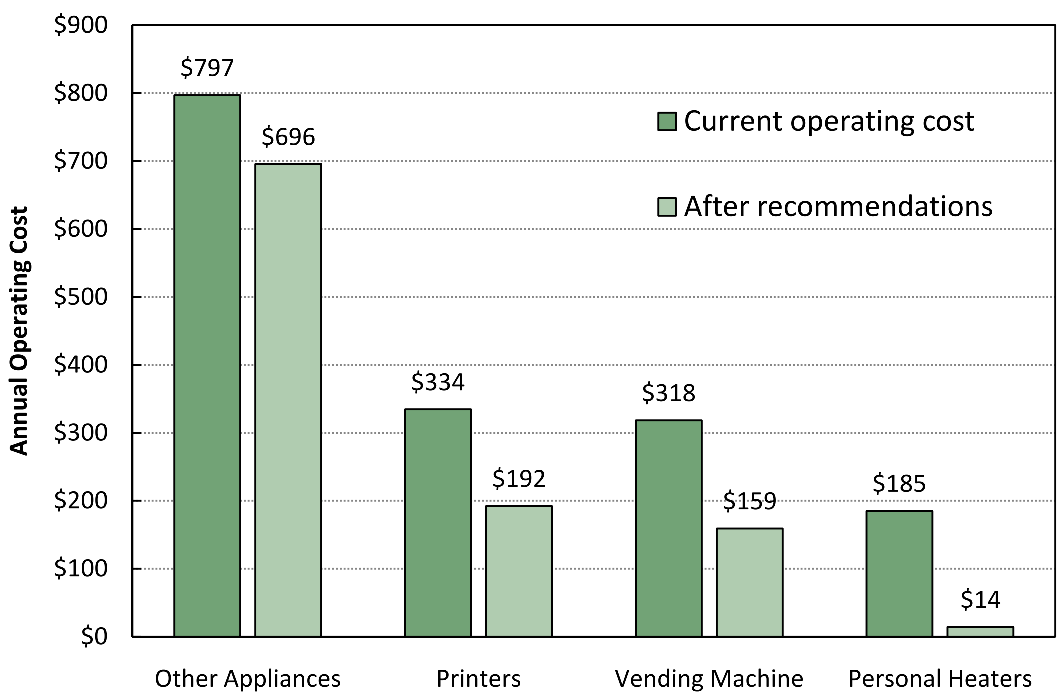

Figure 11. Annual electricity expenditures by appliance.

2.2.5 Recommendation #5: Office Light Delamping and Task Lighting

To reconcile the lighting needs of employees with the desire to minimize electrical consumption, we recommend that the following two steps be taken: (1) Overhead office lighting should be reduced by de-lamping or by re-wiring the lights with separate control switches. (2) Desk lights should be provided at all workstations to improve lighting conditions and reduce the need for overhead lights.

The Occupational Safety and Health Administration recommends lighting levels between 20-50 *footcandles* (fc) for a computerized office (OSHA Ergonomic Solutions). A light meter was used to measure interior lighting levels in the second-floor offices. The average light intensity reading was 68 fc[1] with all window shades open and overhead lights on. Additional measurements made without overhead lighting indicated an average daylighting level of 16.5 fc. According to staff, the overhead office lighting is used during most business hours except on the sunniest of days[2]. A typical RNSP office is lit by six to twelve 32 watt fluorescent fixtures which share a single switch. Staff indicated that only a portion of the overhead lighting was actually needed during the day. The lighting measurements support staff testimony that daylight alone is not always sufficient and supplementing daylight with all the overhead lights leads to over lit conditions.

The eQUEST model was used to predict the office lighting demand for periods when daylight provides less than 50 fc of interior illumination. Comparing the model predictions to the light usage estimated in the energy audit, we estimate that 67% of the artificial light usage is to light offices beyond the OSHA standard.

Stepped light switches were also modeled in eQuest. The simulation parameters were set to turn half of the office lights off when daylighting provided at least 25 fc to the work stations, and to turn all of the lights off at a daylight level of 50 fc. The model results indicate that allowing employees the option to turn all or only half of the overhead office lights on, the total lighting electricity demand could be reduced by 19%[3]. According to the office electrical plans, most of the overhead office fixtures are wired in series rather than parallel. For this reason, separating lights onto individual switches may be cost prohibitive unless other work is to be performed simultaneously.

In the short term, we recommend that two fixtures per office be delamped. This measure will maintain appropriate lighting levels for occupants while minimizing excess consumption. This measure will reduce the lighting electricity consumption by 7% and save $137 in annual costs.

[1] Measurements were made during peak daylight hours on a moderately overcast day. Actual lighting values may be higher depending on daylight influences.
[2] Overhead office light use is conservatively estimated at four hours per day during the work week.
[3] This savings projection represents the maximum attainable savings. The model assumes that employees will actively manage lighting levels as they change throughout the day and year.

In addition to delamping, we recommend that desk lights be provided at all office workstations. A 30-watt fluorescent desk lamp[1] (Figure 12) can provide enough supplementary light to render the overhead lights obsolete during most business hours, while consuming far less electricity. This measure alone may save $257 annually in avoided electricity costs[2] (Figure 13). Other benefits include increased occupant control over their workstation light level, reduced maintenance on overhead fixtures, and improved interior ambience.

The combined measures of task lighting and delamping will reduce lighting electricity consumption by 14% and save $328 annually (Figure 13).

Figure 12. Adjustable desk lamp available through GSA.
Image from <www.sz-wholesale.com>

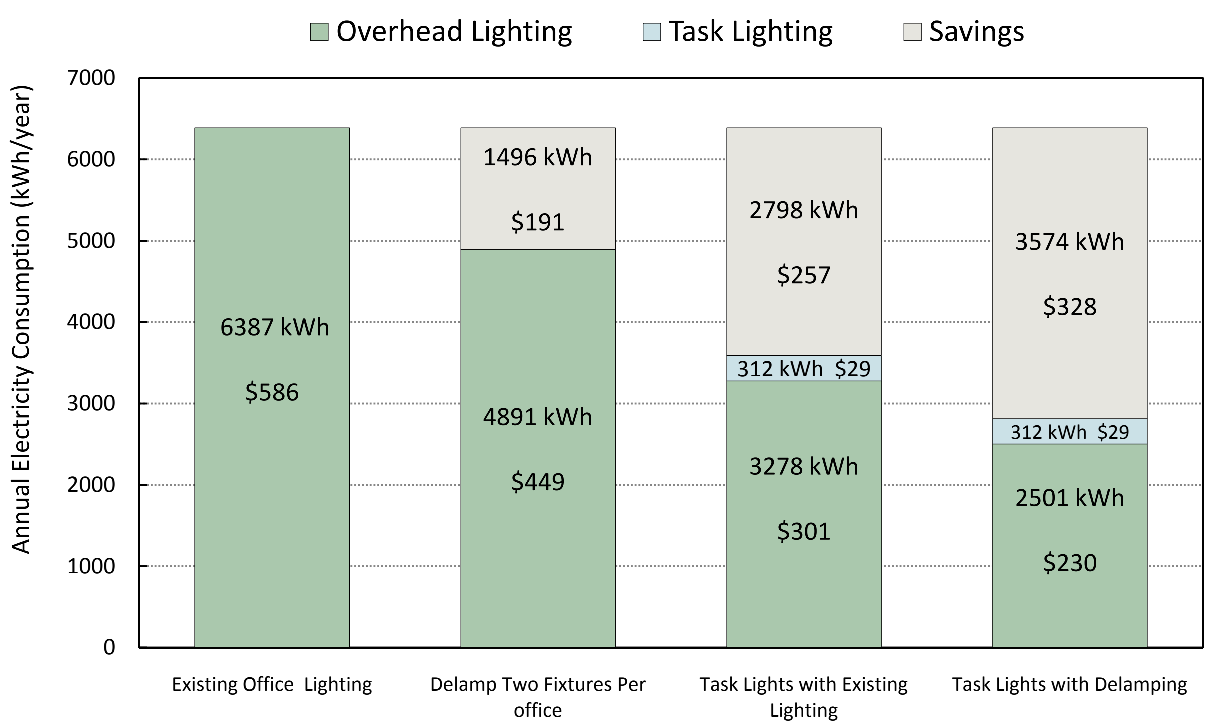

Figure 13. Annual electricity demand of office lighting alternatives.

[1] GSA Advantage Item # 6230-00-299-7771
[2] Assuming task light offsets overhead light use by 2.5 hours per day on average.

2.2.6 Recommendation # 6: Restroom Timed Light Switches

The visitor center restrooms are open to public use during business hours and are used by 30 to 40 persons per day[1]. Each restroom is lit by a single 32 watt fluorescent bulb controlled by a standard on/off switch.

The energy saving potential of implementing timed light switches (Figure 14) was investigated by comparing light usage patterns in the visitor center restrooms to those of the upstairs, which are controlled by timed switches. Light usage was monitored in both cases with a photo-sensing HOBO data logger (Figure 15) tuned to record when the overhead lighting was on or off during the course of a week.

Figure 14. Digital timed light switch, available through GSA.
Image from: <www.gsaadvantage.gov>

Figure 15. Photo-sensing HOBO data logger installed in the visitor center bathroom.

The monitoring results show that the upstairs restroom lights turn on and off in brief, consistent intervals (Figure 16). This is a result of staff conscientiousness and the timed light switches which automatically turn off the lights after 15 minutes. In contrast, the downstairs lighting patterns are much less consistent and reflect the whim of the various public users (Figure 17).

The visitor center restroom lights are commonly turned off between uses. However, multiple intervals were observed where the lights were left on for extended periods. These lapses are largely responsible for the high average light usage rate of 8.6 hours per day. In comparison, the upstairs timed lights run for an average of 0.5 hours per day. Thus, for an estimated three-fold difference in daily traffic, the light usage in the downstairs restrooms is 17 times greater than the usage in the timer-controlled restrooms.

[1] Approximation provided by park staff.

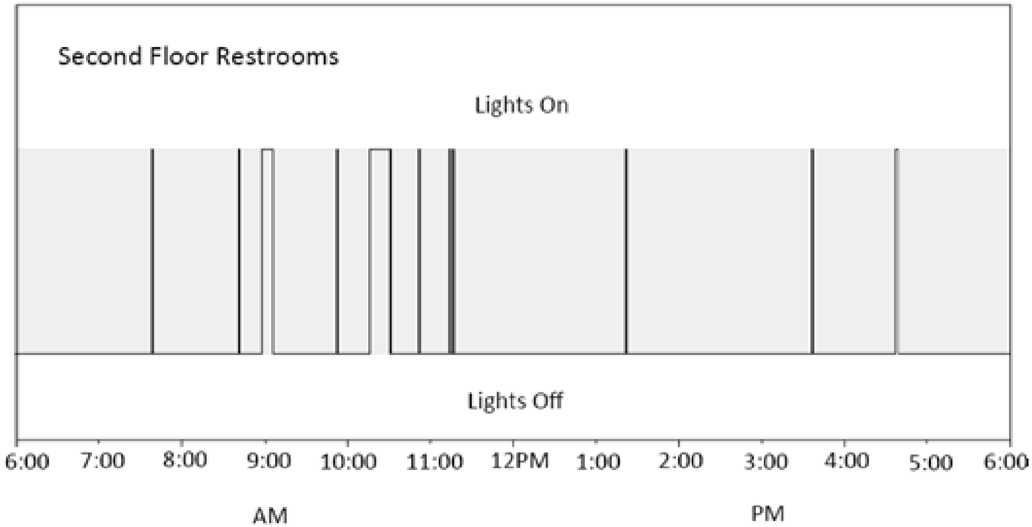

Figure 16. One day record of light usage in the second floor men's restroom. Monitored from 6/03/08 to 6/11/08.

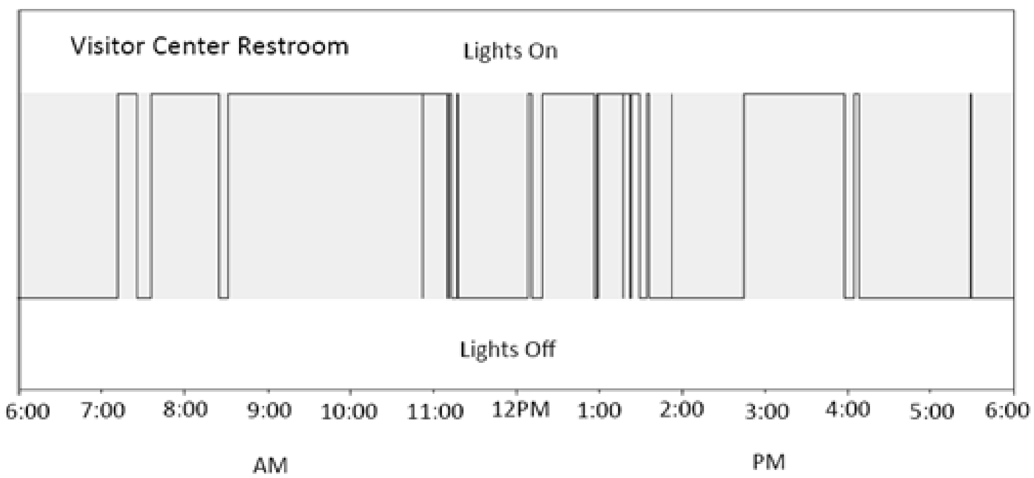

Figure 17. One day record of light usage in the first floor visitor center restroom. Monitored from 6/03/08 to 6/11/08.

We recommend timed light switches[1] be installed in both visitor center restrooms. The savings associated with timed light switches are determined by assuming that their implementation will bring the light usage into proportion with the daily traffic, or a level roughly three times greater than the upstairs restrooms. This amounts to an estimated usage of 1.5 hours per day or an 82% reduction from current levels. This measure will save $31 in annual electricity costs. Occupancy sensors are an alternative to light timers, which come at a higher cost, but have the advantage of never turning off the lights while the restroom is in use. The FinAnswer Express program offers rebates of $20 and $30 for installing timed switches or occupancy sensors of respectively.

[1] GSA Advantage Item #523838, Model#EJ500C. See Appendix 10.6: Digital timed light switch.

2.3 Summary of Electrical Audit

The recommended conservation measures are cost-effective for reducing the electrical demand of the facility. Performing the recommended reductions combined with installation of PV generators will result in a greater fraction of the site energy being met with renewable sources and reduce the environmental impacts of energy use at RNSP headquarters. The total payback period for all of the measures is 2.6 years (Table 1). For an economic breakdown of each recommendation see Appendix 10.2.

Table 1. Economic summary of electricity conservation measures.

Current Annual Load (kWh)	90200
Projected Annual Load (kWh)	80000
Projected Annual Electricity Savings (kWh)	10200
Percent Annual Electricity Savings	11%
Projected Annual Cost Savings	$ 900
Capital costs for retrofits	$ 2,500
Rebates from Pacific Power	$ 100
Net Cost for retrofits	$ 2,400
Simple payback period	**2.6 years**

3 Propane Audit

The propane audit included a review of the historic consumption, performance testing of HVAC components, and continuous monitoring of the facility furnace systems. The results of the audit include: projections of propane consumption since the facility furnaces were replaced, identification of HVAC improvement opportunities, and the associated energy and cost savings associated with recommended retrofits.

Propane use at the headquarters facility is divided between the visitor center fireplace and eight forced air furnaces serving the second floor HVAC zones (Figure 19). The average propane consumption from 2005 through 2007 was determined to be 198,000 ft^3 per year[1] costing $11,500 annually (Figure 19).

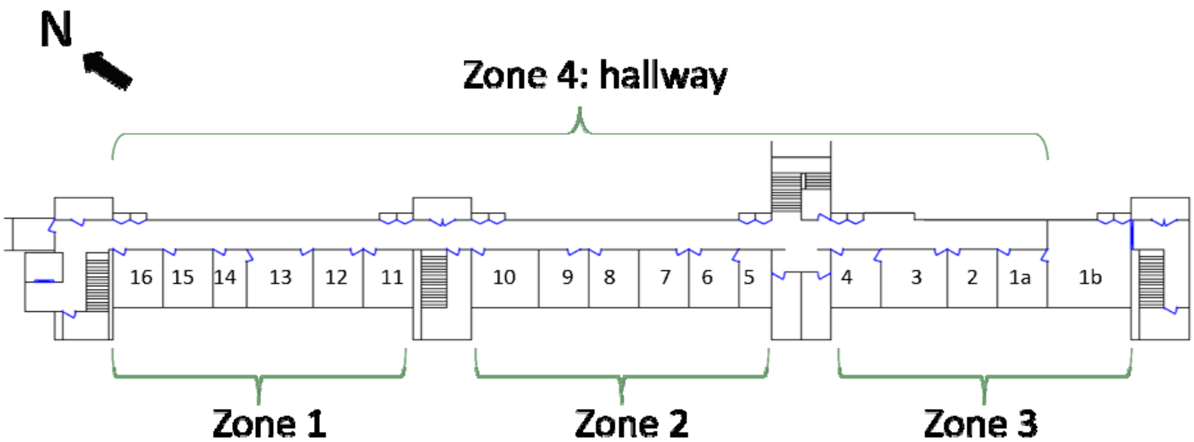

Figure 18. Mapping of the second floor HVAC zones.

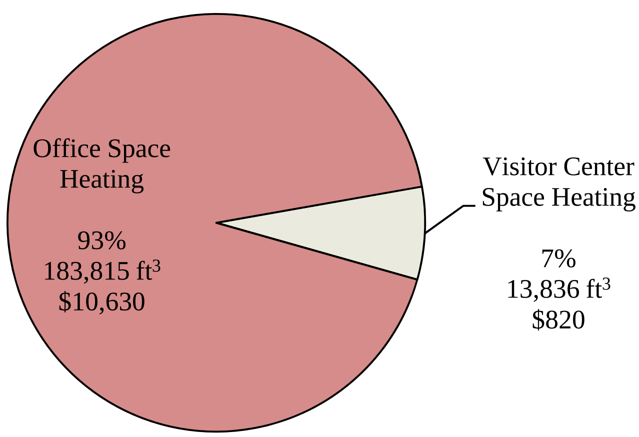

Figure 19. Average annual propane consumption by end-use from 2005 through 2007.

[1] 494 million BTU energy content.

In November 2007, the facility's outdated air handling units were replaced with eight high efficiency condensing furnaces. Due to these recent upgrades, the historic propane consumption records are not fully applicable to the current HVAC conditions and heating demands. For example, the 2008 propane consumption figures have exceeded the consumption for all of 2007[1].

The propane consumption records for the months since the furnace replacement are not directly comparable to pre-retrofit consumption due to three factors: (1) the furnace replacement was followed by a "break-in" period where the units were run beyond typical levels. (2) Damage to the supply ducting appears to have occurred during the furnace replacement. (3) The recently installed thermostats are not programmed optimally.

Due to these data quality issues, eQUEST was utilized to develop a prediction for the facility's annual propane demand, given the current HVAC technologies and duct performance characteristics. The model's projected annual consumption is less than the 2008's current usage trend[2]; but is greater than the average annual consumption from 2005 to 2007. These results reflect that the model rightly excludes the furnaces' post-installation usage spike, while accounting for supply duct damage which some has occurred since the furnace replacement (Figure 20).

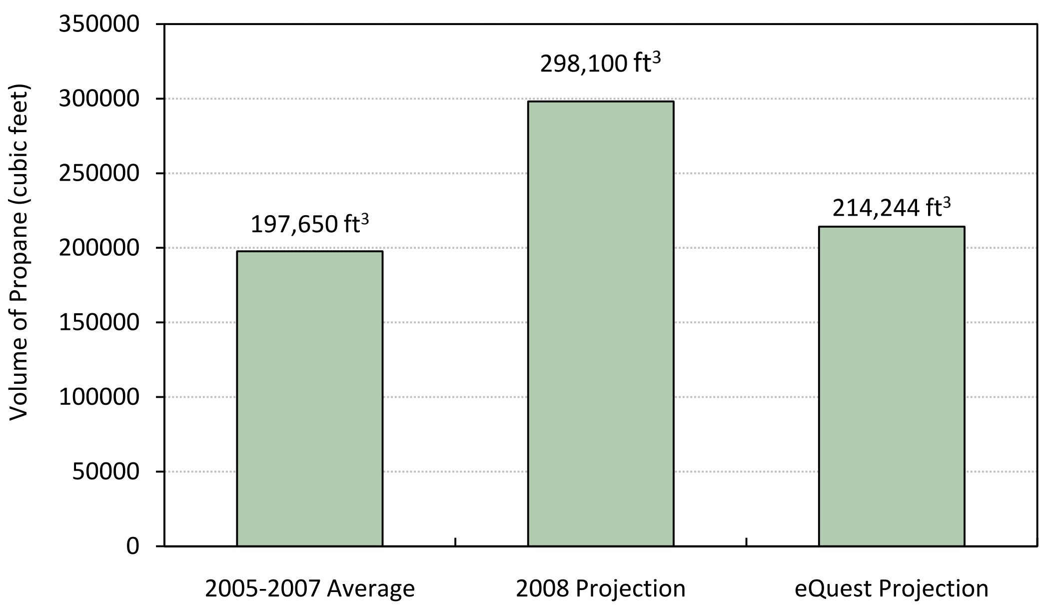

Figure 20. Annual energy consumption in the form of propane.

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[1] As of 5/08, 413 MBTU (165200 ft^3) of propane has been used by RNSP headquarters.

[2] Assuming a constant propane consumption (ft^3) to monthly heating degree days ratio of 56 for the remainder of 2008.

3.1 Furnace Performance Monitoring

A combustion gas analyzer (Figure 21) was utilized to test the combustion efficiency for six of the eight furnaces (Figure 22). All of the units are new condensing furnaces with Annual Fuel Utilization Efficiency ratings of 92%. All of the tested furnaces were determined to be functioning at a high efficiency, in the range of 90%. The two Zone 3 furnaces were not tested because their thermostat temperature could not be adjusted to engage the furnaces.

Figure 21. Fyrite Pro 125 Combustion Gas Analzyer.
Image from <www.apexinst.com>

Figure 22. Combustion gas analyzer being inserted into the furnace exhaust stream.

3.2 Duct Leakage Assessment

Duct leakiness was suspected as a potential factor affecting building energy efficiency due to the system's age (installed 1974) and employee testaments of an imbalance in the distribution of heated air to the offices. Air leaks in the supply ductwork contribute to inflated energy costs due to the loss of heated air to unconditioned crawlspaces (Figure 23). In addition to reduced efficiency, duct leakiness contributes to the degradation of indoor air quality as dust, mold spores, and insulation fibers are drawn into the return ducting and delivered to the building interior.

A Duct Blaster (Figure 24) was used to perform Total Leakage Pressurization tests on the duct systems serving Zone 1 of the 2nd floor, and the entire upstairs hallway (Zone 4). The goal of the test procedure was to measure the total leakage air leakage rate out of the ductwork. The air leakage rate is the air flow through the Duct Blaster fan that is required to maintain a pressure of 25 pascals above atmospheric pressure in the ducting. The measured fan flow rate is equivalent to the total leakage rate out of the ductwork when at this operating pressure.

The Duct Blaster fan was unable to fully pressurize either of the systems due to their size and leakage levels. Leakage rates were estimated using extrapolation factors provided in the test procedure literature. Measurements were further adjusted to reflect only supply duct leakage[1], and to account for the actual operating pressure being less than the test pressure[2].

The final leakage results are reported as a flow rate, and as the Equivalent Orifice Leakage Area (EOLA) (Table 2). The EOLA represents the theoretical sum area of all the individual leaks. The supply duct delivery leakage was determined by comparing the measured leakage rate to the estimated design air delivery rate[3].

Table 2. Total Leakage Pressurization Test results.

Location	Leakage Rate	EOLA	Duct Delivery Air Leakage[4]
North Offices (zone 1)	463 cfm	1.2 ft^2	25%
Hallway (zone 4)	640 cfm	1.8 ft^2	34%

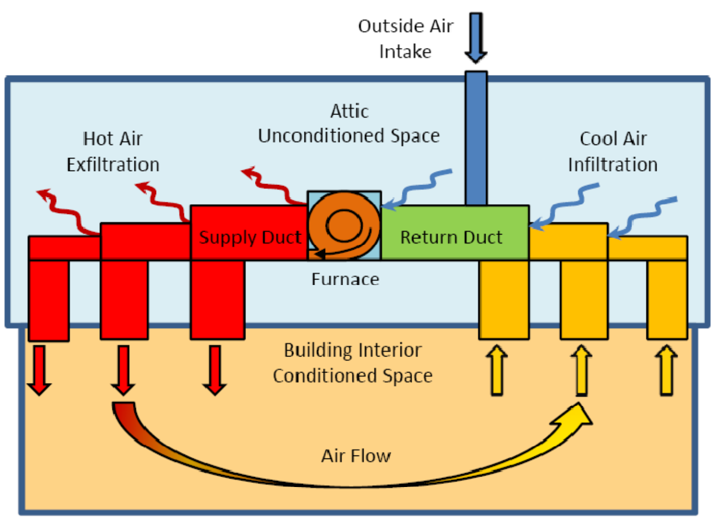

Figure 23. Modes of air leakage in and out of forced air distribution systems.

[1] Total leakage was divided between the supply and return lines based upon their fraction of total duct surface area.
[2] Actual operating pressure is estimated conservatively at 10 pascals above ambient pressure. A leakage derate factor of 0.58 was provided by the literature.
[3] The design delivery air flow is estimated at 1900 cfm per furnace pair. This value was determined from the design heat output of the furnaces (69,000 BTU/hr), the physical properties of air, and an air supply temperature of 140 ˚F.
[4] Title 24 requires duct leakage less than 6%.

Figure 24. Example of Duct Blaster operation.
Image from <www.energyconservatory.com>

3.3 Duct Inspection

Inspections were made of the duct systems to determine the primary cause(s) of their poor performance. The inspections resulted in the following conclusions:

The "new" duct-board near the furnaces is in poor condition. This ducting is composed of duct-board spliced using foil backed butyl-tape. Multiple leaks were found in locations where the tape had peeled off and exposed portions of the conditioned air stream (Figure 25). The leaks in this section are likely to have the highest leakage rates due to the high local duct pressure closer to the furnaces.

The supply ductwork is in poor condition. Problems appear to stem mainly from the age and fragility of the duct-board used in construction. Weaknesses include the loss of duct-board rigidity, absence of plastic radiant/protective sheathing (Figure 27), dust accumulation, degraded duct tape seals, and the presence of large holes at failed seals (Figure 28).

The return ductwork is in satisfactory condition. This ducting is made of sheet metal and no serious structural problems were observed. However, the use of duct-tape to seal duct joints is not a recommended sealing method and may account for a portion of the leakage originating in the return system (Figure 29).

Figure 25. Gaps left where joint tape has separated in the new Zone 2 supply ducting.

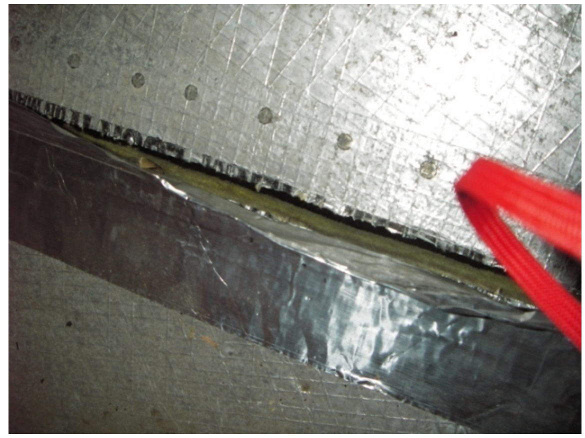

Figure 26. Failed duct-board joint in the new supply ducting.

Figure 27. Non-rigid supply ducting showing evidence of degradation.

Figure 28. Large void found in Zone 1 supply ducting where tape seal has failed.

Figure 29. A degraded seal on the supply ducting.

Figure 30. Duct tape seals on the return ducting.

3.4 HVAC Retrofits

According to staff, the facility's HVAC system struggles to maintain interior comfort levels for its occupants. The results of the field inspection and duct testing attest that the system's ineffectiveness is due to air distribution imbalance and poor supply duct performance. The eQUEST model was used to simulate the effects of retrofit measures on the building's propane consumption. Through the following HVAC modifications, we estimate that annual propane use may be reduced by 46%, with savings of $7000 annually[1]. Recommendations include:

1. Repair at least 50% of the leaks in the supply ducting.
2. Modify thermostat schedules and temperature settings.
3. Rebalance all four HVAC systems.

3.4.1 Duct Repairs

Repairing the facility ductwork has been identified as the most effective measure for reducing building propane consumption and improving the comfort levels of the interior. Current leakage levels are four times higher than the leakage standards defined in the Title 24 building codes[2].

To improve the performance of the air distribution system, all duct joints and grill connections should be sealed using a mastic seal or metal backed butyl tape. The recently installed duct-board nearest the furnaces should be made a priority repair due to its easy accessibility and the severity of the damage. Degrading duct tape seals, especially at supply register connections should be replaced with a mastic seal or otherwise reinforced.

At minimum, 50% of the leaks in the supply ducting should be sealed. This measure alone will reduce annual propane consumption by 34% and save $5200 in annual propane expenditures. The labor and material costs of this measure will vary widely depending on the type of sealing method, and whether repairs are completed by an outside contractor or by park staff. At an estimated project cost of $2000 this measure offers a simple payback of 0.4 years.

If 75% of the leaks in the supply ducting are sealed the annual propane consumption could be reduced by 52%, saving $7400 annually.

3.4.2 System Balancing

According to documents provided by park staff, the building's HVAC system was not rebalanced after the recent furnace upgrade. All four duct systems should be rebalanced by a qualified contractor to establish proper air distribution through the building.

In the short term, building personnel should ensure that all air return registers are fully open. During field visits we noted that damper settings on air return registers have been adjusted in an effort to regulate office temperature. These registers, which span the east side of all interior office ceilings must remain open to allow the air distribution system to function as designed.

[1] Based on a 46% reduction of the annual propane consumption projected by the eQUEST building model.
[2] New duct installations are required to demonstrate duct leakage less than 6% for Title 24 compliance.

Closing these registers can effectively restrict the air flow back to the furnace unit, leading to reduced office comfort and ventilation due to pressurization. Such restriction also reduces furnace performance because any deficit in return air flow to the furnace will be compensated by cold outside air.

3.4.3 Thermostat Adjustment

The second floor interior temperature is regulated via four programmable thermostats. Currently, each of the thermostats has unique temperature settings and schedules (Figure 31). For example, the second floor hallway is held above 64˚F until 3:30 AM; at which time the furnace settings change to maintain the hallway temperature at 72˚F till 5:30 PM. In contrast, the northernmost offices are held above 62˚F until 4:00 AM; at which time the settings change to maintain the office temperature at 72˚F till 4:00 PM. In order to streamline the management of the interior climate, we recommend all thermostats be adjusted to common settings.

The recommended thermostat program will maintain a building temperature of 68˚F during occupied hours beginning at 6:00 AM, and revert to a nighttime setting of 58˚F after 5:30 PM (Figure 31). To ease staff through the shift in interior climate, the temperature should be reduced by a degree each week until the recommended temperature is met. Also, if the ducting repairs are completed, the improved interior comfort may offset a reduction in thermostat temperature.

In conjunction with the previously mentioned duct repairs, these adjustments will save an additional $1900 in annual propane costs. Until the repair work is completed, these adjustments will reduce the current propane expenditure by $2100 annually.

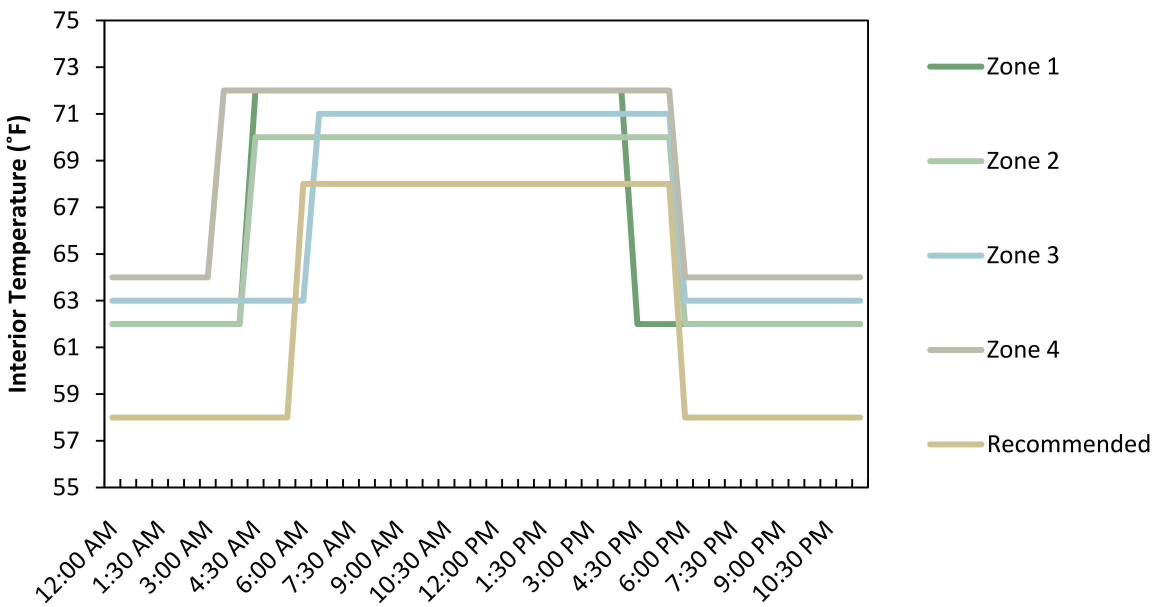

Figure 31. Current and proposed weekday thermostat settings.

3.5 Building Envelope Retrofit

The integrity of the facility envelope was characterized through the facility construction plans, field inspections, and through computer modeling in eQUEST. In general, the building shell was not constructed with thermal performance as a primary design goal. This is reflected by the uniformly low level of shell insulation, lack of distinction between conditioned and unconditioned spaces, and an array of east facing windows as a major architectural feature.

The effects on energy demand of envelope retrofits were modeled using eQUEST. The results of the simulation indicate that the energy demand of the facility is much less sensitive to changes in the envelope construction than it is to improvements to the duct performance. For this reason, the duct repairs recommended previously will have a greater effect on facility energy consumption than envelope improvements. An economic analysis of these retrofits was not performed due to the difficulty of predicting the scope of work involved in renovations. The recommended envelope retrofits include:

1. Increase ceiling, floor, and exterior wall insulation levels.
2. Replace current windows with double-paned, argon filled, low-emissivity windows.
3. Weatherize windows and doors which separate conditioned and unconditioned spaces.

3.5.1 Recommendation #1: Increase insulation levels

We recommend increasing the facility's insulation levels to those specified for the Crescent City climate by the Department of Energy (DOE) (Table 3). The majority of the facility is insulated with R-11 fiberglass batting. Adding insulation to most areas of the facility would not be cost-effective due to the inaccessibility of most insulated areas. An exception is the second floor ceiling insulation which may be accessed through the duct crawlspaces. We recommend implementing insulation retrofits when other facility renovations are made. Increasing insulation levels to the DOE recommended levels would reduce both propane and electric space heating demands according to eQUEST simulation results (Table 3).

Table 3. Recommended insulation additions and associated energy savings.

Area	R-Value Goal[1]	Existing	Add to Existing	Cost for addition[2] ($/ft2)	% Reduction in Propane Use	% Reduction in Electricity Use
Upstairs Ceiling	R-49	R-11	R-38	$0.98	0.5%	-
Upstairs Floor	R-41		R-30	$1.46	0.2%	-
Exterior Wall	R-18		R-5	$1.00	0.1%	1.0%

[1]Source: Energy, EERE Energy Savers: Insulation
[2] Source: Energy, Recommended R-Values for Buildings

3.5.2 Recommendation #2 Window Replacement

We recommend that the prominent window arrays in the visitor center and the upstairs hallway be replaced with high performance windows. Due to the high capital cost of this retrofit we do not recommend performing this retrofit until the end of the current windows' lifecycles. The installation of high performance windows[1] was modeled in eQUEST. According to the model results, this retrofit can reduce propane consumption by 3% and electricity consumption by 0.5%.

3.5.3 Recommendation #3 Improve shell tightness

We recommend that weatherization measures be taken to reduce the infiltration rate of air into and out of conditioned spaces. Measures include caulking window seals, installing weather stripping on doors, and sealing utility penetrations. Before tightening the shell, building managers should confirm that the active ventilation systems can provide adequate ventilation for maintaining indoor air quality. The American Society of Heating, Refrigerating, and Air-Condition Engineers (ASHRAE) recommends an office ventilation rate of 20 cfm per person. This amounts to a facility air exchange rate of 0.47 air changes per hour. Based upon visual indicators, and average values for similar commercial buildings we estimated the current ventilation rate to be 2 air changes per hour. Reducing this ventilation rate to the ASHRAE standard was simulated in eQUEST and determined to affect both the electric and propane heating demands. This retrofit can reduce propane consumption by 5% and electricity consumption by 1.5%.

In addition to tightening the exterior/interior interfaces, the facility lacks clear and necessary distinctions between conditioned and unconditioned indoor areas. The interface between such areas should be treated no differently than the boundary between the interior of the building shell and outdoors.

The concrete stairwells are unheated and have a high *specific heat* or affinity for energy, thus they should be separated from the second floor hallway by doors with a complete seal across the jam and frame. This modification will cut the loss of heated hallway air into the unconditioned stairwells, thus improving furnace efficacy and overall comfort. In addition, the park staff should determine whether the first floor hallway (pillar 1) will be a conditioned or unconditioned space. If conditioned, a partition should be installed between the hallway and the stairwell. A more practical approach would be to treat the first floor hallway as an unconditioned space and make the following modifications to optimize energy savings and to ensure comfort for the office occupants:

1) Ensure there are complete seals across the jam and frame of the office and lounge doors. This will improve the ability of occupants to meet their heating needs with minimal reliance on the electric-resistance wall heaters.

[1] Window properties: emissivity = 0.2, U-value = 0.3 BTU/ft^2-h-°F, argon-filled, double pane.

2) Decommission the electric wall heater in the hallway. Due to the characteristics of the heater's location, including ceiling height and building material, most of the energy used by the appliance is lost to the concrete and stairwell.

3.6 Propane Audit Summary

The recommended propane reduction measures are cost-effective for reducing the propane consumption demand of the facility. The total payback period for all of the measures is 0.3 years (Table 4). For an economic breakdown of each recommendation see Appendix 10.3.

Table 4. Economic summary of propane reduction measures.

Current Annual Load (ft^3)	214,244
Projected Annual Load (ft^3)	115,888
Projected Propane Savings (ft^3)	98,356
Percent Propane Savings	46%
Projected Annual Cost Savings	$ 7,032
Capital costs for retrofits	$ 1,960
Simple payback period	0.3

4 Photovoltaic System

4.1 Background

Photovoltaic (PV) systems convert solar energy into useful electricity. The two main classifications of PV systems are stand alone and grid-intertied. Stand alone systems store excess energy supplied by the PV system in batteries for use during nighttime or on days when the demand is not fully met by the solar array. Grid-intertied systems utilize the utility grid as a pseudo-storage medium. Excess electricity from the solar array is consumed by the utility grid and spins the utility meter backward. When the solar electricity is insufficient to meet building loads, electricity is drawn from the utility grid, spinning the meter forward. This type of electricity metering system is known as net metering.

With net metering, utility companies charge for any electricity consumed beyond the amount produced by the PV system. In addition, utility companies typically charge between $100 and $200 per year to maintain the grid connection.

4.2 System Parameters and Concerns

There are many parameters to be considered when designing a PV system: the existing load (electricity demand), the available solar energy, the area available for solar installation, the financing options for the system, and the system's projected economic benefits. The RNSP facility's existing energy load was determined, with results reported in Section **2** of this report. The available solar energy was quantified by determining the *solar insolation* and the effects of shading at the site of installation. The feasible areas for solar installation were determined by examining the site's physical properties such as geometry, load bearing strength, and shading characteristics. PV systems economic benefits vary in magnitude depending on the current cost of electricity, system components, overall system efficiency, available solar energy at the site, and the available government and private financial incentives.

Concerns indirectly related to the installation, project design, and life expectancy of a PV system include the life expectancy of the rooftop and the expected growth of trees in the vicinity of the solar installation. If rooftop repairs are anticipated within the life of the PV system, those repairs should be made prior to the installation of solar modules or extra costs will be incurred later to remove and replace the solar modules. The growth of trees may result in shading of a solar array, significantly reducing the energy output. A management plan for the trees in the surrounding area should be developed; areas where shading may occur should be avoided. Partial shading of an array will greatly reduce the energy output of the entire array.

4.3 Solar Resource

The energy available from the sun is quantified by measuring the total hemispherical solar radiation upon a given surface for a given time period. The energy available is known as the solar insolation and is expressed in units of power per unit area (W/m^2). The power output of a given PV system can be estimated by using average daily solar insolation values for each month. However, no daily solar insolation data exist for Crescent City.

The National Solar Radiation Database (NSRDB), maintained by the U.S. Department of Energy, consists of measured and modeled solar insolation data sets for various locations throughout the United States. Included in the database are modeled solar insolation data for Arcata, California. These data have been determined to be in close agreement with actual solar insolation data recorded by SERC in Trinidad, California (Zoellick, 2008). Both Arcata and Trinidad are located along the northern coast of California in similar environments to Crescent City. Therefore, the NSRDB solar insolation values provided for Arcata have been used for this PV design.

A *pyranometer* was installed at the RNSP facility to measure the solar insolation and validate the modeled NSRDB data (Figure 32). Data were collected at 5 minute intervals between June 5th and July 16th. The solar insolation data collected are in close agreement with the NSRDB data.[1]

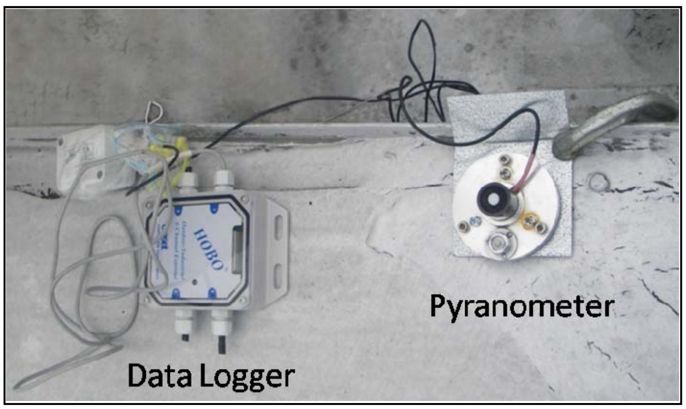

Figure 32. Pyranometer and HOBO data logger installation.

The *available solar insolation* is a measurement of the monthly average solar insolation at a specific location during the hours that shading does not occur. To determine the average daily shading per month on the roof of the RNSP facility, a *Solar Pathfinder™* was used (Figure 33). A Solar Pathfinder™ uses a curved dome to project the average daily percent of shading per month onto a *sun path diagram* (Figure 34). The Solar Pathfinder™ results were used to adjust the NSRDB insolation data to reflect local shading conditions and determine the available solar insolation.[2] The percentage of daily shading on the roof was determined to be less than 1% on an annual basis.

[1] See Appendix 11.1 for a detailed comparison of the pyranometer and modeled data.
[2] See Appendix 11.2 for actual results and the area weighted shading average.

Figure 33. Solar Pathfinder Apparatus.

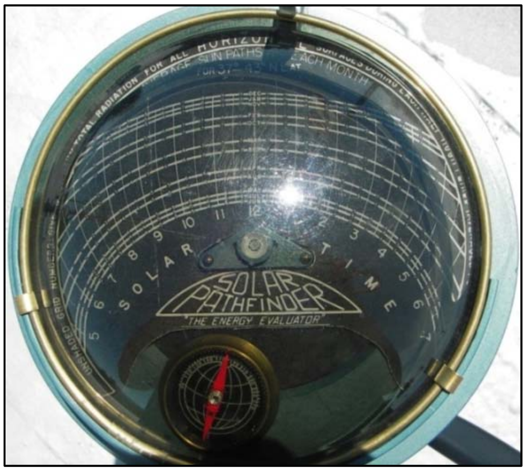

Figure 34. Solar Pathfinder™.

The available area for solar installation is limited by the strength, shading, and geometry of the roof. The roof of the RNSP facility was assumed to be strong enough to support all design alternatives specified, but this needs to be confirmed with a structural engineer before a system is installed. Data collected from the Solar Pathfinder™ were used in conjunction with field observations to determine which areas are poor choices for solar installation due to shading and geometry.

4.4 System Description

A grid-intertied PV system is recommended for the RNSP Facility. System components include: a photovoltaic array, a mounting structure, a DC-AC inverter, and electrical disconnects (Figure 35).

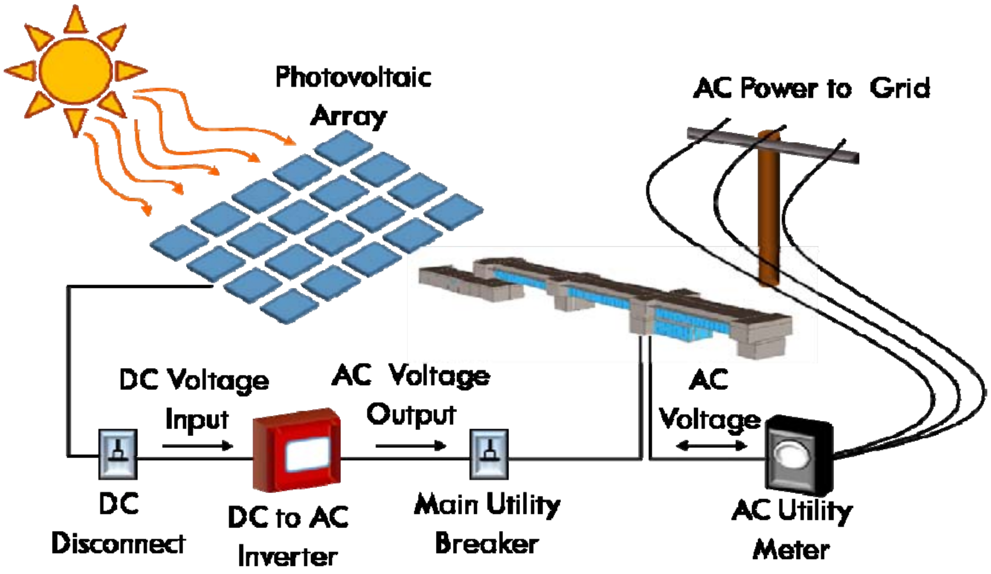

Figure 35. Grid-intertied PV system.

The *tilt* (Figure 36) and *azimuth* (Figure 37) angles were modeled[1] to optimize the row spacing and orientation of the solar arrays. A tilt angle of 44.7^o above horizontal with an azimuth angle of 0^o (due south) was determined to maximize the solar gain on the roof of the RNSP facility. A tilt angle of 30^o was selected for the design alternatives to allow for a closer row spacing of the solar panels and increase the summer solar gain. An azimuth angle of 10^o west of due south was selected for the design alternatives for both aesthetics and ease of installation. Since the RNSP facility is oriented -35^o from due south. The solar panels should be mounted on the roof at a 45^o angle to the southwest edge of the rooftop to achieve the desired azimuth angle (Figure 38). The row spacing of the solar panels should be 5.5 ft to prevent self shading and allow walking space for maintenance.

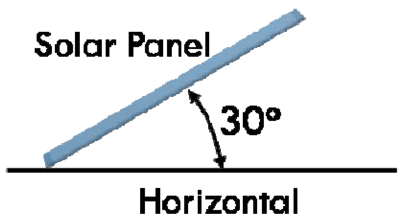

Figure 36. Diagram of tilt angle.

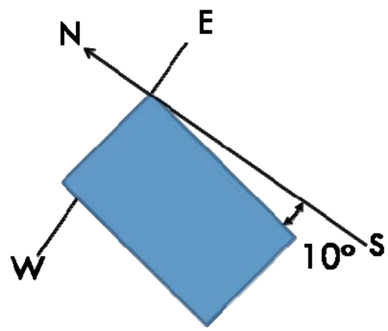

Figure 37. Diagram of azimuth angle.

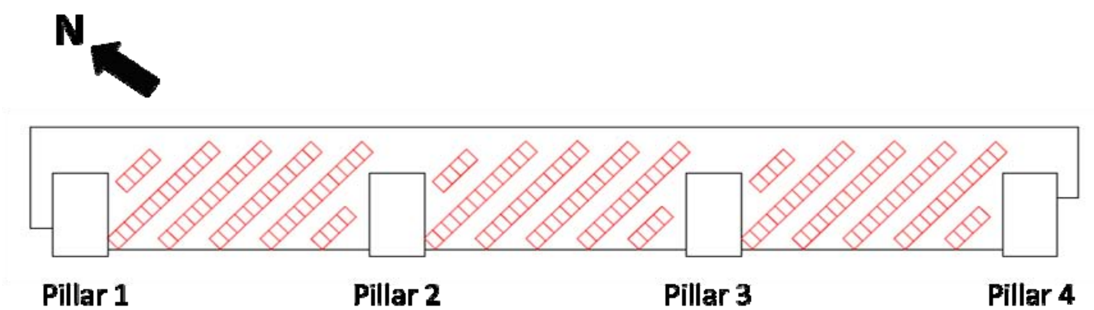

Figure 38. RNSP facility rooftop schematic of possible solar panel orientation.

The modifications to the tilt and azimuth angles were determined to reduce the annual energy gains by less than 2% compared with the solar gain maximizing orientation described above.[2] The model used to determine the solar gain does not account for daily weather variations. During the summer months, coastal areas often receive morning fog which dissipates in the afternoons. If seasonal fog is accounted for in the model, the selected azimuth angle may provide more solar gain than a due south orientation, since facing slightly west will permit collecting more of the solar resource in the afternoon than in the morning.

[1] The KT (Klein and Theilacker) method was applied in a Microsoft Excel program to model the effects of the tilt and azimuth angles of the solar array (Duffie and Beckman, 2006). The row spacing was based on the *Solar Altituded angle* and geometry of the solar panel orientation.

[2] See Appendix 11.3 for more details.

A series of derate factors was used to account for the various system energy losses on the projected energy output of each design alternative (Table 5). A final derate factor of 0.73 was used for each of the PV output calculations.

Table 5. PV derate factors.

	Derate Factor	Source
Production Tolerance	0.95	Marion et al, 2005
High Temperature Losses	0.91	IEEE, 2008
Dirt and Dust Losses	0.95	Marion et al, 2005
Mismatch Losses	0.98	Marion et al, 2005
Wiring Losses	0.97	Marion et al, 2005
Inverter and Transformer Losses	0.96	IEEE, 2008
System Availability	0.98	Marion et al, 2005
Derate Factor	0.73	

4.5 System Components

The Kyocera KD205GX-LP solar panel[1] was selected for each of the designs due to its low cost per watt and 20 year warranty. Using the specifications for the selected Kyocera solar panel, the proper array size and electrical configurations were determined for a variety of inverters[2].

The Sunny Boy SB 5000 inverter was selected for each of the PV designs to match the desired number of Kyocera solar panels per array. The Sunny Boy SB 5000 inverter can operate with one to two parallel strings of 12-15 solar panels in series.

A Unirac mounting system was designed and selected to mount the solar panels to the roof. The mounting system was designed based on the panel type and orientation[3]. The system includes stand-off mounting with flashing to prevent roof leaks.

A system component that is not required but highly recommended for a grid-intertied system is the Sunny WebBox. The Sunny WebBox provides a means to monitor and display a PV system's performance by interfacing with Sunny Boy inverters and posting their performance data to the internet (Figure 39). A monitor should be set up in the visitor center to continuously display the RNSP facility's PV performance; this would demonstrate the feasibility of renewable energy and raise visitor interest.

[1] For PV system component specifications see Appendix 11.6.
[2] For more information on component sizing and pricing see Appendix 11.4.
[3] The price of racking for each alternative PV design was approximated by using an average cost per panel.

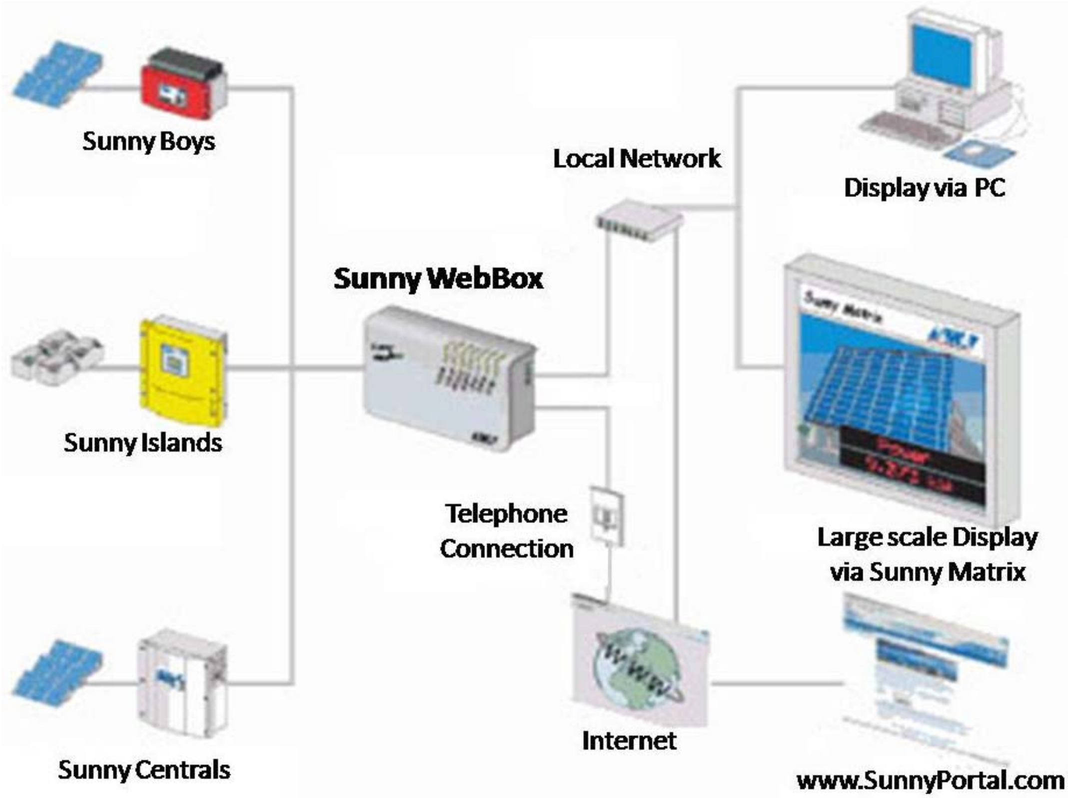

Figure 39. Sunny Webbox networking.
Image from <http://store.altenergystore.com/Solar/descfiles/sma/webbox/systemconfiguration.png>

4.6 Design Alternatives

Four alternative PV designs were developed for the RNSP facility. Each of the designs listed below share the same hardware but vary in scale[1]. For each design, the inverters are assumed to be located in Pillar 3, on the bottom floor (Figure 40).

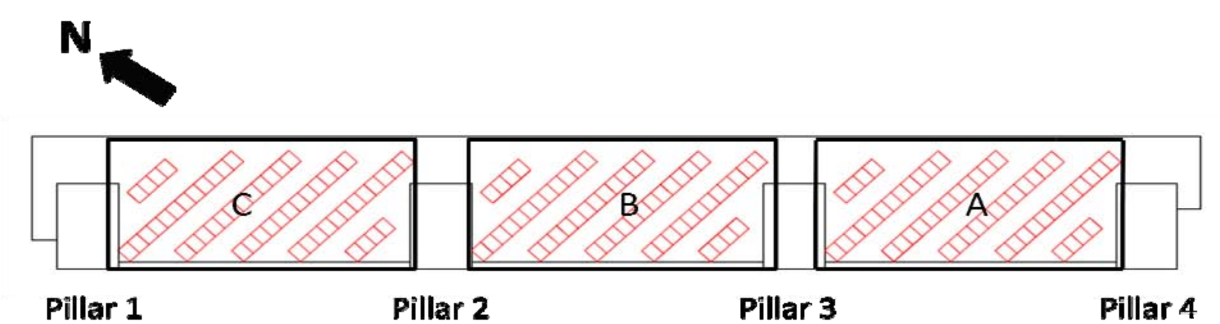

Figure 40. Alternative solar panel arrangements.

[1] For a detailed list of the costs associated with each alternative see Appendix 11.5.

4.6.1 Alternative 1: 6.15 kW System

This system is designed to meet 8% of the facility's annual electricity demand[1] at a cost of $44,400, with a combined payback period[2] of 24 years. This alternative consists of one SB 5000 inverter and 30 solar panels located on the south end of the roof (area A in Figure 40). The solar panels should be wired as two parallel strings of 15 solar panels to the inverter (Figure 41).

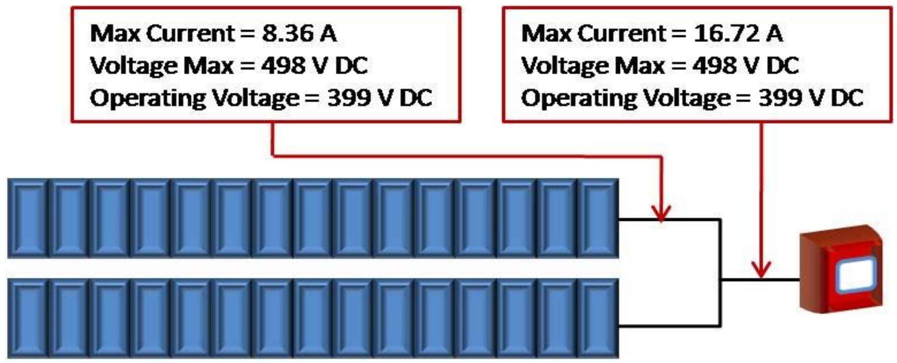

Figure 41. Wiring schematic for PV alternative 1.

4.6.2 Alternative 2: 9.23 kW system

This system is designed to meet 12% of the facility's annual electricity demand at a cost of $68,100, with a combined payback period of 31 years. This alternative consists of two SB 5000 inverters and 45 solar panels located on the south end of the roof (area A in Figure 40). The solar panels should be wired as three strings of 15 solar panels (Figure 42), with two parallel strings wired to one inverter and the remaining string wired to the other inverter.

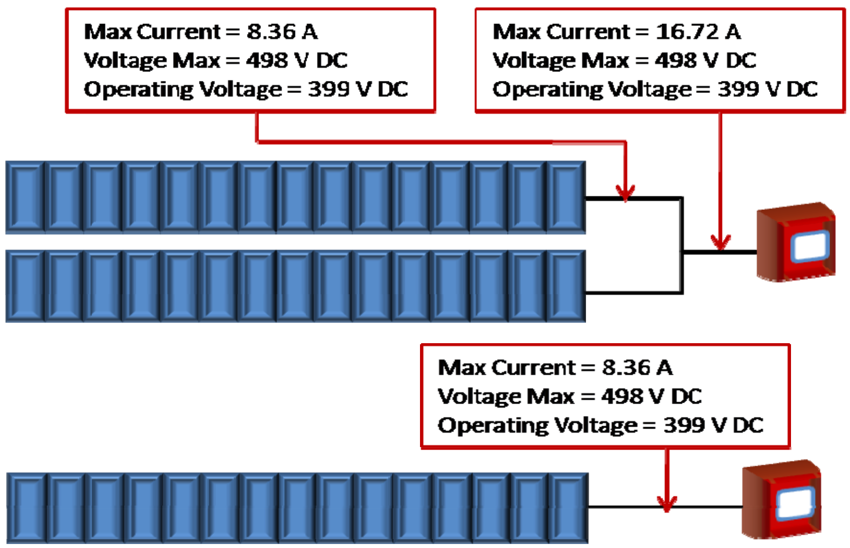

Figure 42. Wiring schematic for PV alternative 2

[1] The percentage of the energy demand met assumes that the RNSP facility has made all the retrofits recommended in the Energy Audit section, with the exception of those for the HVAC system.
[2] The combined payback period is the payback period for the PV design in combination with the recommended retrofits.

4.6.3 Alternative 3: 10.7 kW system

This system is expected to meet 16% of the RNSP facility's annual electricity demand at a cost of $74,600, with a combined simple payback period of 32 years. This alternative consists of two SB 5000 inverters and 52 solar panels located on the south end of the roof (area A in Figure 40). The solar panels should be wired as four strings of 13 solar panels, with two parallel strings wired to each inverter (Figure 43).

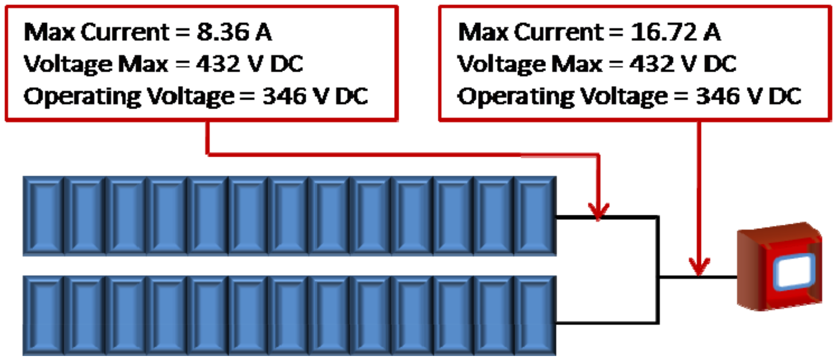

Figure 43. Wiring schematic for PV alternative 3.

4.6.4 Alternative 4: 34.4 kW system

This alternative utilizes the entire area of the roof that is feasible for solar installation (areas A, B, and C in Figure 40). The system is expected to meet 52% of the RNSP facility's annual electricity demand at a cost of $227,000, with a combined simple payback period of 46 years. This alternative consists of six SB 5000 inverters and 168 solar panels. The solar panels should be arranged as 12 strings of 14 solar panels, with two parallel strings wired to each inverter (Figure 44).

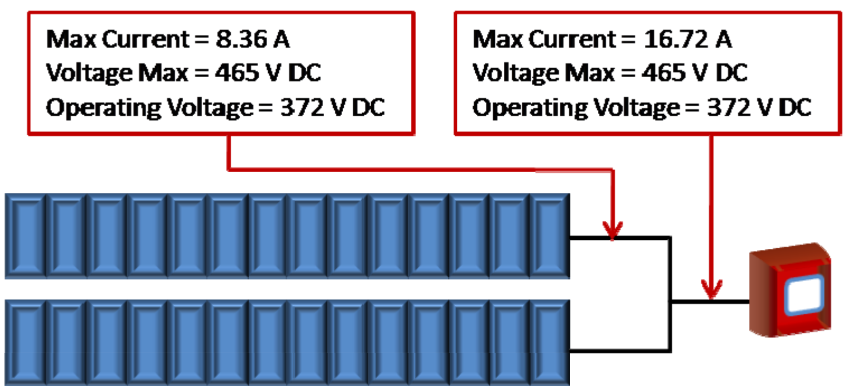

Figure 44. Wiring schematic for PV alternative 4.

4.7 Combined Project Economics

Reduced energy consumption from energy conservation measures results in a PV system that meets more of the electricity demand and improves the economic impact of a combined conservation/PV project compared to PV installation alone. Conservation measures combined with PV installation reduce the payback periods markedly for smaller PV systems and to a lesser extent for the larger PV systems (Figure 45). A combined energy conservation and rooftop-wide PV project (Alternative 4) is expected to result in 52% of the site energy being met with onsite renewable generation – the maximum we expect is feasible based on the building design, internal loads, and roof area (Figure 46). If additional PV or other renewable generation were installed adjacent to the site or off-site, the building could achieve net-zero energy.

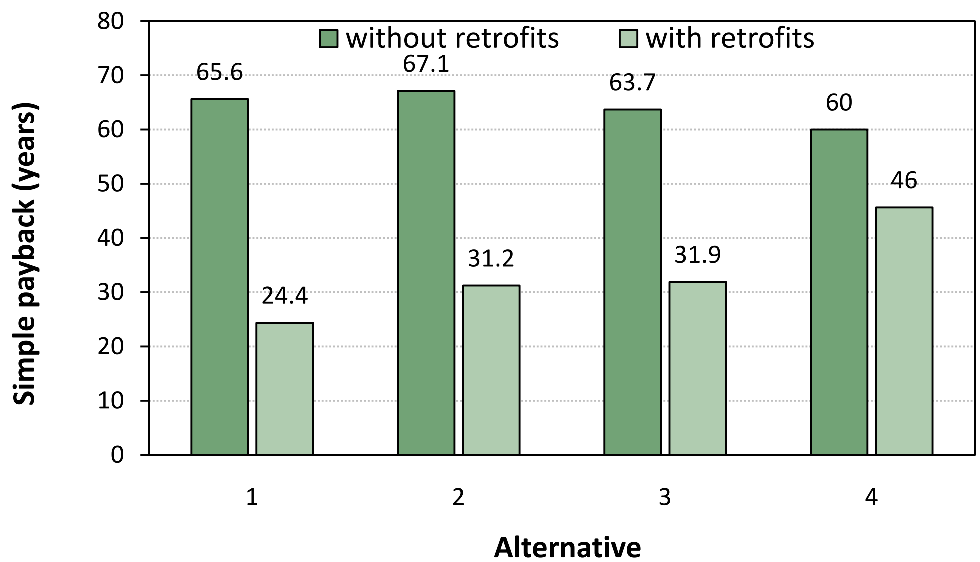

Figure 45. The effects of energy efficiency retrofits on the payback periods of PV systems.

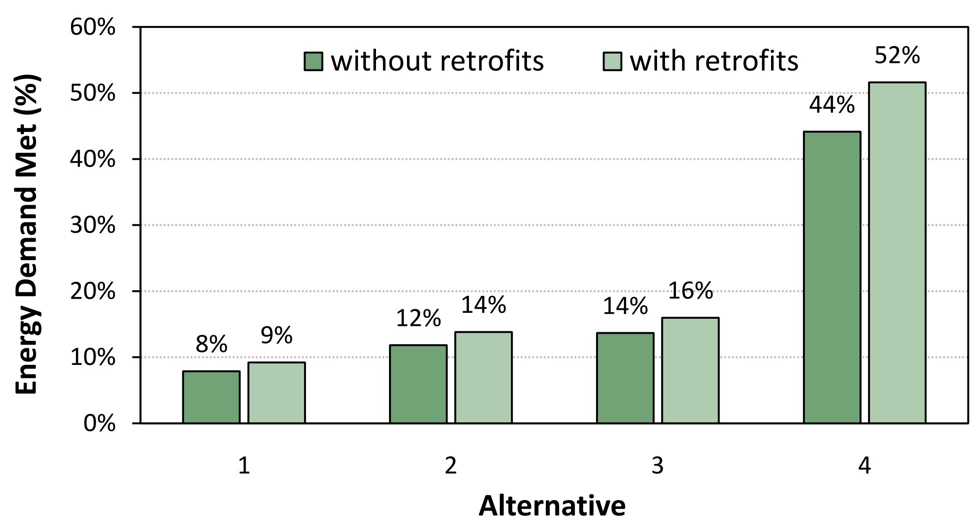

Figure 46. Percentage of the RNSP facility’s energy demand met with and without retrofits.

4.8 Solar Incentives

The development of renewable energy systems has been strongly encouraged through incentives such as rebates, tax breaks, and loans. The number of incentives has been continually increasing. For this reason, the current rebates and loans should be examined when implementing a PV system.

There are many rebates, tax breaks, and loans available through government agencies to encourage the development of renewable energy systems. Currently the “California Solar Initiative,” through the “Million Solar Roofs” program, offers a variety of rebates, loans, and tax incentives for the development of PV systems (CSI, 2008). However, to be eligible for the “California Solar Initiative”, the energy consumer must be a client of Pacific Gas and Electric (PG&E), Southern California Edison (SCE), or San Diego Gas and Electric (SDG&E). Since the RNSP facility is served by Pacific Power, an Oregon based power company, the building is ineligible for the renewable energy incentives outlined by the “California Solar Initiative.” The state of Oregon and Pacific Power also offer incentives for renewable energy systems; however currently only energy consumers located in Oregon are eligible for their incentives. The federal government offers a series of incentives for renewable energy systems in the form of tax breaks; due to the RNSP facility’s tax exemption, these federal incentives do not apply.

Many different types of loans and financing arrangements are available through private financers and solar installers. Often, the loans are of low interest and may be paid back by the monthly dollar savings of the PV system. To find out more about the loans and financing options available in Crescent City, we recommend that a local PV distributor and/or installer be contacted.

5 Climate Friendly Parks

5.1 Project Background

The Climate Friendly Parks (CFP) program was developed by the Environmental Protection Agency (EPA) and the National Parks Service with the goal of protecting and preserving the national parks for future generations. The CFP program uses the Climate Leadership in Parks (CLIP) Tool as a framework to reduce greenhouse gas emissions (GHGs) and criteria air pollutants (CAPs). The CFP program assesses the inner workings of parks and breaks down each component to evaluate the impact it has on the environment. CFP evaluates GHG emissions, helps to train staff, and engages visitors with education and outreach programs.

There are five milestones within the CFP program, each building upon the previous milestone, with the end goal of preserving the park's natural resources and beauty while setting an example of sustainability (CFP, 2008). The milestones are as follows:

> *Milestone 1:* Submit a CFP application.
>
> *Milestone 2:* Develop the Greenhouse Gas emissions inventory using the CLIP Tool.
>
> *Milestone 3:* Create an action plan: policies, procedures, and programs that will help to reduce the greenhouse gas emissions
>
> *Milestone 4:* Implement the action plan.
>
> *Milestone 5:* Monitor progress and report results.

The scope of this project was to generate a GHG emissions inventory for RNSP (milestone 2). Quantitative data were accumulated and entered into the CLIP Tool, to generate a summary sheet of the emissions inventory. Park Biologist Keith Bensen is in the process of submitting a CFP application (milestone 1) and will continue the CFP project through the remaining milestones.

5.2 The CLIP Tool

The CLIP Tool is a Microsoft Excel spreadsheet that identifies GHGs and CAPs emitted by the park. The GHGs evaluated include: Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and hydro fluorocarbons (HFCs). The CAPs considered in the CLIP module include: sulfur dioxide (SO_2), nitrogen oxides (NO_x), volatile organic compounds (VOCs), particulate matter (PM_{10} and $PM_{2.5}$) and carbon monoxide (CO).

The CLIP Tool divides the park into three categories: park operations, visitors, and concessionaires. Park operations information pertains to the national parks and was obtained by park personnel specific to the field of interest[1]. The visitors section of the module represents the impacts tourists have while within park boundaries. Visitor information is considered as the

[1] See Appendix 12.1

visitors to both the national and state parks. Due to the partnership between the nation and state parks in RNSP, the state parks were considered a concessionaire. The state parks include: Del Norte Redwoods, Jedediah Smith, and Prairie Creek Redwoods. The one actual concessionaire to RNSP is the Redwood National and State Parks Hostel. The hostel is located 12 miles south of Crescent City along Highway 101.

Both GHG emissions and CAP emissions are separated into simplified components to determine where and how much of each emission is created. Separating emissions into their primary source provider allows for a more accurate estimate specific to the park. The separations also allow for easier access to values within a specific area. The categories are as follows;

GHG Emission Estimates
1. Stationary Combustion
2. Purchased Electricity
3. Mobile Combustion
4. Fertilizer
5. Wastewater
6. Waste
7. Forestry
8. Refrigeration/AC

CAP Emission Estimates
1. Stationary Sources
2. Mobile Combustion
3. Area Sources (Burning)
4. Area Sources (Non-burning)

5.2.1 Stationary Combustion Sources

Stationary combustion devices consist of generators, boilers, heaters, etc. These devices generate direct GHG emissions when operating. The national park buildings are heated by propane furnaces with the exception of one wood stove used to heat a workshop. The amount of propane consumed by the national park is recorded in billing. The amount of wood consumed was estimated by James Tiffany to be 5 cords per year. There are backup diesel generators for some of the national park facilities including Requa and the park headquarters in Crescent City. No records were found to determine the amount of fuel consumed by these devices. An estimated value of 20 gallons per year of diesel fuel for stationary uses was entered in the CLIP module. This estimate reflects generators being used in emergency situations and running periodically for maintenance checks. The hostel consumes propane for stoves and tankless water heaters fueled by a small storage tank, filled periodically by Blue Star Gas. The hostel has one pellet fireplace and consumes an average of 4 cords of wood a year.

Stationary devices also release CAP emissions into the environment including: SO_2, NO_x, VOC, CO and PM_{10}. The amount of CAPs released by equipment is dependent on both, device type (heater, generator) and control type (recirculation, flue-gas). It was not feasible to determine the make of each stationary combustion device during this project period, so further research will need to be conducted for CAP emissions on stationary sources.

5.2.2 Purchased Electricity

Most of RNSP is grid-tied to either Pacific Gas and Electric or Pacific Power depending on location. According to billing information, the national park consumes approximately 450,000 kWh of electricity annually. The hostel consumes approximately 32,000 kWh per year of electricity from Pacific Power. A few facilities are off the grid and some facilities have grid inter-tied PV systems. The renewable energy technologies within the RNSP include: solar panels, and solar hot water heaters. The RNSP generates 2,400 kWh of electricity from renewable sources.

Pacific Power offers the "Blue Sky" program to help reduce GHG emissions by allowing clients to purchase renewable wind energy.[1] If the national park was to partake in the Blue Sky program they could effectively off set the GHG emissions by 110 metric tons of carbon equivalent per year. The program costs $1.95 per month for every 100 kWh.

5.2.3 Mobile Combustion

The amount of emissions produced from vehicles is of particular importance. CO_2, CH_4, and N_2O are the GHGs released by vehicles. CO_2 is directly released as fuel is burned; the more efficient a car, the less CO_2 released. The amount of CH_4 and N_2O released by vehicles is dependent on the type of emissions control technology of each vehicle. In evaluating the mobile combustion emissions, the amount of fuel, the type of fuel, and the type of vehicle must be considered.

The national park uses vehicles that are park owned and rented from the GSA. The GSA keeps detailed records of vehicle types and vehicle miles traveled, while the national park records gallons of fuel purchased. From these two data sets the total amount of vehicle miles traveled was determined[2].

The hostel does not have any vehicles to add to GHG emissions

Mobile sources contribute to CAP emissions in the form of CO, NO_x, VOCs, SO_2, and $PM_{2.5}$. When examining CAP emissions from vehicles, both temperatures and wind speeds must be taken into consideration. An average summer temperature of 51°F and winter temperature of 47°F were used in the CLIP module[3]. A default wind speed value of 25 mph[4] was used in the model.

---

[1] See Appendix 12.6

[2] Assumptions made when converting gallons into miles traveled; 1) gallons of gasoline was consumed by small trucks averaging 18 miles to the gallon, 2) biodiesel was consumed by larger trucks averaging 16 miles to the gallon (default values provided in the CLIP module).

[3] The CLIP defaults are set to low summer temperatures (51°F) and average winter temperatures (47°F). They are the closest to actual climate temperatures.

[4] The CLIP module was set to "slow" wind speed.

5.2.4 Fertilizer

The RNSP does not use any fertilizer on park lands; thus, the addition of greenhouse gases from fertilizer is not applicable. The only small exception is the hostel, which applies approximately 20 lbs of fertilizer a year to its grounds.

5.2.5 Wastewater

As organic material breaks down anaerobically, it releases CH_4 and N_2O into the environment. The wastewater from RNSP is either treated on site or sent to one of three wastewater treatment facilities in McKinleyville, Eureka, or Crescent City. The majority of the state parks are on septic systems, with the pumped waste sent to McKinleyville or Eureka for disposal. The Requa national park facility treats its waste in an onsite treatment plant. The headquarters building in Crescent City sends its waste to the treatment plant in Crescent City. The volume of waste sent to Crescent City is unknown. The hostel uses a septic system with the solid material extracted by RNSP.

Wastewater will also generate CAP emissions; specifically VOCs. The CLIP module is only concerned with wastewater treated within the park boundaries. The Requa facility is the only on-site treatment plant and treats 115,000 gallons of wastewater annually.

5.2.6 Waste

The waste category refers to solid waste and all products sent to a landfill. As organic material decomposes anaerobically, it releases CH_4. This continues for the life of the decomposition, approximately 30 years (CFP, 2007). Waste fromm RNSP is collected from sites and condensed into dumpsters. The north end of the park (Del Norte Co.) is serviced by Del Norte Solid Waste Management. Their waste is taken to the Crescent City transfer station. Waste from the southern sections of the parks (Humboldt County) is collected from dumpsters by Humboldt Sanitation. This waste is taken to a transfer station in Orick, CA, to be trucked to the Anderson Landfill in Oregon.

The waste value entered into the CLIP module combined waste for both the national and state parks. The value was assumed to be 81 tons of waste annually, but to date there is little record of the waste volume and mass. This estimate seems low and should be adjusted as more detailed data on waste removal are collected.

The waste from the hostel is serviced by Del Norte Solid Waste Management. The hostel pays for waste removal by the cubic yard. An average weight of 1,500 lbs per cubic yard was used for municipal garbage (Morse, 2007). Using this value the hostel generates 1,300 tons of waste annually. In this case, the figure appears unreasonably high and should be checked.

5.2.7 Forestry

When determining the forest emissions, two aspects must be examined: 1) the total acres of forest and type and 2) the quantity of the forest burned annually. Forests help in reducing greenhouse gases by absorbing CO_2 from the air; however as forests burn they release CO_2, CH_4

N_2O into the atmosphere. As plants break down and decompose aerobically they release CO_2. Natural anaerobic bacteria and microbiological processes in the soil release CH_4 and N_2O. When a forest sequesters more GHG than it produces from fires, decomposition, and other soil processes it is considered a “net sink”. The CLIP module takes these forest conditions into consideration.

The National Parks Forestry and Prescribed Fire Technician, John McClelland, gathered data pertaining to acres of forest type and acres of prescribed burns. The CLIP model has 14 preset categories for forest type. Of these categories only four pertain to the forest types within the RNSP boundaries;

- Hemlock-Sitka Spruce
- Redwood
- Other Hardwoods
- Other Forest Type 2

The national park consists of approximately 97,500 acres of forests. Out of those, roughly 100 acres per year are burned in prescribed burns. The majority of the prescribed burns in the national park are grass land, which is not accounted for in the CLIP module.

5.2.8 Refrigeration/AC

Refrigerators and air conditioners will generate emissions through the leakage of coolants. Variables of age and type of coolant used have an impact on the amount of emissions. CFC-12 and HCFC-22 are two common types of coolants previously used, but due to their contribution to ozone depletion, these coolants are being phased out. The replacement coolants are made with hydro-fluorocarbons. The most common are HFC-134a and R-410. However, these replacements also release some GHGs when introduced into the environment.

Due to low temperatures along the northern coast of California, the use of AC is unlikely. There are no known air conditioners within the RNSP boundaries. There is one walk in refrigerator at the Wolf Creek Outdoor School, and about 20 residential or smaller refrigerators throughout the remaining facilities that use coolants.

The CLIP module analyzes the amount of coolant within each mobile vehicle. The module asks for the number of vehicles by type (car, truck, SUV, etc) as well as the number of vehicles by model year. The CLIP module default values were used to estimate the model year and type from total number of vehicles.

5.3 Criteria Air Pollutants (CAP)

CAP emissions are generated from several sources: gas storage tanks, road paving, household cleaning products, paints, coatings, adhesives, and sealants. These activities generate VOC. Gas storage tanks generate VOC in two ways: 1) evaporation from fuel put in or taken out, or 2) gas leaks. The amount of VOC’s emitted from road paving varies depending on the type of asphalt cure. The CLIP module gives three primary options for cure type; rapid, medium, and slow.

There are no records for the amount of solvents, adhesives, coatings and other VOC containing products used by the national park. Maintenance personnel for state parks generated estimates for the values entered into the CLIP module.

5.4 Results

5.4.1 Greenhouse Gases

The RNSP generates approximately 2,600 metric tons of carbon equivalent (MTCE) in GHGs annually (Figure 47). GHGs are divided into two emission categories: *gross emissions* and *net emissions*. Gross emissions are the total GHG emissions. Net emissions are the gross minus the sequestered emissions of GHGs. Table 6 compares the gross emissions to the net emissions for each park sector. A negative number is generated when more carbon is sequestered than produced. The overall net emission for the RNSP is -97,000 MTCE annually, implying that more carbon is sequestered than produced. From a five year running annual average, approximately 99,000 MTCE GHG is sequestered by the park forests, offsetting 70 MTCE generated annually by the RNSP from prescribed burns.

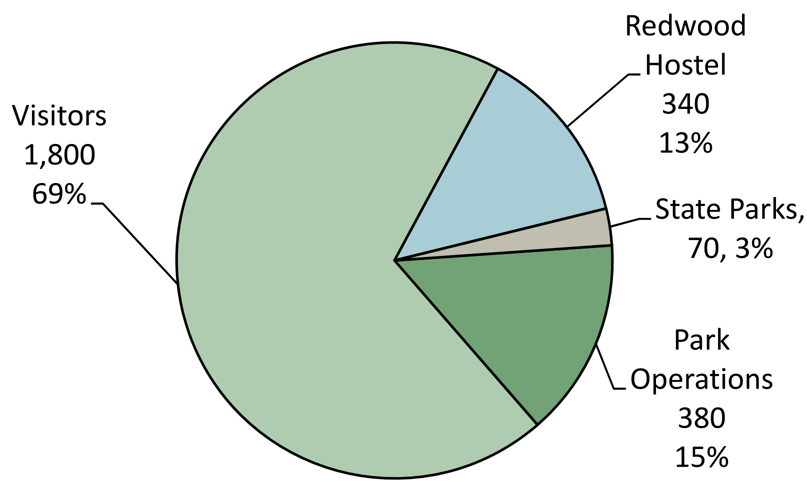

Figure 47: GHG gross emissions (in MTCE/year) by park unit.

Table 6: GHG gross emissions vs. net emissions by park sector.

Park Unit	Gross Emissions*	Net Emissions*
Park Operations	380	-99,000
Visitors	1,800	1,800
Redwood Hostel	340	340
State Parks	70	70
Total	2,600	-96,900

*GHGs in MTCE/yr

GHGs are generated in a variety of ways (Figure 48). The largest source of GHGs is mobile combustion, which generates 73% of the gross emissions, with 92% from visitors. The second largest source of GHG emissions is solid waste, generating 14% of the total GHG emissions. The lowest source of GHGs is wastewater; this is in part due to the methane recovery system at the Eureka Wastewater Treatment Facility.

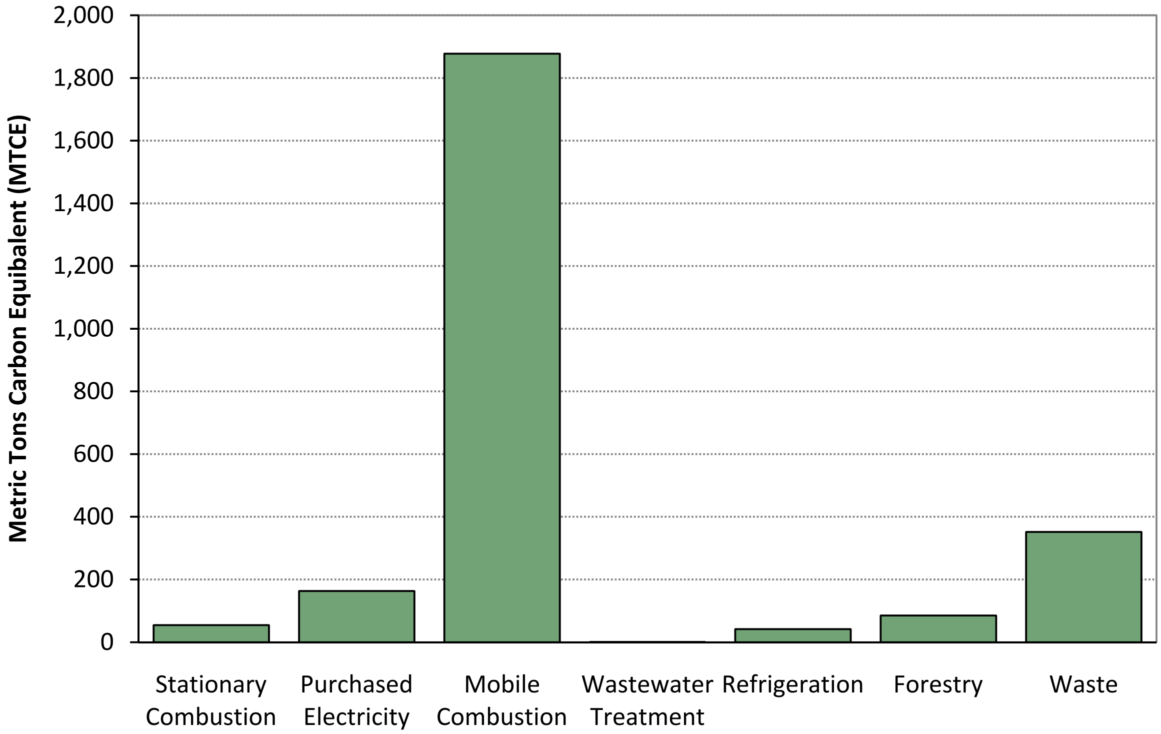

Figure 48: GHG gross emissions by park sector.

GHGs are emitted from the RNSP in the forms of CO_2 (carbon dioxide), CH_4 (methane), HFC, and N_2O (nitrous oxide).[1] Mobile combustion accounts for 1,800 MTCE of CO_2, 79% of the GHGs emitted annually. Disposal of solid wastes accounts for 350 MTCE of CH_4, 17% of the GHGs emitted annually. N_2O and HFC each account for 2% of the total gross GHG emissions.

5.4.2 Criteria Air Pollutants

Annually, the RNSP generates 2,225,000 lbs of CAP emissions (Figure 49). The majority of the CAP emissions are from the national park, which generates 1,106,000 lbs/yr, accounting for 50% of the gross emissions. The second largest emitters of CAP emissions are the visitors, generating 892,000 lbs/yr, 40 % of the total gross emissions.

[1] See Appendix 12.2 for a complete summary of the GHG emissions.

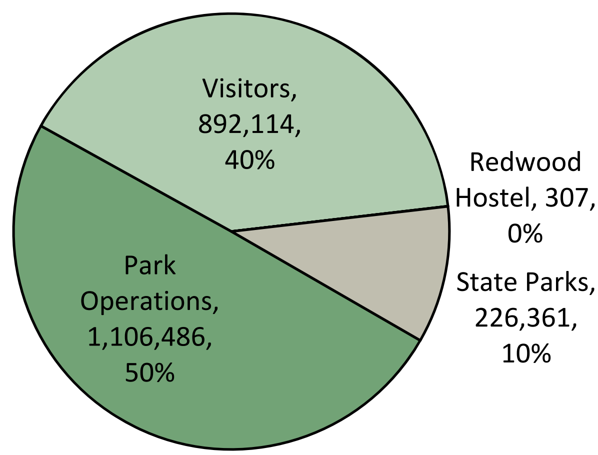

Figure 49: CAP emissions results by park unit.

The sources of CAP emissions are divided into four categories: stationary sources, mobile sources, area source burning, and other area sources (Figure 50).[1] The majority of CAP emissions are generated from area source burning (57%). Prescribed burns of Douglas-firs accounts for 68% of the CO released in Area Source burning.[2] The second most prevalent source of CAP emissions is in the form of VOCs. VOCs account for 11% of the total RNSP CAP emissions. The majority of VOCs come from mobile combustions sources, mainly visitor transportation.

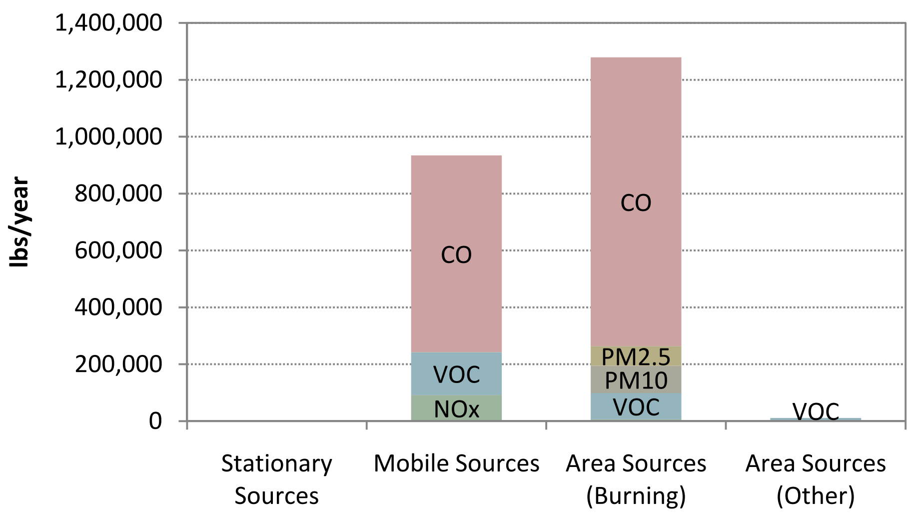

Figure 50: CAP emissions results by sector and pollutant type.

[1] See Appendix 12.3 for a complete summary of the emissions.
[2] Douglas-firs release high amounts of CO when burned. The CLIP module assumes that for every 20 acres of Douglas-fir burned; 648,000 lbs of CO are released.

5.5 Future Research

To continue work on the CFP project, the summary sheet should be updated as more data are collected. There are several areas were no data were available, or data were insufficient. Estimates were made where applicable for the CFP project. The estimates were based on existing data and outside reference sources. The estimated values should be adjusted as more information is gained.

5.5.1 Areas of Insufficient Information

- Acres of forests and types within the state parks (add to acres of forest for park operations).
- Acres of forest fires annually for all of the RNSP.
- The amount of non-burning area source pollutants used for the national park.
- The amount of solid waste sent to landfills for RNSP.[1]
- Types and control devices used on stationary combustion devices for RNSP.
- Number and volume of fuel storage tanks in Prairie Creek and Del Norte Coast parks.

5.5.2 Areas Estimated

- Vehicle miles traveled by visitors.[2]
- Vehicle miles traveled and type of vehicles used by the state parks.[3]
- Speed of curing for asphalt paving.
- Hours of use for off-road equipment.

[1] Discrepancies exist between the amount of waste produced by the national parks (81 tons) and the redwood hostel (300 tons).
[2] See Appendix 12.5
[3] A number of vehicles was given and it was assumed that the types of state park vehicles had the same ratios as the national park vehicles.

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7 Glossary

Available Solar Insolation- a measurement of the average solar insolation at a specific location in which shading is accounted for, often expressed in units of power per area (W/m^2).

Azimuth Angle- is the angle between the compass direction that a solar collector faces and due South, with east negative and west positive (Duffie and Beckman, 2006).

Criteria Air Pollutant (CAP)-Compounds found by the EPA to have negative human health effects, including: sulfur dioxide (SO_2), nitrogen oxides (NO_x), volatile organic compounds (VOCs), particulate matter (PM_{10} and $PM_{2.5}$) and carbon monoxide (CO).

Footcandles- a unit of measure for determining the intensity of light falling on a surface, equivalent to one lumen per square foot.

Greenhouse Gas (GHG)- Consists of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and hydro fluorocarbons (HFCs), all compounds that contribute to global warming.

Gross Emissions-a total of all emissions generated.

Phantom Loads- the electric power consumed by electronic appliances while they are switched off.

Net Emissions- the amount of gross emissions minus the sequestered emissions.

Pyranometer- a device which measures the total hemispherical solar radiation (beam plus diffuse radiation), typically on a horizontal surface. A pyranometer may also be used to measure only diffuse radiation through the use of a shade ring or disc, which keeps the pyranometer shaded 100 percent of the time (Duffie and Beckman, 2006).

Solar Altitude Angle- The angle between a horizontal surface and a line projected from the surface to the center of the sun (Duffie and Beckman, 2006).

Solar Insolation- the solar energy available from the sun in the form of radiation falling upon a given surface for a given time period, often expressed in units of power per area [W/m^2] (Duffie and Beckman, 2006).

Solar Pathfinder™- a device used to measure the year-round shading occurring at a specific location. A curved dome is used to project the average daily percent of shading per month onto a sun path diagram which has a series of lines representing the path the sun takes in the sky each month.

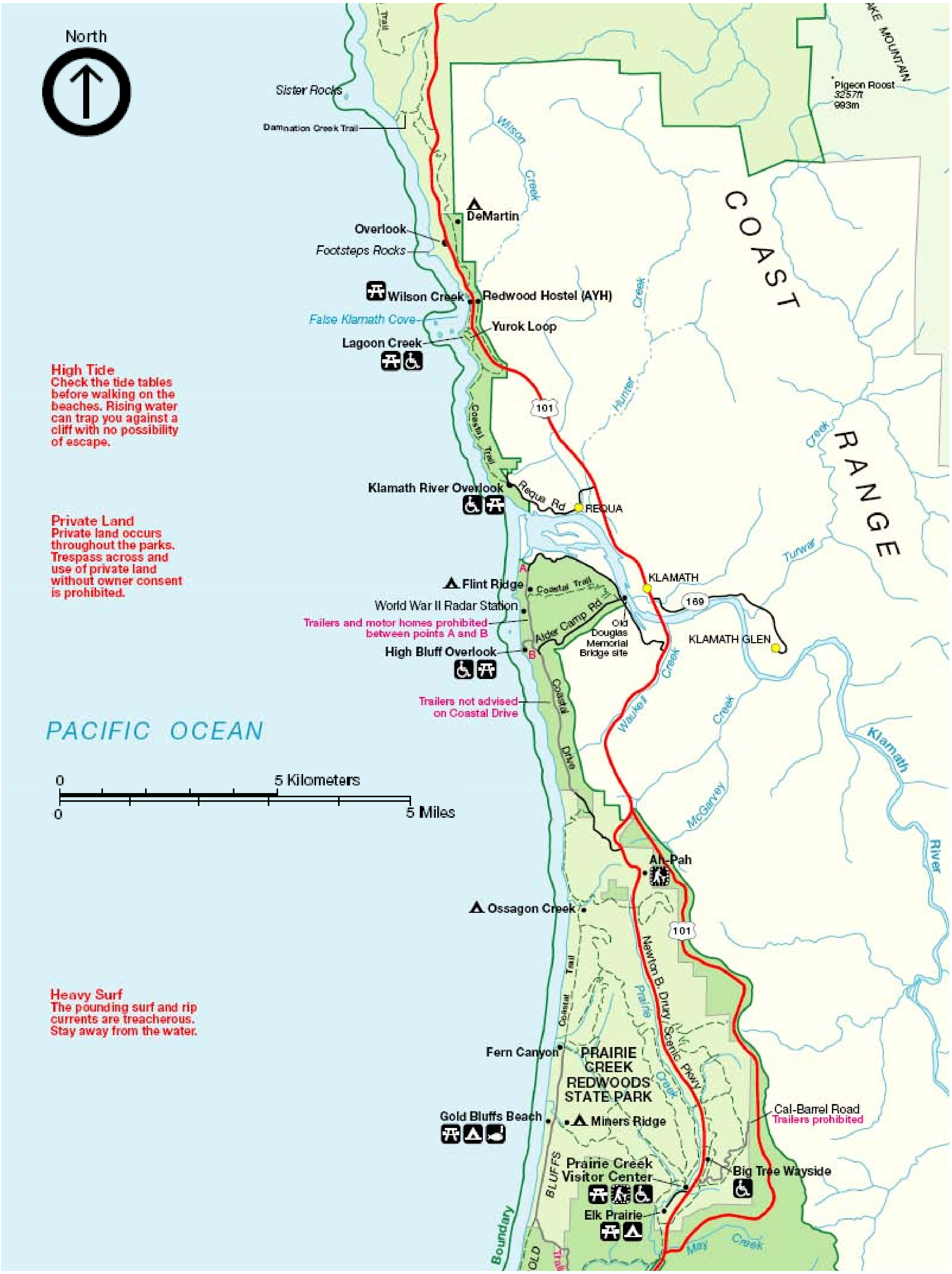
Specific Heat- The amount of heat needed to raise the temperature of one gram of a substance by 1°C.

Sun Path Diagram- a 2-D mapping of the sun's path at a given latitude, which estimates the expected percentage of daily solar insolation available per hour during various months of the year.

Tilt Angle-the angle between the solar collector and a horizontal surface (Duffie and Beckman, 2006)

8 Appendix A: Map of the RNSP[1]

[1] Image from <http://www.nps.gov/carto/PDF/REDWmap1.pdf>.


North
Sister Rocks
Damnation Creek Trail
DeMartin
Overlook
Footsteps Rocks
Wilson Creek
Redwood Hostel (AYH)
False Klamath Cove
Yurok Loop
Lagoon Creek
High Tide
Check the tide tables before walking on the beaches. Rising water can trap you against a cliff with no possibility of escape.
Klamath River Overlook
Requa Rd
REQUA
Private Land
Private land occurs throughout the parks. Trespass across and use of private land without owner consent is prohibited.
Flint Ridge
Coastal Trail
KLAMATH
World War II Radar Station
Trailers and motor homes prohibited between points A and B
Alder Camp Rd
Old Douglas Memorial Bridge site
KLAMATH GLEN
High Bluff Overlook
Trailers not advised on Coastal Drive
Coastal Drive
PACIFIC OCEAN
0
5 Kilometers
0
5 Miles
COAST RANGE
Pigeon Roost
3257ft
993m
Wilson Creek
Hunter Creek
Turwar
Waukell Creek
McGarvey Creek
Klamath River
Ah-Pah
Ossagon Creek
Newton B. Drury Scenic Pkwy
Prairie Creek
Heavy Surf
The pounding surf and rip currents are treacherous. Stay away from the water.
Fern Canyon
PRAIRIE CREEK REDWOODS STATE PARK
Gold Bluffs Beach
Miners Ridge
Cal-Barrel Road
Trailers prohibited
Prairie Creek Visitor Center
Big Tree Wayside
Elk Prairie
May Creek
Boundary
BLUFFS
101
169


North
Prairie Creek Visitor Center
Big Tree Wayside
Elk Prairie
Redwood National Park Boundary
Lost Man Creek
Trailers not advised
Elk Meadow
Lady Bird Johnson Grove
Orick Horse Trails
Kuchel Visitor Center
ORICK
Redwood Creek
Redwood Creek Trail
Permit required for overnight travel
Freshwater Lagoon
Elam Camp
Redwood Creek Overlook
2100ft 640m
Stone Lagoon
HUMBOLDT LAGOONS STATE PARK
Stone Lagoon Boat-in Camp
Information
Dry Lagoon Beach
44 Camp
Tall Trees Access Road By permit only
Dolason Prairie
Tall Trees Grove
Tall Trees Trail
Emerald Ridge Trail
Motorhomes and trailers not advised
HARRY A. MERLO STATE RECREATION AREA
Big Lagoon
Big Lagoon Beach and County Park
Rodgers Peak 2745ft 837m
BRIDGE CREEK RIDGE
Childs Hill Prairie
Schoolhouse Peak 3097ft 944m
To Weitchpec
Lyons Ranch
Schoolhouse Prairie
PATRICK'S POINT STATE PARK
TRINIDAD STATE BEACH
TRINIDAD
To Eureka 21mi 33km
Redwood National and State Parks boundary
Trail
National parkland
Unpaved road
State parkland
0
5 Kilometers
0
5 Miles
Picnic area
Interpretive trail
Fishing
Wheelchair accessible
Boat access
Campground
Primitive campsite
Steep Cliffs
Cliffs are likely to crumble and slide. Climbing on them or walking near the edge invites catastrophe. Because of falling rocks, walking below cliffs is dangerous. Keep away!
Falling Limbs
Tree limbs can fall during high winds, especially in old-growth forests.

9 Appendix B: RNSP Headquarters Floor Plan

10 Appendix C: Energy Audit

10.1 eQUEST Model Validation

To validate the model, historical electrical and gas billing records were compared with the model's energy demand predictions and readjusted to represent the present building. It is important to note that when modeling the headquarters facility, eQUEST overestimates the minimum energy use and underestimates the maximum energy use. Figure 51 compares the electrical consumptions on a monthly basis for historical billing data and the eQUEST predicted values. eQUEST underestimates the energy consumed in the winter and spring months (Dec-May) and overestimated electrical consumption for the summer and fall (June-Nov). This is true for both electrical and gas energy consumption. This discrepancy may be caused by the weather data used in the model. Arcata is the closest town to Crescent City that has available weather data and the two towns may have different weather patterns.

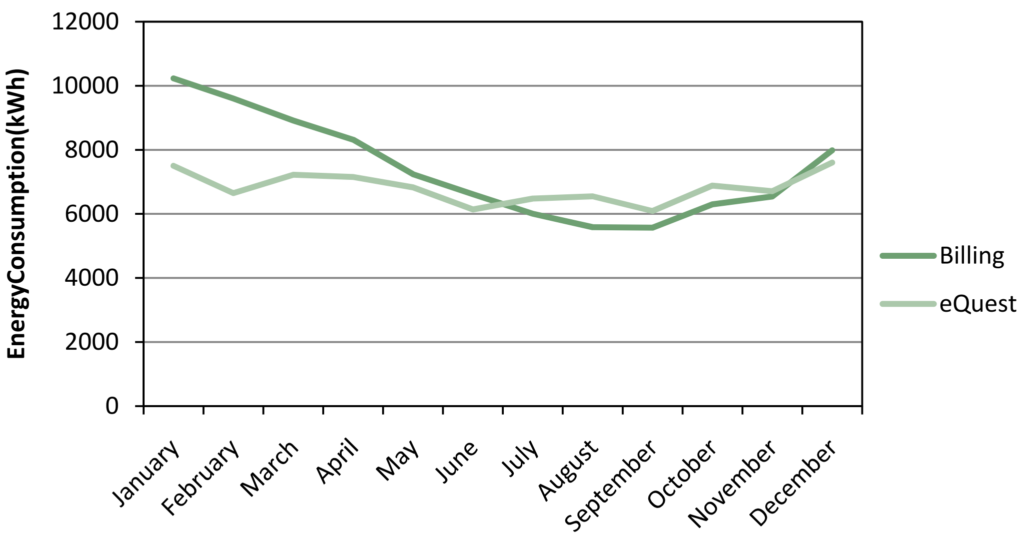


Figure 51: Comparison of electrical consumption for historical billing monthly averages and eQUEST monthly averages.

10.2 Recommendation Economic Summary

Recommendation	Annual Electricity Use (kWhr/year)	Annual Operating Cost ($/year)	Material Cost of Alternative ($)	Labor Cost of Alternative ($)	Annual Electricity Savings kWh	Annual Savings ($/year)	Simple Payback (years)
Existing Office Lighting	6387	$586	$0	$0	0	$0	-
Delamp Two Fixtures per office	4891	$449	$0	$60	1,496	$137	0.4
Task Lights with Existing Lighting	3589	$330	$1,763	$0	2798	$257	6.9
Task Lights with Delamping	2813	$258	$1,763	$60	3,574	$328	5.6
Existing lighting control	408	$37	$0	$0	0	$0	-
Implement two light timers	71	$7	$55	$45	337	$31	3.2
Existing phantom loads	2267	$208	$0	$0	0	$0	-
Manage with power strips	1167	$107	$0	$90	1100	$101	0.89
Existing Vending Machine	3468	$318	$0	$0	0	0	-
Install VendingMiser	1734	$159	$151	$30	1734	$159	1.1
Existing space heaters	2016	$185	$0	$0	0	0	-
Low-wattage units	154.8	$14	$228	$0	1861	$171	1.3
Existing office printers	3643	$334	$0.00	$0.00	0	0	-
Remove 14 upstairs printers and replace old printers	2093	$192	$0.00	$90.00	1550	$142	0.63

- All savings estimates are based on a uniform energy cost of $0.09182/kWh

10.3 Propane Recommendation Economic Summary

Recommendation	Annual Propane Use (MBTU)	(ft^3)	Annual Cost ($)	Materials Cost ($)	Labor Cost ($)	Annual Savings ($/year)	Simple Payback (years)
Existing duct performance and thermostat settings	536	214400	$15,318	$0	$0	$0	-
Repair 50% of leaks	355	142000	$10,152	$500	$1,460	$5,166	0.38
Repair 75% of leaks	259	103600	$7,400	$750	$3,000	$7,918	0.47
Adjust thermostats	461	184400	$13,185	$0	$0	$2,134	Immediate
Repair 50% of leaks and Adjust thermostats	290	116000	$8,286	500	$1,460	$7,032	0.28

10.4 VendingMiser

VendingMiser®

ENERGY MANAGEMENT SYSTEM
For Refrigerated Vending Machines

Improve the profitability of your existing cold drink machines. Vending Miser® puts you on a cost-effective refresher course for energy savings and conservation.

VendingMiser cuts energy costs down to size

VendingMiser incorporates its innovative energy-saving technology into a small, plug-and-play powerhouse that installs in minutes either on the wall or on the vending machine. It's that easy.

With VendingMiser there's no need to have new machines to achieve maximum energy savings resulting in a reduction in operating costs and greenhouse gas emissions. When equipped with the VendingMiser, refrigerated beverage vending machines use less energy and are comparable in daily energy performance to new ENERGY STAR® qualified machines.

Power play

Compatible with all types of cold drink vending machines, the VendingMiser uses a Passive Infrared Sensor (PIR) to power down the machine when the area surrounding it is vacant. Then it monitors the room's temperature and automatically re-powers the cooling system at one- to three-hour intervals, independent of sales, to ensure that the product stays cold.

This Miser runs the bank

For a series of up to four machines, VendingMiser can use its embedded Sensor Repeater, which allows it to be controlled from the PIR sensor of any other Miser in the bank.

Refresher course

VendingMiser's microcontroller will never power down the machine while the compressor is running, eliminating compressor short-cycling. In addition, when the machine is powered up, the cooling cycle is allowed to finish before again powering down. This reduces the wear and tear on your machines, extending the lifespan and prolonging your profitability. Maintenance savings is generated through reduced running time of vendor components – estimated at $40 - $80 per year, per machine. The VendingMiser has been tested and accepted for use by major bottlers.

VendingMiser reduces energy consumption an average of 46%—typically $150 per machine.

Vending Miser offers...

- A quick, inexpensive solution to energy savings and conservation
- Longer machine lifespan
- Early return on investment
- Environmental benefits

VendingMiser can also control other cooled product vending machines, such as refrigerated candy machines.

VendingMiser Technical Specifications
Electrical Specifications
Input Voltage: 115 Volts
Input Frequency: 50/60 Hz
Maximum Load: 12 Amps (Steady-State)
Power Consumption: Less than 1 Watt (Standby)

Environmental Specifications
Operating Temp: -15°C to 75°C
Storage Temp: -40°C to 85°C
Relative Humidity: 95% Maximum (Non-Condensing)

Compatibility
Vending Machines: Any machine, except those containing perishable goods such as dairy products

Inactivity Timeouts
Occupancy Timeout: 15 minutes
Auto Re-power: One to three hours, dynamically adjusted, based on ambient temperature

Dimensions
Size: 4.5"W x 1.75"H x 3.25"D
Weight: 2.2 lbs. (includes power cable)

Regulatory Approvals
Safety: UL/C-UL Listed
Information Technology Equipment (ITE) 9T79

Other energy-saving products offered by USA Technologies include VM2IQ™, CoolerMiser™, SnackMiser™ and PlugMiser™.

ENERGY STAR PARTNER

USA TECHNOLOGIES

USA Technologies Eastern Region Sales Office: 800.633.0340 Western Region Sales Office: 800.770.8539 www.usatech.com

Frequently Asked Questions

Will VendingMiser® keep my drinks cold?
Absolutely - VendingMiser® has been tested and accepted for use by both major bottlers.

Is the VendingMiser® easy to install?
Yes! VendingMiser® is a simple external plug-and-play product. The VendingMiser® can be installed on the wall with simple hand tools or it can be attached to the vending machine without tools using the new Easy-Install system. The Easy-Install System allows quick installation in 5 minutes.

Is VendingMiser® safe for all machines?
Yes! VendingMiser® is compatible with all types of cold drink vending machines. In fact, by reducing run time of the machines, VendingMiser® reduces maintenance costs.

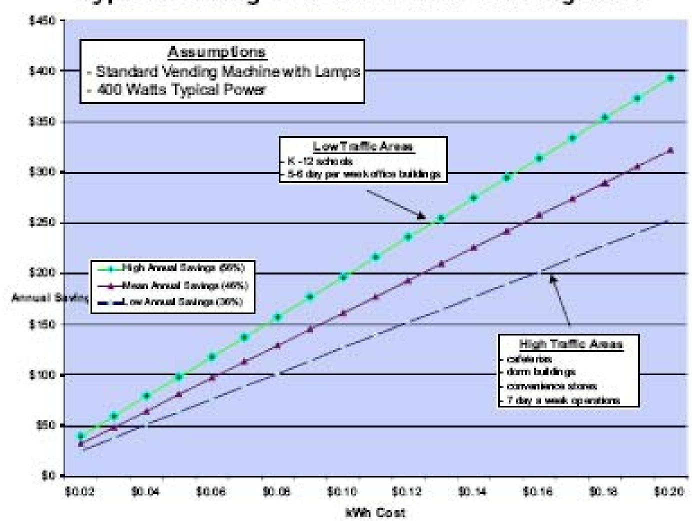
Has VendingMiser® been field tested?
Tens of thousands of VendingMisers® are operational in the field. Typical energy savings have been independently documented to be between 35% and 45%. Measurement and verification test results as well as testimonials are available on the website.

Are there any locations not appropriate for VendingMiser®?
VendingMiser's® savings are generated as a result of location vacancy. Therefore, a machine in a location that is occupied 24-hours, 7 days a week will likely generate little savings. Our VM2IQ is more appropriate for this type of location and will typically save up to 35% energy use.

Technical Specifications

ELECTRICAL SPECIFICATIONS	
Input Voltage:	115 Volts (230 Volts available)
Input Frequency:	50/60 Hz
Maximum Load:	12 Amps (Steady-State)
Power Consumption:	Less than 1 Watt (Standby)
ENVIRONMENTAL SPECIFICATIONS	
Operating Temp:	-15°C to 75°C
Storage Temp:	-40°C to 85°C
Relative Humidity:	95% Maximum (Non-Condensing)
COMPATIBILITY	
Vending Machines:	Any machine, except those containing perishable goods such as dairy products.
INACTIVITY TIMEOUTS	
Occupancy Timeout:	15 minutes
Auto Repower:	One to three hours, dynamically adjusted, based on ambient temperature
DIMENSIONS	
Size:	4.5"W x 1.75"H x 3.25"D
Weight:	2.2 lb. (incl. power cable)
REGULATORY APPROVALS	
Safety:	UL/C-UL Listed Information Technology Equipment (ITE) 9T79

Typical Saving Generated with VendingMiser®



VendingMiser® Products

VM150	VendingMiser® with PIR Sensor
VM151	VendingMiser® only
VM160	Weatherproof VendingMiser® with PIR Sensor
VM161	Weatherproof VendingMiser® only
VM170	Easy-Install VendingMiser® with PIR Sensor
VM171	Easy-Install VendingMiser® only
VM180	Weatherproof Easy-Install VendingMiser w/PIR sensor
VM181	Weatherproof Easy-Install VendingMiser only

USA Technologies Eastern Region Sales Office: 800.633.0340 Western Region Sales Office: 800.770.8539 www.usatech.com

10.5 Personal Footrest/Space Heater

Product Name: McGill Deluxe Heated Footrest and Panel - 18.25" x 13" x 3.87" - Black

Product Details Use two ways—as a heated, tilt-adjustable footrest to warm feet, ease backstrain and improve posture. Or, rotate panel and use as a freestanding radiant heat unit. Radiates safe, even heat in two heat settings.

Manufacturer Name: McGill Metal Products Company

Product ID: MCG10604 **Equivalents:** MCG-10604, MCG 10604, HLSHMH120U, 10604

Catalog ID: MCG-10604 **Manufacturer Part Number:** 10604

UPC: 00072835106042

Vendor Description: HEATER,ELECT,FOOT WARM,BK

Product Notes: Deluxe Personal Warmer™/**Footrest**, 100 Watt, 18-1/4w x 3-7/8d x 13h, **Black**

Dimension (L x W x H): 19.2 x 12.8 x 4.1

Shipping Weight: 4 lbs.

Product Weight: 4 lbs.

Product Cube: 0.79

10.6 Digital timed light switch

PRODUCT FACT SHEET

08/01/04

EJ500C

MODELS:
EJ500C

DESCRIPTION:
Indoor Digital Wall Switch with Self Adjusting Feature

FEATURES AND BENEFITS:
- 7 ON/OFF settings per day
- Self adjusting option follows daily sunrise/sunset time changes: - set it and forget it.
- For 2-way and 3-way switching
- Battery backup

ELECTRICAL RATINGS:
- 500 Watts Incandescent
- 120 VAC, 60 Hz.

PACKAGING:

LANGUAGE:	English, Spanish
	Instructions – English, Spanish
PACK TYPE:	Clamshell
CASE:	6-Bin Box (11.5" L x 7.75" W x 9.25" H)
	Weight - 7.0 pounds Cube - .48

I 2 of 5 Code (Master Pack):
50078275089698

UPC CODE:
0 78275 08969 3

AGENCY APPROVAL:
C US

INTERMATIC INCORPORATED
Intermatic Plaza
Spring Grove, IL 60081-9698
www.intermatic.com

MADE IN CHINA

INTERMATIC INCORPORATED

300EJ10009

11 Appendix D: Photovoltaic System

11.1 NSRDB Insolation Comparison

A pyranometer was installed at a central location on the rooftop of the RNSP facility to measure the solar insolation at 5 minute intervals between June 5th and July 16th. The solar insolation data collected from the pyranometer was averaged per day per month and then compared to the NSRDB modeled data for Arcata, CA (Figure 52). The average solar insolation values collected from the pyranometer were above those provided by the NSRDB model which suggests that more solar energy may be available in Crescent City than in Arcata. However, after a closer inspection of the values, the pyranometer values were determined to be within two standard deviations of the average monthly values provided by the NSRDB model data and within the maximum monthly average solar insolation values for Arcata. Thus, the pyranometer values were determined to be in close agreement to the NSRDB values used in the PV calculations.

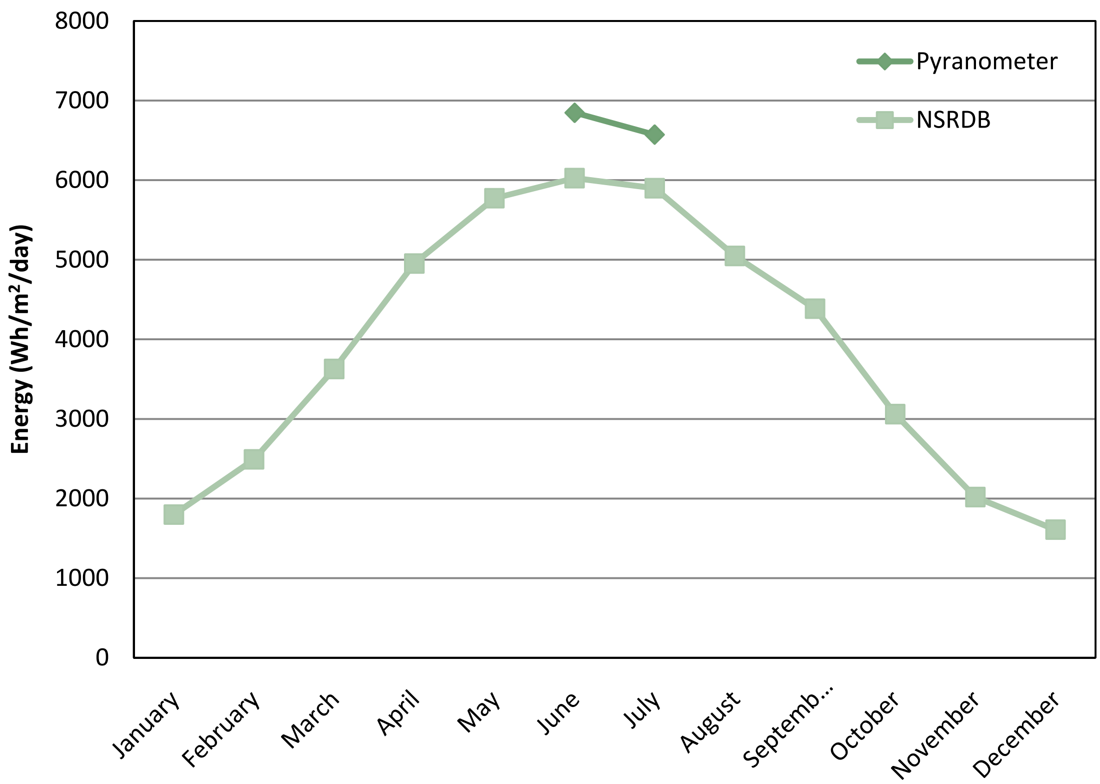


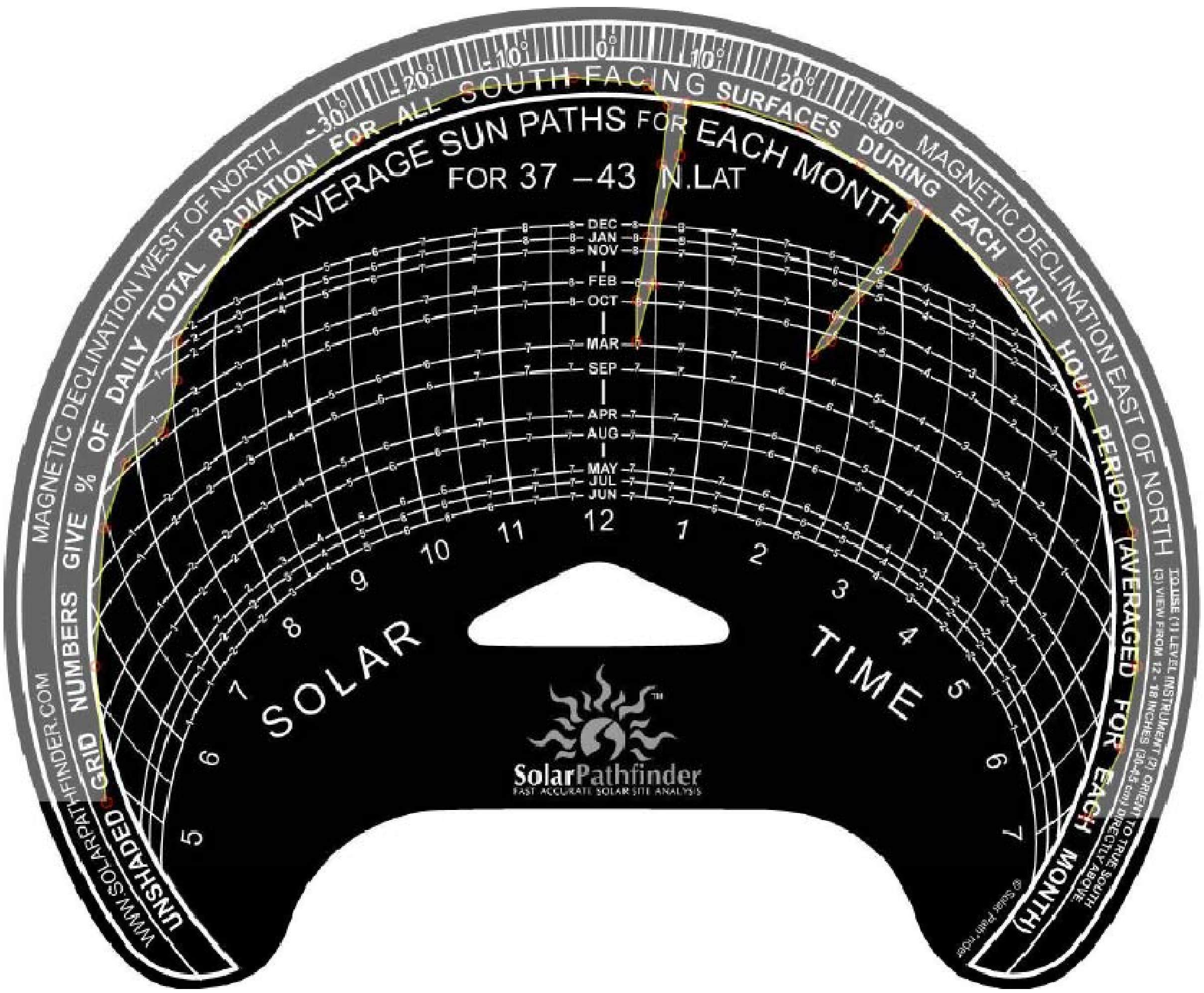
Figure 52. Comparison of NSRDB modeled data for Arcata to actual measured data from Crescent City.

11.2 Solar Path Finder Results

Solar Site Analysis Report

Report Title	Flag pole
Image File	IMGP0443.JPG
Report Date	Friday, June 27, 2008
Declination	15d 48m
Latitude/Longitude	41.744 / -124.057
Analysis Site	CRESCENT CITY, CA, Zipcode: 95531
Weather Station	ARCATA, CA, Elevation: 69 m
Station/Site Distance	52.69 miles
Array Type	Fixed
Tilt Angle	41.74 degrees
Cost of Electricity	6 cents/kWhr
DC Rate	4.00 kW
Derate Factor	0.77
Azimuth (180 = south)	180.00 degrees

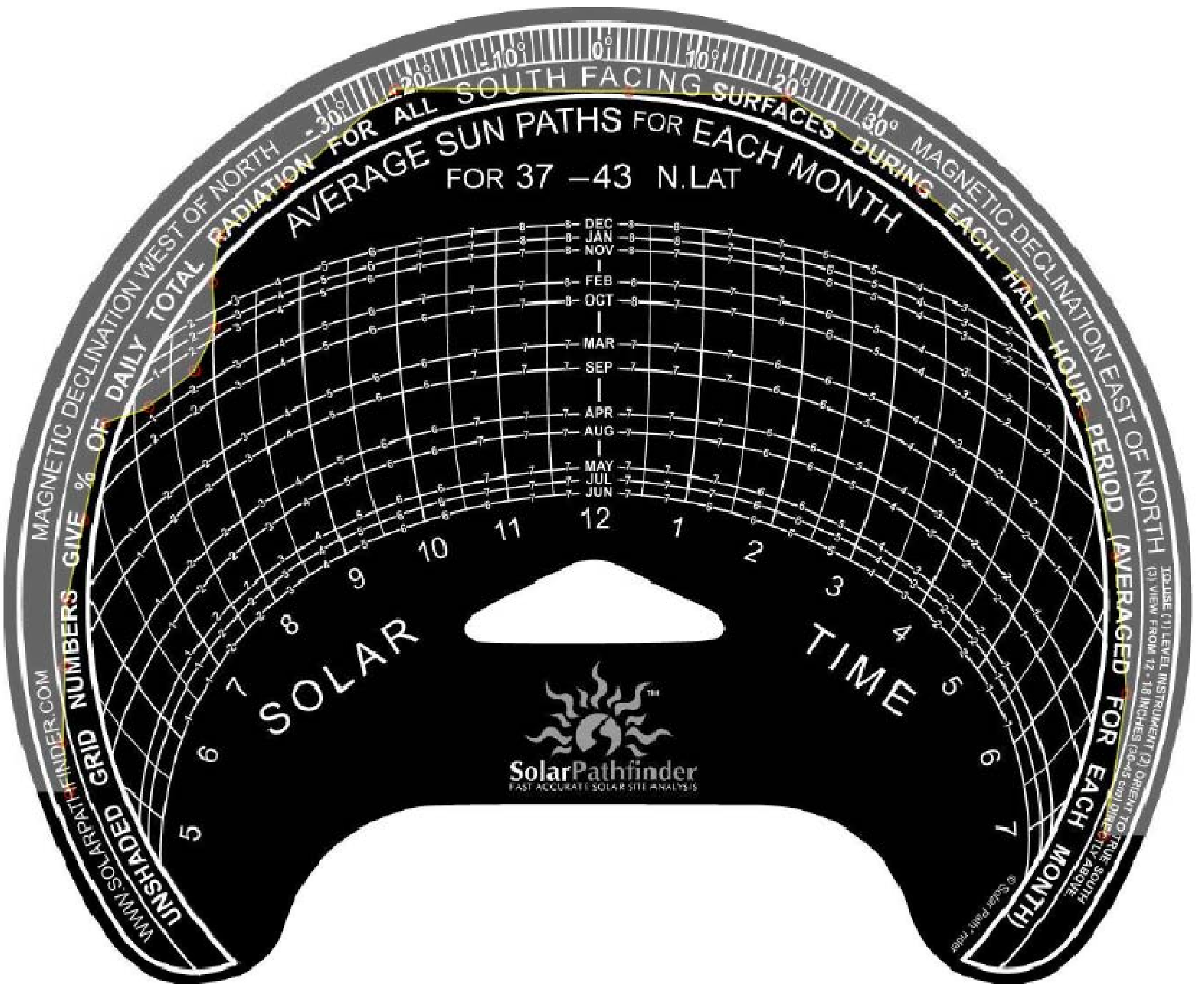
Month	Unshaded % of Ideal Site Azimuth=180.0 Tilt=41.7	Actual Solar Rad w/ Shading Azimuth=180.0 Tilt=41.7 KWH/m ^{2} /day
January	97.00%	3.05
February	96.20%	3.41
March	100.00%	4.39
April	100.00%	5.42
May	100.00%	5.42
June	100.00%	5.18
July	100.00%	5.47
August	100.00%	4.97
September	100.00%	5.06
October	97.20%	4.04
November	96.10%	3.44
December	95.50%	3.10
Totals	98.50%	52.96 [98.82%]



Solar Site Analysis Report

Report Title	Middle
Image File	IMGP0435.JPG
Report Date	Friday, June 27, 2008
Declination	15d 48m
Latitude/Longitude	41.744 / -124.057
Analysis Site	CRESCENT CITY, CA, Zipcode: 95531
Weather Station	ARCATA, CA, Elevation: 69 m
Station/Site Distance	52.69 miles
Array Type	Fixed
Tilt Angle	41.74 degrees
Cost of Electricity	6 cents/kWhr
DC Rate	4.00 kW
Derate Factor	0.77
Azimuth (180 = south)	180.00 degrees

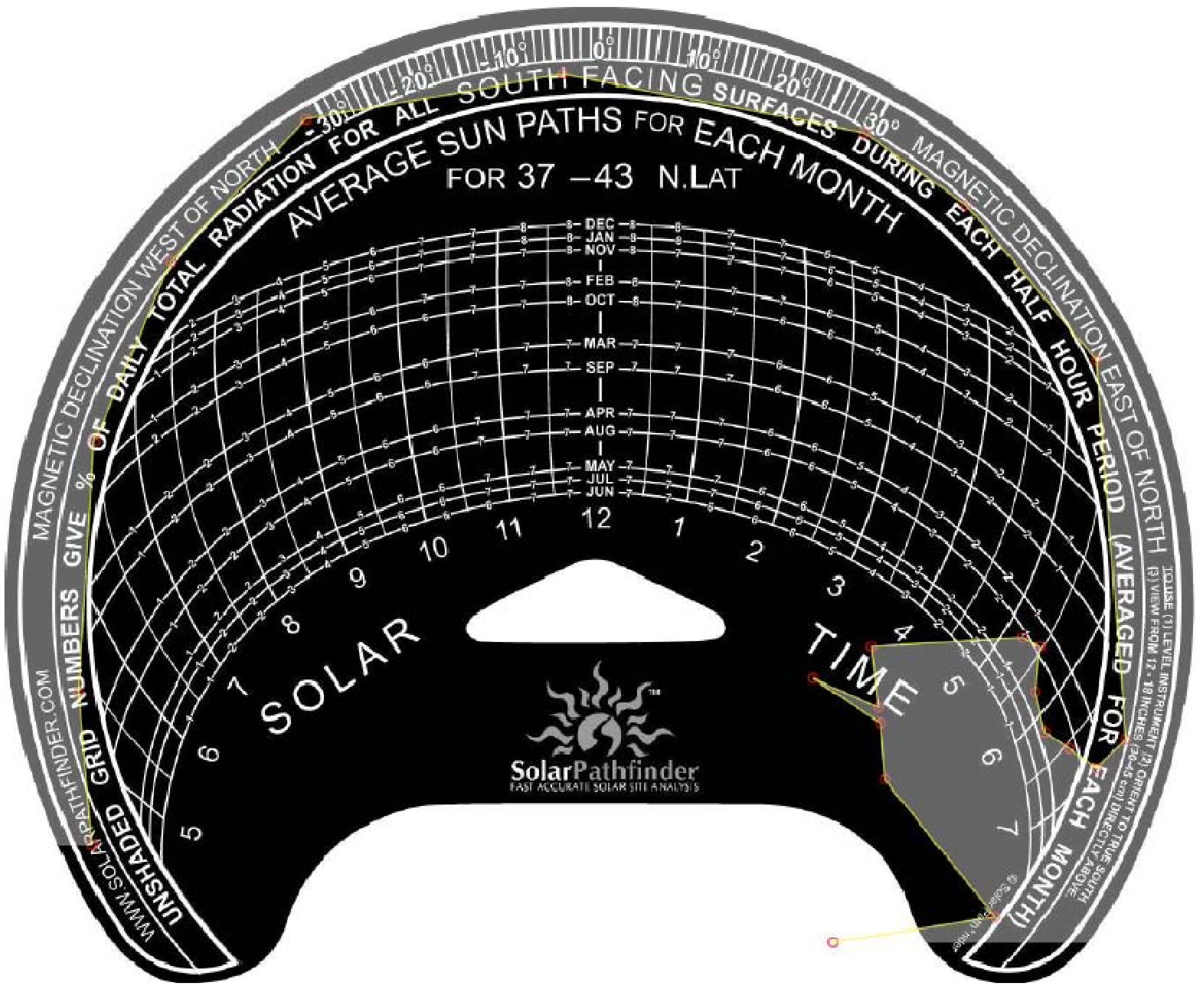
Month	Unshaded % of Ideal Site Azimuth=180.0 Tilt=41.7	Actual Solar Rad w/ Shading Azimuth=180.0 Tilt=41.7 KWH/m ^{2} /day
January	97.70%	3.07
February	100.00%	3.55
March	100.00%	4.39
April	100.00%	5.42
May	100.00%	5.42
June	100.00%	5.18
July	100.00%	5.47
August	100.00%	4.97
September	100.00%	5.06
October	100.00%	4.16
November	97.20%	3.48
December	98.00%	3.18
Totals	99.41%	53.36 [99.56%]



Solar Site Analysis Report

Report Title	Northwest Courner
Image File	IMGP0452.JPG
Report Date	Friday, June 27, 2008
Declination	15d 48m
Latitude/Longitude	41.744 / -124.057
Analysis Site	CRESCENT CITY, CA, Zipcode: 95531
Weather Station	ARCATA, CA, Elevation: 69 m
Station/Site Distance	52.69 miles
Array Type	Fixed
Tilt Angle	41.74 degrees
Cost of Electricity	6 cents/kWhr
DC Rate	4.00 kW
Derate Factor	0.77
Azimuth (180 = south)	180.00 degrees

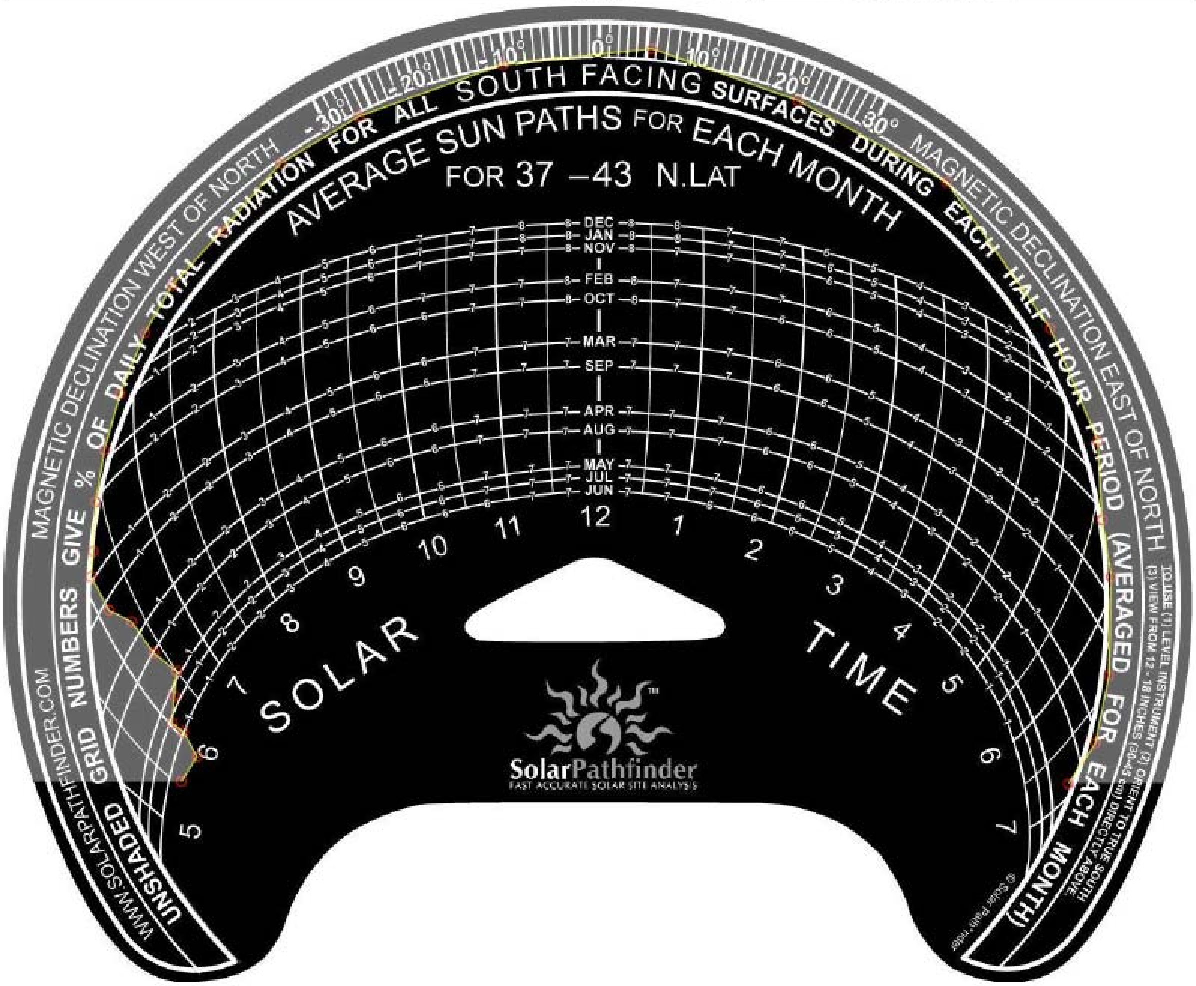
Month	Unshaded % of Ideal Site Azimuth=180.0 Tilt=41.7	Actual Solar Rad w/ Shading Azimuth=180.0 Tilt=41.7 KWH/m ^{2} /day
January	100.00%	3.14
February	100.00%	3.55
March	100.00%	4.39
April	100.00%	5.42
May	98.60%	5.34
June	96.40%	5.00
July	98.20%	5.37
August	99.70%	4.95
September	100.00%	5.06
October	100.00%	4.16
November	100.00%	3.58
December	100.00%	3.25
Totals	99.41%	53.22 [99.30%]



Solar Site Analysis Report

Report Title	SouthEastEdge
Image File	IMGP0431.JPG
Report Date	Friday, June 27, 2008
Declination	15d 48m
Latitude/Longitude	41.744 / -124.057
Analysis Site	CRESCENT CITY, CA, Zipcode: 95531
Weather Station	ARCATA, CA, Elevation: 69 m
Station/Site Distance	52.69 miles
Array Type	Fixed
Tilt Angle	41.74 degrees
Cost of Electricity	6 cents/kWhr
DC Rate	4.00 kW
Derate Factor	0.77
Azimuth (180 = south)	180.00 degrees

Month	Unshaded % of Ideal Site Azimuth=180.0 Tilt=41.7	Actual Solar Rad w/ Shading Azimuth=180.0 Tilt=41.7 KWH/m ^{2} /day
January	100.00%	3.14
February	100.00%	3.55
March	100.00%	4.39
April	100.00%	5.42
May	100.00%	5.42
June	99.90%	5.18
July	100.00%	5.47
August	100.00%	4.97
September	100.00%	5.06
October	100.00%	4.16
November	100.00%	3.58
December	100.00%	3.25
Totals	99.99%	53.59 [99.99%]



Solar Site Analysis Report

Report Title	SouthWest Edge
Image File	IMGP0433.JPG
Report Date	Friday, June 27, 2008
Declination	15d 48m
Latitude/Longitude	41.744 / -124.057
Analysis Site	CRESCENT CITY, CA, Zipcode: 95531
Weather Station	ARCATA, CA, Elevation: 69 m
Station/Site Distance	52.69 miles
Array Type	Fixed
Tilt Angle	41.74 degrees
Cost of Electricity	6 cents/kWhr
DC Rate	4.00 kW
Derate Factor	0.77
Azimuth (180 = south)	180.00 degrees

Month	Unshaded % of Ideal Site Azimuth=180.0 Tilt=41.7	Actual Solar Rad w/ Shading Azimuth=180.0 Tilt=41.7 KWH/m ^{2} /day
January	100.00%	3.14
February	100.00%	3.55
March	100.00%	4.39
April	100.00%	5.42
May	100.00%	5.42
June	100.00%	5.18
July	100.00%	5.47
August	100.00%	4.97
September	100.00%	5.06
October	100.00%	4.16
November	100.00%	3.58
December	100.00%	3.25
Totals	100.00%	53.59 [100.00%]

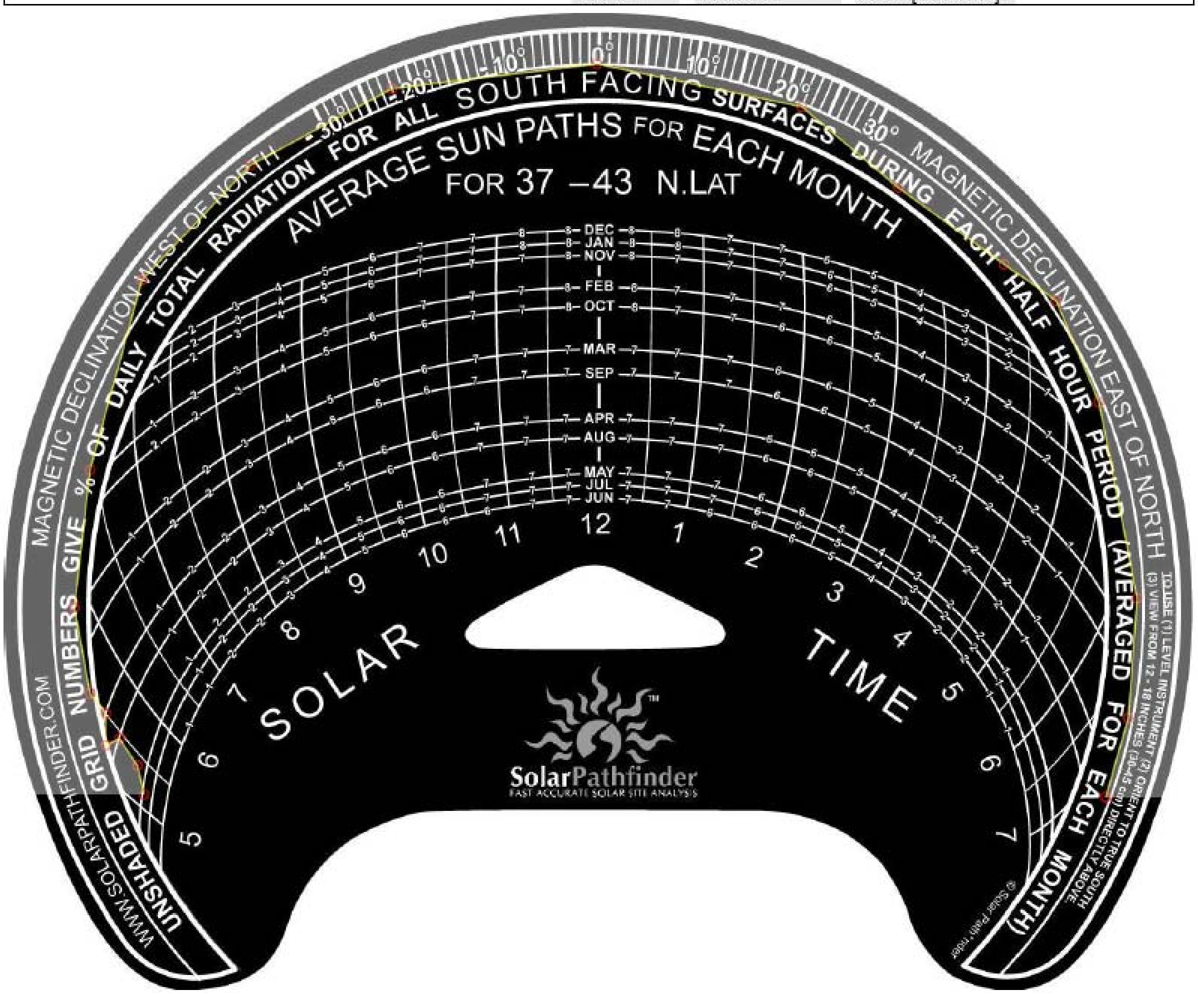


Table 7. Area weighted average of the percent shading occurring on the RNSP facilities rooftop.

	Area Shaded							
Location	ft^2	%	Jan	Feb	Mar	Apr	May	Jun
Flag Pole	500	0.0675	97.00%	96.20%	100.00%	100.00%	100.00%	100.00%
Middle	500	0.0675	97.70%	100.00%	100.00%	100.00%	100.00%	100.00%
Northwest Corner	25	0.0034	100.00%	100.00%	100.00%	100.00%	98.60%	96.40%
South East Edge	150	0.0202	100.00%	100.00%	100.00%	100.00%	100.00%	99.90%
South West Edge	N/A		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Other	6237	0.8415	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Area Weighted Average	N/A		99.64%	99.74%	100.00%	100.00%	100.00%	99.99%

	Area Shaded								
Location	ft^2	%	Jul	Aug	Sep	Oct	Nov	Dec	Average
Flag Pole	500	0.0675	100.00%	100.00%	100.00%	97.20%	96.10%	95.50%	98.87%
Middle	500	0.0675	100.00%	100.00%	100.00%	100.00%	97.20%	98.00%	99.62%
Northwest Corner	25	0.0034	98.20%	99.70%	100.00%	100.00%	100.00%	100.00%	99.17%
South East Edge	150	0.0202	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	99.98%
South West Edge	N/A		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Other	6237	0.8415	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Area Weighted Average	N/A		99.99%	100.00%	100.00%	99.81%	99.55%	99.56%	99.89%

11.3 Solar Insolation and Array Spacing

The KT method was applied to model the effects of changing the tilt and azimuth angles of the solar panels (Duffie and Beckman, 2006). The solver function in excel was used to determine the tilt and azimuth angles which maximize the solar gain on the roof of the RNSP facility's rooftop. The maximum solar gain was then compared to alternative tilts. A solar panel with a tilt angle of 30 degrees and an azimuth angle of 10 degrees was determined to reduce the maximum solar gain by less than 2 percent while allowing the solar panels to be spaced close enough to maximize the available area on the roof of the RNSP facility (Table 8).

Table 8. Average daily solar insolation per month and required module spacing at specified tilt and azimuth angles.

For Crescent City			
	Latitude	41.744	
	Longitude	124.057	
	Reflectance	0.65	
	Alternative	**max**	
Tilt Angle	30.00	44.67	
Azimuth Angle	10	0	
Month	Ht Bar (kWh/m^2/day)		
January	2.827	3.195	
February	3.421	3.721	
March	4.368	4.539	
April	5.384	5.351	
May	5.822	5.592	
June	5.885	5.570	
July	5.843	5.566	
August	5.293	5.182	
September	5.112	5.230	
October	4.110	4.431	
November	3.079	3.451	
December	2.643	3.020	
Avg.	4.482	4.571	
% Max	0.9806		

Module Spacing			
Module	Kyocera KD205GX-LF		
Length (ft)	4.925		
Width (ft)	3.250		
		Alternative	**Max**
Module Orientation	Tilt Angle	30.00	44.67
	Azimuth Angle	10.00	0.00
	Solar Alt. Angle	24.000	24.85
Module at Tilt	Height (ft)	2.463	3.462
	Length (ft)	4.265	3.503
	Width (ft)	3.250	3.250
	Area (ft^2)	13.86	11.38
Shading	Length (ft)	5.53	7.476
	Width (ft)	3.250	3.250
	Area (ft^2)	18.0	24.30
Area Required per panel	Length (ft)	9.80	10.98
	Width (ft)	3.250	3.250
	Area (ft^2)	31.8	35.68

11.4 Solar Panel and Inverter Sizing and Price Comparison

Table 9. Comparison of solar panel power ratings, prices, sizes, and warranties.

Make	Module	Power (W)	Price ($)[54]	$/Watt	Size (in x in)	Area (ft^2)	W/ft^2	Weight (lb)	Warranty
BP Solar	SX 3200B, 200 Watt, 16v	200	1100	5.50	66.14 x 32.95	15.1	13.2	33.95	25
	SX-3195S, 195 Watt, 16v	195	899	4.61	66.14 x 32.95	15.1	12.9	33.95	25
	3115J, 115 Watt , 12 V	115	597	5.19	59.4 x 26.5	10.9	10.5	26.5	25
CDT Solar	CDT-175 W, 18 V	175	789	4.51	52 x 39	14.08	12.4	33.9	20
Day 4 Energy	MC48 180 W, 16V	180	850	4.72	51.46 x 39.02	13.94	12.9	38.28	
	MC48 175 W, 16V	175	820	4.69	51.46 x 39.02	13.94	12.5	38.28	
	MC48 170 W, 16V	170	791	4.65	51.46 x 39.02	13.94	12.2	38.28	
Evergreen Solar	ES-195 16V	195	936	4.80	61.8 x 37.5	16.1	12.1	40.1	25
	ES-190 16V	190	869	4.57	61.8 x 37.5	16.1	11.8	40.1	25
	ES-180 16 V	180	829	4.61	61.8 x 37.5	16.1	11.2	40.1	25
GE Energy	GEPV-200, 16 V	200	999	5.00	58.5 x 38.6	15.68	12.8	39	25
	GEPV-173, 16 V	173	829	4.79	58.1 x 38.4	15.49	11.2	39	25
Kyocera	KD205GX-LP, 205 Watt, 16v	205	910	4.44	59.1 x 39.0	16.01	12.8	40.8	20
	KD180GX-LP, 180 Watt, 16v	180	799	4.44	52.8 x 39.0	14.30	12.6	36.4	20
	KD135GX-LP, 135 Watt	135	629	4.66	59.1 x 26.3	10.79	12.5	28.7	20
Mitsubishi Electric	PV-UD185MF5, 185 Watt 16v	185	883	4.77	65.3 x 32.8	14.87	12.4	37	25
	PV-UD180MF5, 180 Watt 16v	180	839	4.66	65.3 x 32.8	14.87	12.1	37	25
Sanyon	HIP-200BA3, 200 Watt	200	1051	5.26	51.9 x 35.2	12.69	15.8	30.9	20
	HIP-195BA3, 195 Watt	195	1012	5.19	51.9 x 35.2	12.69	15.4	30.9	20
	HIP-190BA3, 190 Watt	190	987	5.19	51.9 x 35.3	12.69	15.0	30.9	20
	HIP-190DA3, 190 W Bifacial	190	1065	5.61	53.2 x 35.35	13.06	14.5	39.4	20
	HIP-186DA3, 186 W Bifacial	186	1043	5.61	53.2 x 35.35	13.06	14.2	39.4	20
Schott Solar	ASE-300-DGF/50	300	1830	6.10	74.5 x 50.5	26.1	11.5	107	20
	ASE 300-DG/17	300	1800	6.00	74.5 x 50.5	26.1	11.5	107	20
Sharp	ND-224U1F, 224 Watt 20V	224	1075	4.80	64.6 x 39.1	17.54	12.8	44	25
	ND-216U2, 216 Watt, 20v	216	1019	4.72	64.6 x 39.1	17.54	12.3	44	25
	ND-176U1Y, 176 Watt 16V	176	823	4.68	52.87 x 39.76	14.60	12.1	36.4	25
	NE-170U1, 170 watt	170	839	4.94	62.01 x 35.52	15.30	11.1	37.48	25

[54] PV prices and specifications from <http:///www.affordable-solar.com>. The prices of solar panels are subject to change.

Table 10. Comparison of inverter prices and maximum power capacities.

Inverter	Prices ($)[55]	# Strings[56]	Panels/String	W max	$/W
SB 3000US (208)	2184	1	9-13	2665	0.8195
		2	9	3690	0.5919
SB 3000US (240)	2184	1	10-13	2665	0.8195
SB 4000US (208)	2602	1	11-16	3280	0.7933
		2	11	4510	0.5769
SB 4000US (240)	2602	1	11-16	3280	0.7933
		2	11-12	4920	0.5289
SB 5000 (208,240,277)	3536	1	12-16	3280	1.0780
		2	12-15	6150	0.5750
SB 6000US (208, 240)	3628	1	12-16	3280	1.1061
		2	12-16	6560	0.5530
		3	12	7380	0.4916
SB 6000US (277)	3628	1	12-16	3280	1.1061
		2	12-16	6560	0.5530
		3	12	7380	0.4916
SB 7000US (208)	4108	1	12-16	3280	1.2524
		2	12-16	6560	0.6262
		3	12-14	8610	0.4771
SB 7000US (240, 277)	4108	1	12-16	3280	1.2524
		2	12-16	6560	0.6262
		3	12-14	8610	0.4771

[55] Inverter prices and specifications from <http://affordable-solar.com>.
[56] Inverter string sizing from <http://sma-america.com>.

11.5 PV Components and Prices

Table 11. PV rack components and prices per set[57].

Stand-Off Mounting: 2x12, 1x4			**5740 W system**		
Quantity	Number	Category	Part	Unit	Total
6	300002	Preferred Rail	RAIL, SM, CLR, 48"	$33.00	$198.00
112	321001	Bottom Up Clips	SM CLIP, CLR, HDW	$2.29	$256.48
6	310506	Aluminum Flat Tops	STANDOFF, 6 in. ALUM CLR @ 1	$18.10	$108.60
6	310068	Single L-Feet	L-FOOT SERR, CLR W/ HDW @1	$5.63	$33.78
6	990110	Flashing	GALV FLASH, 1 @ 1.25in-1.5in	$9.07	$54.42
6	980010	Grounding Lugs	GROUNDING LUG NO. 1 @ 1 EA	$13.30	$79.80
				Total List Price	$731.08
				Price/Watt	$0.13
				Price/Module	$26.11

Table 12. List of alternative PV design components and prices.

Alternative 1	6150	W System			
Component	Quantity	Unit Price	Cost	Model	Source
Lightning Arrestor	1	$42.00	$42.00	LA602 DC Lightning Arrestor	Affordable Solar
Ground Wire (ft)	45	$0.85	$38.25	Bare #6 wire	Piersons Building Center
PV-Inverter Wires (ft)	180	$0.16	$28.80	10 AWG Stranded Copper Wire	Piersons Building Center
Conduit (10 ft)	5	$8.99	$40.46	1 inch EMT Conduit	Piersons Building Center
Conduit Fittings	5	$1.79	$8.06		Piersons Building Center
Racking (Average $/Panel)	30	$26.11	$783.30	Unirac Stand-Off Mounting sys.	Unirac
Kyocera Solar Panel	30	$910.00	$27,300.00	KD205GX-LP, 205 Watt, 16v	Affordable Solar
Sunny Boy Inverter	1	$3,536.00	$3,536.00	SB 5000 (208,240,277)	Affordable Solar
Digital Display (Optional)	1	$975.00	$975.00	Sunny Webbox	Affordable Solar
Labor	960	$10.00	$9,600.00	UNPEPP Interns	
Labor	20	$100.00	$2,000.00	Professional Installer	
		Total	$44,351.86		
			$7.73	per watt	

Alternative 2 9225 W System

[57] List of PV rack components and prices from <http:///unirac.com/>. PV component unit prices are subject to change.

Component	Quantity	Unit Price	Cost	Model	Source
Lightning Arrestor	2	$42.00	$84.00	LA602 DC Lightning Arrestor	Affordable Solar
Ground Wire (ft)	120	$0.85	$102.00	Bare #6 wire	Piersons Building Center
PV-Inverter Wires (ft)	960	$0.16	$153.60	10 AWG Stranded Copper Wire	Piersons Building Center
Conduit (10 ft)	24	$8.99	$100.00	1 inch EMT Conduit	Piersons Building Center
Conduit Fittings	24	$1.79	$42.96		Piersons Building Center
Racking (Average $/Panel)	45	$26.11	$1,174.95	Unirac Stand-Off Mounting sys.	Unirac
Kyocera Solar Panel	45	$910.00	$40,950.00	KD205GX-LP, 205 Watt, 16v	Affordable Solar
Sunny Boy Inverter	2	$3,536.00	$7,072.00	SB 5000 (208,240,277)	Affordable Solar
Digital Display	1	$975.00	$975.00	Sunny Webbox	Affordable Solar
Labor	1440	$10.00	$14,400.00	UNPEPP Interns	
Labor	30	$100.00	$3,000.00	Professional Installer	
		Total	$68,054.51		
			$7.38	per watt	

Alternative 3 10660 W System

Component	Quantity	Unit Price	Cost	Model	Source
Lightning Arrestor	2	$42.00	$84.00	LA602 DC Lightning Arrestor	Affordable Solar
Ground Wire (ft)	120	$0.85	$102.00	Bare #6 wire	Piersons Building Center
PV-Inverter Wires (ft)	960	$0.16	$153.60	10 AWG Stranded Copper Wire	Piersons Building Center
Conduit (10 ft)	24	$8.99	$100.00	1 inch EMT Conduit	Piersons Building Center
Conduit Fittings	24	$1.79	$42.96		Piersons Building Center
Racking (Average $/Panel)	52	$26.11	$1,357.72	Unirac Stand-Off Mounting sys.	Unirac
Kyocera Solar Panel	52	$910.00	$47,320.00	KD205GX-LP, 205 Watt, 16v	Affordable Solar
Sunny Boy Inverter	2	$3,536.00	$7,072.00	SB 5000 (208,240,277)	Affordable Solar
Digital Display	1	$975.00	$975.00	Sunny Webbox	Affordable Solar
Labor	1440	$10.00	$14,400.00	UNPEPP Interns	
Labor	30	$100.00	$3,000.00	Professional Installer	
		Total	$74,607.28		
			$7.00	per watt	

Alternative 3 34440 W System

Component	Quantity	Unit Price	Cost	Model	Source

Lightning Arrestor	1	$42.00	$42.00	LA602 DC Lightning Arrestor	Affordable Solar
Ground Wire (ft)	370	$0.85	$314.50	Bare #6 wire	Piersons Building Center
PV-Inverter Wires (ft)	8880	$0.16	$1,420.80	10 AWG Stranded Copper Wire	Piersons Building Center
Conduit (10 ft)	222	$8.99	$1,995.78	1 inch EMT Conduit	Piersons Building Center
Conduit Fittings	222	$1.79	$397.38		Piersons Building Center
Racking (Average $/Panel)	168	$26.11	$4,386.48	Unirac Stand-Off Mounting sys.	Unirac
Kyocera Solar Panel	168	$910.00	$152,880.00	KD205GX-LP, 205 Watt, 16v	Affordable Solar
Sunny Boy Inverter	6	$3,536.00	$21,216.00	SB 5000 (208,240,277)	Affordable Solar
Digital Display	1	$975.00	$975.00	Sunny Webbox	Affordable Solar
Labor	3840	$10.00	$38,400.00	UNPEPP Interns	
Labor	50	$100.00	$5,000.00	Professional Installer	
		Total	$227,027.94		
			$6.59	per watt	

11.6 PV Component Specification Sheets

Additional Documentation for the UTA/HOBO

The UTA/HOBO is designed as a precision interface between LI-COR light sensors (Quantum PAR, Pyranometer or Photometer) and the Onset HOBO data logger. LICOR sensors provide a small signal in the range of microamps, whereas the HOBO inputs require a signal in the range of 0–2.5 volts. The UTA/HOBO provides this amplification, and it also has features that allow it to operate directly from the HOBO power supply.

Figure 1:

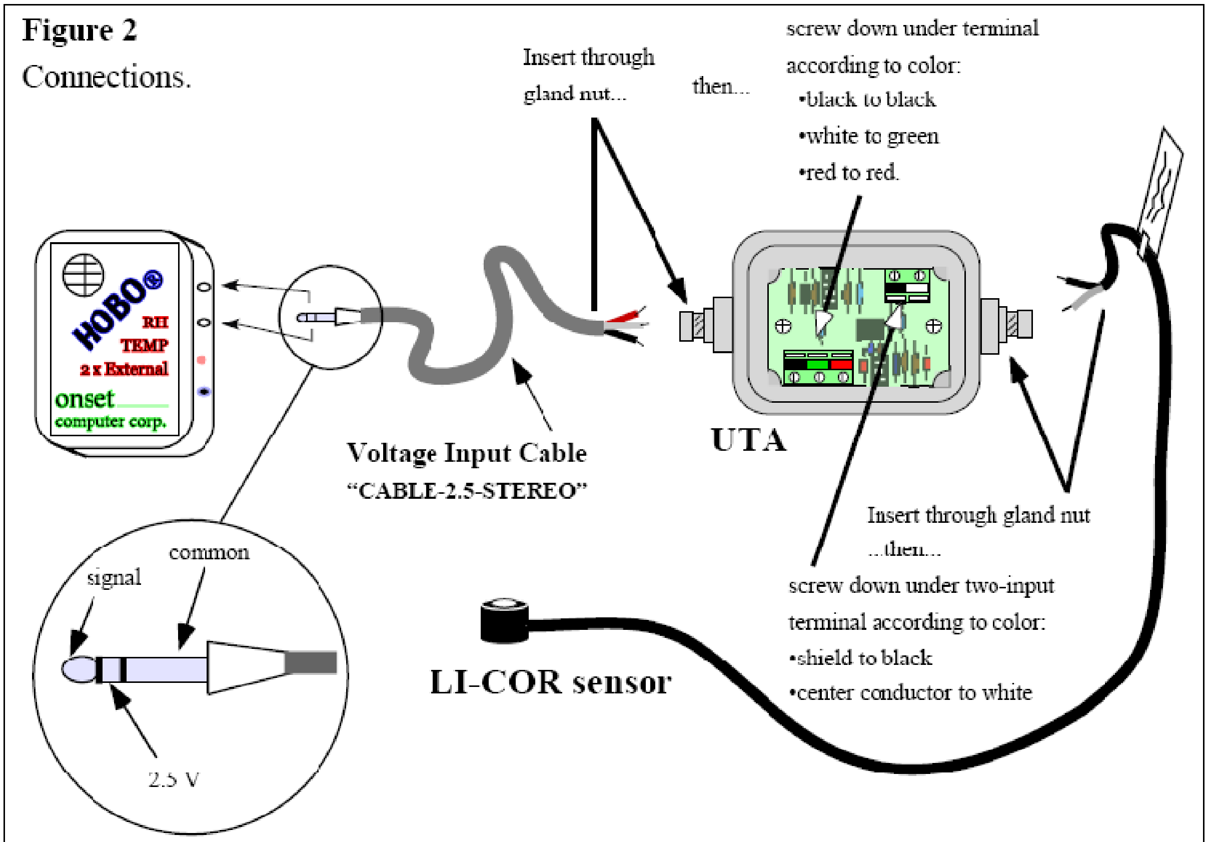
A UTA serves as a link between a LI-COR sensor and the Onset HOBO data logger. The UTA amplifies the tiny current signal from the LI-COR sensor and outputs a voltage compatible with the HOBO.

The UTA/HOBO is manufactured in two models. The base model ("UTA/HOBO") is for use with a SZ model LI-COR sensor, while the "UTA/HOBO/BNC" is for use with the SA model LI COR sensors which have BNC connectors on their input cables. It should be noted that BNC connectors are not waterproof, and should be used only in areas that are sheltered from water exposure. For best water resistance, use the SZ model LI-COR sensors

The UTA/HOBO connects to the HOBO via a voltage input cable available from Onset (their part number "CA-BLE-2.5-STEREO"). The mini stereo plug connects to one of the input ports on the side of the HOBO data logger. The other end of the cable end has three bare wires and goes through the gland nut on the side of the UTA nearest the three-position terminal on the UTA circuit board. The wires are then be screwed down under the terminals according to color code(Figure 2, next page). The LI-COR sensor attaches to the UTA through the gland nut closest to the two-position terminal for SZ model LI-COR sensors (figure 2), or by simply connecting to the BNC connector for the SA model sensors.

The HOBO power supply is a small 3V lithium battery, but despite its small size, it is capable of operation for long periods of time between battery changes. Most of the time, the HOBO is in a sleep mode wherein it requires little power. At a specific time interval (which you determine when you launch the HOBO), the data logger wakes up, turns on the external power supply (red wire on the stereo cable), and records the data coming in from the sensors. There is a 2 millisecond pause between the wake up and the first measurement. After taking up to four measurements in quick succession, the power supply turns off and the HOBO goes back to sleep. The UTA is powered from the 2.5 volts provided by the HOBO on the red wire in the cable. The UTA draws about the same current (125 µamps) as the Onset thermistor temperature probe, so the UTA does not compromise the HOBO battery life. In the UTA/HOBO, some components of the base model UTA have been replaced in order to meet the special low voltage, low current, and high speed, requirements of the HOBO.

Figure 2
Connections.



Calculations:

The external channels on the Onset HOBO data loggers record voltage. When you acquire readings from the logger, using the Boxcar software, those readings will be in volts. You will want to convert Volts to units of light measurement. Drop the negative sign from the LI-COR sensor multiplier.

LI190 Quantum PAR sensor example:
- UTA/HOBO gain = 6.4 microamps per Volt (2.5 Volts full scale output at 16 µamps input)
- multiplier, from LI190 calibration tag or certificate (for example) = 145 µmoles/m²s per µamp
- Volts reading from HOBO = 1.25 (for example)

=> light level = [(HOBO Volts)*6.4]*multiplier = (1.25*6.4)*145 = **1160 µmoles/m²s**

LI200 Pyranometer sensor example:
- UTA/HOBO gain = 48 microamps per Volt (2.5 volts full scale output at 120 µamps input)
- multiplier, from LI200 calibration tag or certificate (for example) = 11.5 watts/m² per µamp
- volts reading from HOBO = 1.25 (for example)

=> light level = [(HOBO volts)*48]*multiplier = (1.25*48)*11.5 = **690 watts/m²**

LI210 Photometer sensor example:
- UTA/HOBO gain = 19.2 volts per microamp (2.5 volts full scale output at 48 µamps input)
- multiplier, from LI210 calibration tag or certificate (for example) = 2.88 K lux per µamp
- volts reading from HOBO=1.25 (for example)

=> light level = [(volts from HOBO*19.2]*multiplier = (1.25*19.2)*2.88 = **69.12 K lux**

Solar Electric Modules

The balance of this catalog lists and describes all of the equipment that you might need for a renewable energy system. We start with solar modules since they are your power producers and we progress through your system concluding with the loads your system will operate.

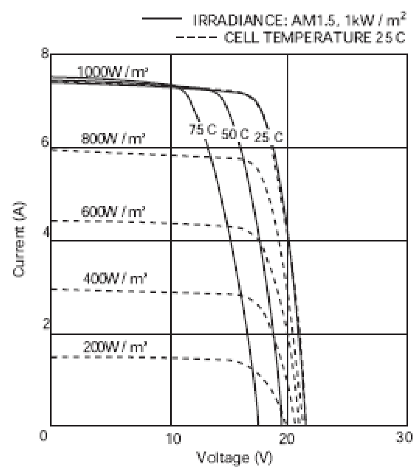
Solar Module Power Characteristics

The current and power output of photovoltaic modules are approximately proportional to sunlight intensity. At a given intensity, a module's output current and operating voltage are determined by the characteristics of the load. If that load is a battery, the battery's internal resistance will dictate the module's operating voltage.

A module which is rated at 17 volts will put out less than its rated power when used in a battery system. This is because the working voltage will be between 12 and 15 volts. As wattage (power) is the product of volts times amps, the module output will be reduced. For example: a 50 watt module working at 13.0 volts will produce 39.0 watts (13.0 volts x 3.0 amps = 39.0 watts). This is important to remember when sizing a PV system.

An I-V curve as illustrated to the right is simply all of a module's possible operating points, (voltage/current combinations) at a given cell temperature and light intensity. Increases in cell temperature increase current slightly, but drastically decrease voltage.

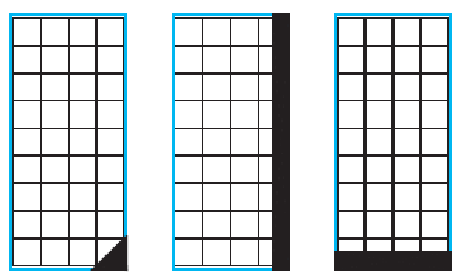
Maximum power is derived at the knee of the curve. Check the amperage generated by the solar array at your battery's present operating voltage to better calculate the actual power developed at your voltages and temperatures.



Shading

PV modules are very sensitive to shading. Unlike a solar thermal panel which can tolerate some shading, many brands of PV modules cannot even be shaded by the branch of a leafless tree.

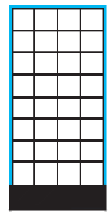
Shading obstructions can be defined as soft or hard sources. If a tree branch, roof vent, chimney or other item is shading from a distance, the shadow is diffuse or dispersed. These soft sources significantly reduce the amount of light reaching the cell(s) of a module. Hard sources are defined as those that stop light from reaching the cell(s), such as a blanket, tree branch, bird dropping, or the like, sitting directly on top of the glass. If even one full cell is hard shaded the voltage of that module will drop to half of its unshaded value in order to protect itself. If enough cells are hard shaded, the module will not convert any energy and will, in fact, become a tiny drain of energy on the entire system.



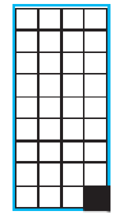
Examples of partial-cell shading that reduce PV module power by ½

Partial-shading even one cell of a 36-cell module, such as the KD135SX, will reduce its power output. Because all cells are connected in a series string, the weakest cell will bring the others down to its reduced power level. Therefore, whether ½ of one cell is shaded, or ½ a row of cells is shaded as shown above, the power decrease will be the same and proportional to the percentage of area shaded, in this case 50%.

When a full cell is shaded, it can act as a consumer of energy produced by the remainder of the cells, and trigger the module to protect itself. The module will route the power around that series string. If even one full cell in a series string is shaded, as seen on the right, it will likely cause the module to reduce its power level to ½ of its full available value. If a row of cells at the bottom of a module is fully shaded, as seen in Figure 7, the power output may drop to zero. The best way to avoid a drop in output power is to avoid shading whenever possible.



Example of full-cell shading that can reduce PV module power to zero



Example of full-cell shading that can reduce PV module power by ½

Tilt Angle

To capture the maximum amount of solar radiation over a year, the solar array should be tilted at an angle approximately equal to a site's latitude, and facing within 15° of due south. To optimize winter performance, the solar array can be tilted 15° more than the latitude angle, and to optimize summer performance, 15° less than the latitude angle. At any given instant, the array will output maximum available power when pointed directly at the sun.

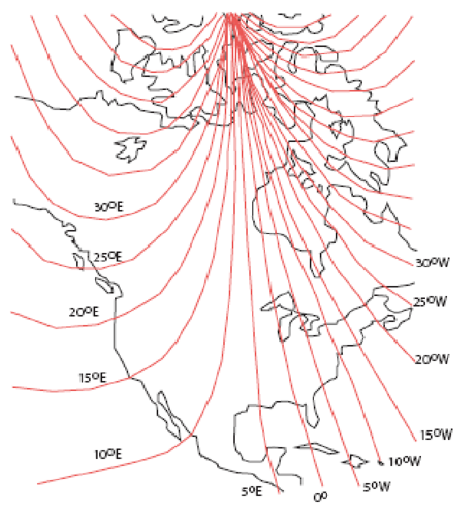
To compare the energy output of your array to the optimum value, you will need to know the site's latitude, and the actual tilt angle of your array-which may be the slope of your roof if your array is flush-mounted. If your solar array tilt is within 15° of the latitude angle, you can expect a reduction of 5% or less in your system's annual energy production. If your solar array tilt is greater than 15° off the latitude angle, the reduction in your system's annual energy production may fall by as much as 15% from its peak available value. During winter months at higher latitudes, the reduction will be greater.

Azimuth Angle and Magnetic Declination

If a south-facing roof is unavailable, or the total solar array is larger than the area of a south-facing roof section, an east or west-facing surface is the next best option. Be aware that solar power output decreases proportionally with a horizontal angle, or "azimuth," greater than 15° from due south. The decrease in annual power output from a latitude-tilted east or west-facing array may be as much as 15% or more in the lower latitudes or as much as 25% or more in the higher latitudes of the United States. Avoid directing your tilted solar panels northwest, north or northeast, as you'll get little power output.

Magnetic declination, the angle difference between magnetic south and true solar south, must also be taken into account when determining proper solar array orientation. If a magnetic compass alone is used to determine where to point the array, you may not capture the maximum amount of solar radiation. For a general view of the magnetic declination field lines in North America, see the map on the right.

If you wish to gain in-depth information about magnetic declination, visit the following website: http://www.ngdc.noaa.gov/seg/geomag/declination.shtml .



Magnetic declination map of North America for the year 1995

SMA

SUNNY BOY 5000US / 6000US / 7000US

- UL 1741/IEEE 1547 compliant
- 10 yr. standard warranty
- Highest CEC efficiency in its class
- Integrated load-break rated AC and DC disconnect switch
- Integrated fused series string combiner
- Sealed electronics enclosure & Opticool
- Comprehensive SMA communications and data collection options
- Ideal for residential or commercial applications
- Sunny Tower compatible

SUNNY BOY 5000US / 6000US / 7000US

The best in their class

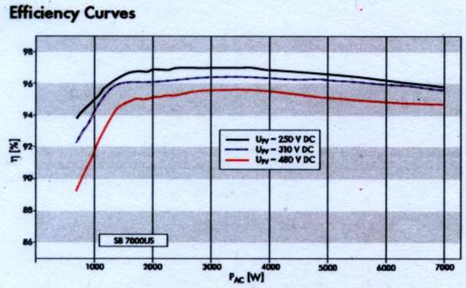
SMA is proud to introduce our new line of inverters updated with our latest technology and designed specifically to meet IEEE 1547 requirements. The Sunny Boy 6000US and Sunny Boy 7000US are also compatible with SMA's new Sunny Tower. Increased efficiency means better performance and shorter payback periods. All three models are field-configurable for positive ground systems making them more versatile than ever. With over 750,000 fielded units, Sunny Boy has become the benchmark for PV inverter performance and reliability throughout the world.

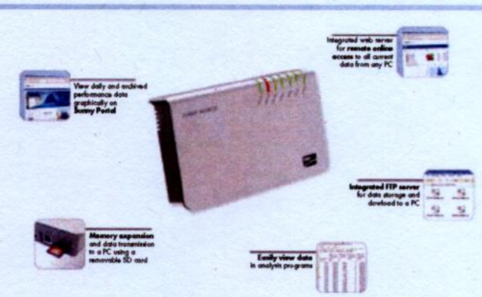
C UL US

Technical Data
SUNNY BOY 5000US / 6000US / 7000US

	SB 5000US	SB 6000US	SB 7000US
Max. Recommended Array Input Power (DC @ STC)	6250 W	7500 W	8750 W
Max. DC Voltage	600 V	600 V	600 V
Peak Power Tracking Voltage	250 - 480 V	250 - 480 V	250 - 480 V
DC Max. Input Current	21 A	25 A	30 A
DC Voltage Ripple	< 5%	< 5%	< 5%
Number of Fused String Inputs	4	4	4
PV Start Voltage	300 V	300 V	300 V
AC Nominal Power	5000 W	6000 W	7000 W
AC Maximum Output Power	5000 W	6000 W	7000 W
AC Maximum Output Current (@ 208, 240, 277 V)	24 A, 20.8 A, 18 A	29 A, 25 A, 21.6 A	34 A, 29 A, 25.3 A
AC Nominal Voltage / Range	183 - 229 V @ 208 V 211 - 264 V @ 240 V 244 - 305 V @ 277 V	183 - 229 V @ 208 V 211 - 264 V @ 240 V 244 - 305 V @ 277 V	183 - 229 V @ 208 V 211 - 264 V @ 240 V 244 - 305 V @ 277 V
AC Frequency / Range	60 Hz / 59.3 Hz - 60.5 Hz	60 Hz / 59.3 Hz - 60.5 Hz	60 Hz / 59.3 Hz - 60.5 Hz
Power Factor	1	1	1
Peak Inverter Efficiency	96.8 %	97.0 %	97.1 %
CEC weighted Efficiency	95.5 % @ 208 V 95.5 % @ 240 V 95.5 % @ 277 V	95.5 % @ 208 V 95.5 % @ 240 V 96.0 % @ 277 V	95.5 % @ 208 V 96.0 % @ 240 V 96.0 % @ 277 V
Dimensions W x H x D in inches	18.4 x 24.1 x 9.5	18.4 x 24.1 x 9.5	18.4 x 24.1 x 9.5
Weight / Shipping Weight	143 lbs / 154 lbs	143 lbs / 154 lbs	143 lbs / 154 lbs
Ambient temperature range	-13 to +113 °F	-13 to +113 °F	-13 to +113 °F
Power Consumption: standby / nighttime	< 7 W / 0.25 W	< 7 W / 0.25 W	< 7 W / 0.25 W
Topology	PWM, true sinewave, current source	PWM, true sinewave, current source	PWM, true sinewave, current source
Cooling Concept	Convection with regulated fan cooling	Convection with regulated fan cooling	Convection with regulated fan cooling
Mounting Location Indoor / Outdoor (NEMA 3R)	●/●	●/●	●/●
LCD Display	●	●	●
Lid Color: aluminum / red / blue / yellow	●/○/○/○	●/○/○/○	●/○/○/○
Communication: RS485 / Wireless	○/○	○/○	○/○
Warranty: 10-year	●	●	●
Compliance: IEEE-929, IEEE-1547, UL 1741, UL 1998, FCC Part 15 A & B	●	●	●
Specifications for nominal conditions	● Included ○ Option – Not available		

Efficiency Curves





www.SMA-America.com
Phone 916 625 0870
Toll Free 888 4 SMA USA

SMA America, Inc.

Sunny WebBox™

Web enabled data logging and control for alternative energy systems

- System access from any Web browser - anywhere in the world
- Recording of daily, monthly and annual energy yield via Sunny Portal ™
- Remote plant diagnosis
- Remote system configuration
- Automatic data transfer at chosen intervals
- Data storage and display via Ethernet
- Compatible with all SMA utility interactive inverters
- Low power consumption
- Automated communication with Sunny Portal ™

The new Sunny WebBox from SMA is a powerful communications tool that allows the operating data of your solar system to be logged and easily transmitted via modem or Ethernet to the Web or directly to your PC. It can also send the data to SMA's new internet portal (Sunny Portal) which provides free long-term data storage and graphical display of your system data. Collected information is stored in common file formats so that you can use it in various spreadsheets, graphs or your own web site. The Sunny WebBox is extremely versatile; making the storage, transmission, management and display of your system data easier than ever before.

The new way to monitor your system

A new standard in communication

The Sunny WebBox provides complete plant monitoring, remote diagnosis, data storage and display at an affordable price. It features an integrated HTTP web interface that allows you to access plant information via a PC, regardless of operating system or browser type.

The Sunny WebBox is the link between the Sunny Boy PV plant and its owner. It combines computing power, storage capacity, and versatile communication interfaces in a compact enclosure. Networked with the Sunny Portal, the data-logger offers up-to-date display and control options on the internet.

The Sunny WebBox supports RS232 or RS485 protocols for data transfer to and from all SMA utility interactive inverters.

Data transfer and plant configuration via the internet is handled either by Ethernet connection or telephone modem. Data transfer is automatic - all you have to do is to set the desired intervals. A single WebBox can monitor up to 50 Sunny Boy inverters, saving even more costs when used in larger Sunny Boy solar systems.

Around the clock, around the world

Check the status of your PV plant - from your home, your office or anywhere you may be. A PC with an internet browser is all that is needed to access the WebBox.

The Sunny WebBox is equipped with its own web server that is preconfigured to work with your internet browser. This allows you to view the output of your plant and the operating channels of each inverter. You can also adjust the parameters of the Sunny WebBox via your web browser.

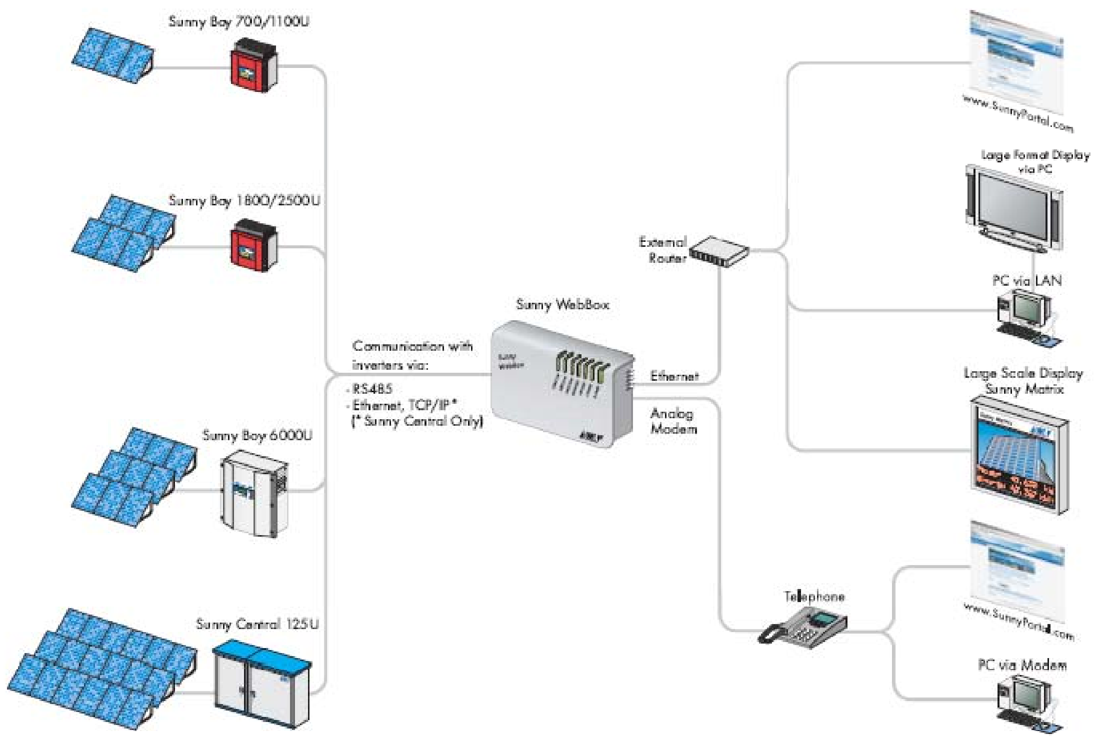
The Sunny WebBox can also be used in combination with SMA's Sunny Portal Web site (www.sunnyportal.com). Our internet portal offers free graphical presentation of your plant data in charts and diagrams.
The Sunny Portal is WebBox ready, simply set up an account and connect the WebBox to the internet.

A perfect match

Sunny WebBox and Sunny Portal are a perfectly matched team. They offer you long-term storage of your solar power plant data, inform you about changes in plant performance, and let you review the performance of your investment at any time, from anywhere.

To learn more about this new method of plant monitoring visit www.SunnyPortal.com. We have set up demonstration accounts that allow you to view actual PV plants. Visit www.sunnyportal.com and see for yourself what the Sunny WebBox and Sunny Portal has to offer.

Customer plant in Sunny Portal, 10.4 kWp



Specifications

Interfaces	
SMACOM	RS485 (up to 50 inverters, max. 4000 ft. cable)
Ethernet	10Mb / 100 Mb auto sensing

External Data Storage	
SD-Card	from 16 MB upwards
USB-Stick	USB 2.0 Host

Dimensions	
Size	8.85 x 2.25 x 5.11 in. (w x d x h)
Weight	1.65 lb.

Power Requirements	
Wall Transformer	Typ. 300 mA @ 12 V
(120 VAC 60Hz)	Max. 1 A @ 12 V
Power Consumption	Max. 12W

Ambient Temperature Rating	
Ambient Temperature Range	0°C to 55°C
Relative Humidity Range	5 % to 95 %, non-condensing

Miscellaneous	
Operating System	Windows CE.NET
Status Display	7 LED´s
Mounting Options	Wall mount, DIN rail mount, desktop

Options
Integrated Analog Modem

11.7 Registered Solar Installers and Retailers Near Crescent City[58]

46.21 miles away

Company Best Buy Solar 94199 Caughell St. _ Gold Beach, OR 97444	**Phone:** (760) 955-3466 **Fax:** (760) 955-3416 **Email:** erika@partsonsale.com **Web:** partsonsale.com **Install:** N/A Retail: Yes

61 miles away

Company Roger 1527 Buttermilk Ln @ The Little House Arcata, CA 95521	**Phone:** (707) 826-9901 **Fax:** _ **Email:** _ **Web:** _ **Install:** Yes, no price break down Retail: Yes

63.22 miles away

Company Alchemy Construction Incorporated PO Box 4154 _ Arcata, CA 95518	**Phone:** (707) 822-8013 **Fax:** (707) 822-8013 **Email:** amy@alchemyinc.com **Web:** www.alchemyinc.com **Install:** Yes, $9-$10 per AC Watt Retail: Yes

69.69 miles away

Company Bob White Electric 3375 Cindy Lane _ Eureka, CA 95501	**Phone:** (707) 443-1511 **Fax:** (707) 442-7723 **Email:** cwhite@suddenlink.net **Web:** _ **Install:** Yes, no price break down Retail: Yes

69.99 miles away

Company Linn Construction & Design 4524 Excelsior Rd. _ Eurkea, CA 95503	**Phone:** (707) 443-2617 **Fax:** _ **Email:** linnconstruction@yahoo.com **Web:** _ **Install:** Yes, $8.5-$9.5 per AC Watt Retail: Yes

69.99 miles away

Company Scurfield Solar 1635 Glatt St. Eureka, CA 95503	**Phone:** (707) 443-0759 **Fax:** (707) 443-0759 **Email:** ben@scurfieldsolar.com **Web:** http://www.scurfieldsolar.com/ **Install:** Yes, $11-$12 per AC Watt Retail: Yes

[58] Contact information from < http://www.gosolarcalifornia.org/retailers/search.php>.

12 Appendix E: Climate Friendly Parks

12.1 CFP Contacts

Park Unit	Name	Title	Contact Information (e.g., phone number, email)	Additional Notes
Stationary Combustion				
Park Operations	James Tiffany	Park Electrician	707.465.7365	Estimated fuel consumption
Redwood Hostel	Kaci Elder	Owner	707-482-8265 info@redwoodhostel.org	
Other Concessionaires	Jim Schlotter(JS), Mark Webberly(DNCR), Dave Pitts (PC)	Park Maintenance	707.458.3279, 707.464.6101.ex2147, 707.465.7351	
Purchased Electricity				
Park Operations	Glen Fickbohm	Mainteance	707.465.7373	
Redwood Hostel	Kaci Elder	Owner	707-482-8265 info@redwoodhostel.org	
Other Concessionaires	Gail Chaney		707.465.7773 Gail_Chaney@parter.nps.gov	
Mobile Combustion				
Park Operations	Keith Bensen	Wildlife Biologist	707.465.7777 Keith_Bensen@nps.gov	
Visitors	Teresa Persons	Energy Consultant	530.514.0321 tbp5@humboldt.edu	Estimate based on length of parks and visitor numbers
Redwood Hostel	Kaci Elder	Owner	707-482-8265 info@redwoodhostel.org	
Other Concessionaires	Gail Chaney		707.465.7773 Gail_Chaney@parter.nps.gov	
Fertilizer				
Park Operations	-			Now allowed to be used within park boundaries
Redwood Hostel	Kaci Elder	Owner	707-482-8265 info@redwoodhostel.org	
Wastewater				
Park Operations	Ned Geigle	Scientist	707.465.7369 Ned_Geigle@nps.gov	For all of Redwood National and State Parks
Redwood Hostel	Kaci Elder	Manager	707-482-8265 info@redwoodhostel.org	Septic and leach fields
Other Concessionaires	-			State combined with national
Waste				
Park Operations	Larry Eisenman	Maintenance	707.465.7362 L	Estimate is low and needs to be revised.

Redwood Hostel	Kaci Elder	Owner	707-482-8265 info@redwoodhostel.org	
Other Concessionaires	-			State combined with national value
Forestry				
Park Operations	John McClelland	Forestry Technitician	(707) 465-7732	Used a five year average
Refrigeration				
Park Operations	James Tiffany	Electrician	707.465.7367 James_Tiffany@nps.gov	Estimate
Visitors	Rick Nolan	Interpretation	707.465.7304 Rick_Nolan@nps.gov	Olny vehicle AC,estimated from visitor numbers and length of park
Redwood Hostel	Kaci Elder	Owner	707-482-8265 info@redwoodhostel.org	
Other Concessionaires	Jim Schlotter(JS), Mark Webberly(DNCR), Dave Pitts (PC)	Park Maintenance	707.458.3279, 707.464.6101.ex2147, 707.465.7351	
Mobile Criteria Air Pollutant				
Park Operations	Keith Bensen	Wildlife Biologist	707.465.7777 Keith_Bensen@nps.gov	Estimated non-road equipment use
Visitors	Rick Noland	Interpretation	707.465.7304 Rick_Nolan@nps.gov	Estimates based on number of visitors
Redwood Hostel	Kaci Elder	Owner	707-482-8265 info@redwoodhostel.org	
Other Concessionaires	Gail Chaney		707.465.7773 Gail_Chaney@parter.nps.gov	
Stationary Criteria Air Pollutant				
Park Operations				
Redwood Hostel	Kaci Elder	Owner	707-482-8265 info@redwoodhostel.org	
Other Concessionaires				
Area Sources (Burning Activities)				
Park Operations	James Tiffany & John McClelland			
Visitors	Rick Noland	Interpretation	707.465.7304 Rick_Nolan@nps.gov	Estimates based on number of campers
Redwood Hostel	Kaci Elder	Owner	707-482-8265 info@redwoodhostel.org	
Other Concessionaires	Jim Schlotter(JS), Mark Webberly(DNCR), Dave Pitts (PC)	Park Maintenance	707.458.3279, 707.464.6101.ex2147, 707.465.7351	Estimates were also made (Appendix 12.4)
Area Sources (Non-Burning Activities)				
Park Operations	Keith Bensen	Wildlife Biologist	707.465.7777 Keith_Bensen@nps.gov	
Redwood Hostel	Kaci Elder	Owner	707-482-8265 info@redwoodhostel.org	

12.2 Greenhouse Gas Detailed Results

EMISSION RESULTS BY SECTOR AND PARK UNIT

Metric Tons Carbon Equivalent (MTCE)

Park Unit	Stationary Combust-ion	Purchased Electricity	Mobile Combust-ion	Wastewater Treatment	Refrigeration	Forestry	Waste	Gross Emission	Net Emission
Park Operations	28	112	126	0	9	-99,361	19	379	-99,067
Visitors	23		1,728		31			1,782	1,782
Redwood Hostel	2	8	0	0	0		333	342	342
State Parks	2	43	23	0	1		0	70	70
Gross Emissions	55	163	1,877	0	42	85	352	2,573	-96,872
Net Emissions*	55	163	1,877	0	42	-99,361	352		

* Net Emissions = Gross Emissions - Carbon Sequestration

EMISSION RESULTS BY SECTOR AND GAS

Metric Tons Carbon Equivalent (MTCE)

Gas	Stationary Combustion	Purchased Electricit	Mobile Combustion	Wastewater Treatment	Refrigeration	Forestry	Waste	Gross Emission	Net Emissions

y

CO2	30	163	1,839			-99,446	0	2,032	-97,414
CH4	20	0	2	0		69	352	443	443
N2O	4	0	36	0		16	0	56	56
HFC					42			42	42
Gross Emissions	55	163	1,877	0	42	85	352	2,573	-96,872
Net Emissions*	55	163	1,877	0	42	-99,361	352		

EMISSION RESULTS BY GAS AND PARK UNIT

Metric Tons Carbon Equivalent (MTCE)

Park Unit	CO2	CH4	N2O	HFC	**Gross Emissions**	**Net Emissions**
Park Operations	-99,184	89	20	9	379	-99,067
Visitors	1,694	21	36	31	1,782	1,782
Redwood Hostel	9	333	0	0	342	342
State Parks	67	1	1	1	70	70
Gross Emissions	2,032	443	56	42	2,573	-96,872
Net Emissions*	-97,414	443	56	42		

* Net Emissions = Gross Emissions - Carbon Sequestration

12.3 Criteria Air Pollutants Detailed Results

EMISSION RESULTS BY SECTOR AND GAS

lbs/year

Gas	Stationary Sources	Mobile Sources	Area Sources (Burning)	Area Sources (Other)	Gross Emissions
SO_2	0	0	3,568	0	3,568
NO_x	6	91,530	2,412	0	93,949
VOC	436	151,054	92,699	11,218	255,407
PM_{10}	0	0	95,811	0	95,811
$PM_{2.5}$	0	577	69,060	0	69,637
CO	1	691,306	1,015,590	0	1,706,897
Total	443	934,466	1,279,141	11,218	2,225,269

EMISSION RESULTS BY GAS AND PARK UNIT

lbs/yr

Park Unit	SO_2	NO_x	VOC	PM_{10}	$PM_{2.5}$	CO	Gross Emissions
Park Operations	3,403	3,736	26,228	81,621	69,110	922,388	1,106,486
Visitors	0	88,616	127,069	0	514	675,916	892,114
Redwood Hostel	1	55	108	14	1	129	307
State Parks	164	1,542	102,002	14,176	13	108,464	226,361
Gross Emissions	3,568	93,949	255,407	95,811	69,637	1,706,897	2,225,269

TOTAL STATIONARY SOURCE EMISSION RESULTS

lbs/year

	SO_2	NO_x	VOC	PM_{10}	$PM_{2.5}$	CO
Park Operations	0	0	1	0	0	0
Redwood Hostel	0	6	83	0	0	1
State Parks	0	0	352	0	0	0
Gross Emissions	0	6	436	0	0	1

TOTAL MOBILE COMBUSTION EMISSION RESULTS

lbs/year

	SO_2	NO_x	VOC	PM_{10}	$PM_{2.5}$	CO
Park Operations	0	2,439	22,720	0	50	11,948
Visitors	0	88,616	127,069	0	514	675,916
Redwood Hostel	0	4	1	0	1	2
State Parks	0	470	1,265	0	13	3,440
Gross Emissions	0	91,530	151,054	0	577	691,306

TOTAL AREA SOURCE EMISSION RESULTS

lbs/year

	SO_2	NO_x	VOC	PM_{10}	$PM_{2.5}$	CO
Park Operations	3,403	1,297	3,508	81,621	69,060	910,440
Redwood Hostel	1	44	25	13	0	126
State Parks	164	1,072	100,385	14,176	0	105,024
Gross Emissions	3,568	2,412	103,917	95,811	69,060	1,015,590

12.4 Cumulation of state park CFP information

State Parks	Jedidiah Smith Redwoods	Del Norte Cost Redwoods	Parire Creek Redwoods	Totals
Statioary Conbustion				
Fuel Use				
Diesel	20 gal	10 gal	10 gal	40 gal diesel
Propane			30 gal	30 gal Propane
Forestry				
acres burned	None	None	None	
Refrigeration	6	1	none	7 units
(# of units)				
Wood burned	Campers: 35640	Campers: 21726	Campers: 84438	Assumption A & B
campfires	bundles: 11880 = 123.72 cords	bundles: 7242 = 75.42 cords	bundles: 28146 = 293.1 cords	492.25 cords bruned by visitors
fireplaces	1 2 cords	2 4 cords		6 cords
wood stoves	4 stoves 8 cords		4 stoves 8 cords	16 cords
Asphalt Paving				
tons	90 tons	90 tons	50 tons	230 tons
Consumer Solvents				Assumption C
personal care products	56 gal 463.88 lbs	849 gal 7069 lbs	3298 gal 27475 lbs	35009 lbs
household	30 gal 249.9 lbs	72 gal 599.8 lbs	30 gal 249.9 lbs	1100 lbs
Coatings				
water based	20 gal	5 gal	15 gal	40 gal
solvent based	20 gal	5 gal	15 gal	40 gal
Contacts	Jim Schlotter Park Mainteanance 707.458.3279	Mark Webberly Park Mainteanance 707.464.6101ex.2147	Dave Pitts Park Mainteanance 707.465.7351	

Assumptions:

A) 3 persons per bundle
   Campsites burns 1 bundle per night
   32 bundles to a cord.

B) Average house hold burns 2 cord/yr for heat source

C) Every camper uses .2 oz of household products (shampoos, soaps, ect.)
   Weight of household products are assumed to be equivlant of water.

Facts:

season= may 26-Sept 1   1 cord = 4x4x8 ft
season = 97 days   1 cord = 128 ft3
1 gallon water = 8.3 lbs.
128 oz in gallon
1 cord = 96 bundles
1 bundle=1x1x1.33
1 bundle = 1 ft3

12.5 Visitor Vehicle Miles Traveled.

No information was known on vehicle type for RNSP visitors. In the CLIP module an estimate was made for the total VMT and the default setting was used to separate into car type. Visitor mobile sources information does not add into VMT where the visitor came from, only the distance traveled within RNSP boundaries. Two main estimates were made; 1) there is an average of three visitors per vehicle, and 2) each vehicle travels the length of the park one way (~60 miles).

State Park	**Number of visitors**	**Length of Park:** 56.4	miles
Jedidiah	134919		
Mill Creek	60532	249367	Cars for all visitors
Parire Creek	167479		
Total state park visitors	362930	**Vehicle Miles Traveled**	
National Visitors	385171	**14,064,299**	**miles**
Total RNSP	748101		

Assumptions:

The average visitor drives through park one way.

Length of park was distanced to be from Orick to Gasquet determined from Google maps

3 persons to a car

12.6 Blue Sky Renewable Wind Power Program:

PACIFIC POWER | For Your Home | For Your Business

PacifiCorp: Pacific Power

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/// Blue Sky

Buy Blue Sky renewable wind power
If you believe in pollution-free power, here's your chance to purchase new wind power through our Blue Sky program.

Buying renewable energy is not only good for the environment, it's good for business. Our Blue Sky program offers you an easy way to meet your organization's environmental goals and assert yourself as a leader in your community. Buying renewable power provides environmental, social and economic benefits, and Blue Sky is an easy way to help make a difference.

Hundreds of small and large businesses and government agencies in our areas are purchasing wind power through our Blue Sky program.

You can sign up now online or by calling 1-800-842-8458. For as little as $1.95 more per month than you're paying now, you can:

- visibly demonstrate your commitment to environmental stewardship and the community
- minimize your business operations' impact on the environment; for every kilowatt-hour of wind energy purchased, you can offset 2 pounds of carbon dioxide emissions (see our online calculator to help you determine the environmental benefits of your purchase)
- enhance your public impact and visibility through regional and national recognition programs – Pacific Power's business partnership program, EPA's Green Power Partner program or the U.S. Green Building Council's LEED system
- increase awareness about the benefits of renewable energy, help encourage more renewable energy development and create a more sustainable future

Help make a difference with Blue Sky options
Washington and Wyoming businesses have two Blue Sky options. You choose which one is right for you. With either option, you can purchase 100 percent clean wind energy from newly developed projects in our region. These options are also endorsed by regional environmental groups and overseen by your state's utility commission. Buying Blue

Sky helps ensure more of our growing energy needs will be met with clean renewable sources.

Blue Sky – Our standard option offers you the flexibility to buy wind energy in 100 kilowatt-hour (kwh) increments (called blocks) for an additional $1.95 per block per month. Your commitment and level of participation is up to you. There is no minimum purchase requirement and you can cancel your enrollment at any time. Enroll now.

Blue Sky QS – This is a program for businesses that want to make large wind energy purchases at a reduced cost. With Blue Sky QS, you get a "Quantity Savings" for purchasing at least 101 blocks of Blue Sky per month. The cost starts at $1.94 per 100 kwh and is based on a sliding scale. The more you buy, the less the per unit (block) cost. Enroll now, see our calculator to help you determine the cost of Blue Sky QS or view a s imple pricing table as an example of the cost structure .

Buying one block of Blue Sky each month for a year is the same as planting 1/2 acre of trees (250 trees) or not driving 2,500 miles.

For both programs, we work with businesses to receive local and national recognition through our Blue Sky partnership program .

The additional charges for these options will be included as a separate line item on your monthly bill. Your payments go directly to purchase renewable energy and to operate the program. Pacific Power buys 100 percent wind energy from new facilities in the West.

Enroll online now or get more information below:

- Read our Frequently Asked Questions
- See a list of participating businesses
- Learn more about our Blue Sky business partnership/recognition program
- See our calculators to help you determine the environmental impact of your purchase or to compare costs between Blue Sky and QS
- View clips from our Blue Sky video featuring interviews with wind farmers, civic officials and businesses
- Find out what some customers have to say about Blue Sky
- Read our Forecast newsletter for updates on renewable energy in our region
- See how some businesses are practicing sustainability at GreenBiz.com
- E-mail us at bluesky@pacificorp.com
- Call us at **1-800-842-8458**

Other information on renewable energy generation

Separate from Blue Sky, we also offer a net metering option. This is for customers interested in generating all or a portion of their electricity needs from small-scale solar, wind or other renewable generating equipment. See more information on photovoltaics.

Pacific Power's commitment to renewable energy
As a company, we also generate and purchase renewable power for all our customers as part of our resource mix. Today, we generate of purchase power from four renewable energy facilities in Wyoming, Oregon and Utah. Learn more about Pacific Power's environmental commitment.

Our future plans include adding even more renewable energy to the power system. Our Integrated Resource Plan calls for adding 1,400 megawatts of renewable energy to the power system in the next 10 years. This is enough energy to power 409,000 homes.

Blue Sky is a registered service mark of Pacific Power.

Calculations use an average of PacifiCorp's system generation resources and are current as of July 31, 2003. This average may change as PacifiCorp acquires of changes system generation resources. PacifiCorp is the parent company of Pacific Power.

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http://www.pacificpower.net/Article/Article46988.html

12.7 Environmental Impact Calculator

Environmental Benefits

The environmental benefits of the proposed purchase:

Enter number of blocks purchased per month: 4523

Pounds of CO_2 offset 904600

Pacific Power/Rocky Mountain Power purchases the exclusive right to claim all of the benefits of electricity produced by renewable energy power plants in the exact amount of Blue Sky purchases over a one month period. The environmental benefit figures are calculated using that one month period and the annual average of the environmental effects of the company's owned or controlled electric system generation resources as of 2006. These effects are determined by continuous emissions monitoring of company facilities, and data provided by the U.S.

Environmental Protection Agency and other sources. The average may change as the company acquires or changes its system generation resources.

904600	pounds CO_2	=	410	Metric tons CO_2
410	Metric tons CO_2	=	**111**	**MTCE**