DOE/GO/10065--1

NEOS Corporation

Corporate Headquarters
3569 Mt. Diablo Boulevard, Suite 200
Lafayette, California 94549
510/284-3780, Fax: 510/284-3147

COMMERCIALIZATION OF PV-POWERED PUMPING SYSTEMS FOR USE IN UTILITY PV SERVICE PROGRAMS

Final Report

Prepared by:

NEOS Corporation
165 South Union Boulevard, Suite 260
Lakewood, Colorado 80228

Prepared for:

U.S. Department of Energy
Golden Field Office
1617 Cole Blvd.
Golden, Colorado 80401

Contract No. DE-FC36-95GO10065

March 1997

NEOS Corporation

Corporate Headquarters
3569 Mt. Diablo Boulevard, Suite 200
Lafayette, California 94549
510/284-3780, Fax: 510/284-3147

COMMERCIALIZATION OF PV-POWERED PUMPING SYSTEMS FOR USE IN UTILITY PV SERVICE PROGRAMS

Final Report

Prepared by:

NEOS Corporation
165 South Union Boulevard, Suite 260
Lakewood, Colorado 80228

Prepared for:

U.S. Department of Energy
Golden Field Office
1617 Cole Blvd.
Golden, Colorado 80401

Contract No. DE-FC36-95GO10065

March 1997

PROJECT OVERVIEW

The project described in this report was a commercialization effort focused on cost-effective remote water pumping systems for use in utility-based photovoltaic (PV) service programs. The project combined a commercialization strategy tailored specifically for electric utilities with the development of a PV-powered pumping system that operates conventional ac pumps rather than relying on the more expensive and less reliable "PV pumps" on the market. By combining these two attributes, a project goal was established of creating sustained utility purchases of 250 PV-powered water pumping systems per year.

The project was implemented by NEOS Corporation (NEOS), a woman-owned small business. NEOS teamed with Golden Photon, Inc. (Golden Photon), a manufacturer of advanced PV panels and systems, and 25 electric utilities in the western U.S. to propose a project with three primary objectives: 1) to demonstrate the performance and reliability of a PV-powered ac pumping system; 2) to implement a new business enterprise, called the Photovoltaic Services Network (PSN), with a mission of "working proactively on behalf of member utilities to ensure that they purchase and install quality PV systems that meet established design criteria, are competitively priced through quantity purchases, and meet the utility customer's expectations for performance and reliability;" and 3) to aggregate utility purchases by supporting each utility's activities through the business enterprise.

These project objectives were implemented through six project tasks: 1) business plan development to create a new business venture aimed at PV-powered ac water pumping; 2) utility installations to develop in field utility data regarding the performance and reliability of the Golden Photon pumping system; 3) strategic alliance development to consolidate PV pumping interest into a new business venture called the Photovoltaic Services Network; 4) utility marketing strategy implementation to develop and implement utility-specific marketing strategies ; 5) aggregate system purchases to create a sustainable utility market "pull" for PV pumping systems; and 6) project documentation to thoroughly document the project's lessons learned, so they can be applied to other PV applications within the domestic utility market and to international PV pumping markets.

The results of each of these tasks are presented in two parts contained in this Final Summary Report. The first part summarizes the results of the PSN as a new business venture, while the second part summarizes the results of the Golden Photon system installations. Specifically, results and photographs from each of the system installations are presented in this latter part.

NEOS Corporation

Corporate Headquarters
3569 Mt. Diablo Boulevard, Suite 200
Lafayette, California 94549
510/284-3780, Fax: 510/284-3147

COMMERCIALIZATION OF PV-POWERED PUMPING SYSTEMS FOR USE IN UTILITY PV SERVICE PROGRAMS

PART 1 - Review of the Photovoltaic Services Network

Final Report

Prepared by:

NEOS Corporation
165 South Union Boulevard, Suite 260
Lakewood, Colorado 80228

Prepared for:

U.S. Department of Energy
Golden Field Office
1617 Cole Blvd.
Golden, Colorado 80401

Contract No. DE-FC36-95GO10065

March 1997

CONTENTS

Mission

The Photovoltaic Services Network (PSN) is an independent, not-for-profit corporation comprised of electric utilities of all types including rural electric cooperatives, municipal utilities, public power districts, investor owned utilities, and power marketing agencies.

The mission of the PSN is to work proactively to promote utility involvement in PV through education and training and to work on behalf of member utilities to ensure that the PV systems they purchase and install:

- Meet established design criteria;
- Are competitively priced; and,
- Meet the utility customer's expectations for cost, performance, and reliability.

Objectives

To accomplish this mission, the PSN has developed the following objectives:

- provide education, training, and installation support as required by member utilities;
- establish a forum for information exchange between utility members and the PV industry;
- accelerate market development through customer outreach;
- create standardized PV system specifications for a variety of applications;
- coordinate PV product purchases for appropriate applications;
- become financially self-sufficient through member support and product purchases; and
- pursue alliances with other organizations to support PSN service, product development, and testing activities.

The PSN was created specifically for the benefit of electric utilities and their customers; however, other organizations, such as PV industry companies or governmental agencies, are encouraged to participate as well. There are four ways to participate in the PSN: 1) retail utility membership; 2) utility association membership; 3) PSN sponsorship; and 4) a subscription to PSN information.

PSN Membership

The PSN was created specifically for the benefit of electric utilities and their customers; however, other organizations, such as PV industry companies or governmental agencies, are encouraged to participate as well. There are four ways to participate in the PSN: retail utility membership; utility association membership; PSN sponsorship; or a subscription to PSN information.

Utility and Satellite Utility Membership

This membership level can include rural electric cooperatives, municipal power companies, public power companies, investor owned utilities and any other electric utility that provides service to retail (i.e., end use) consumers. Utilities that serve both wholesale and retail consumers may also join at this level.

Utility Association Membership

This membership level is for organizations that are involved in the electric utility trade but may not directly serve retail consumers. Such organizations include generation and transmission companies, trade associations, power marketing associations and organizations involved with electric power research. Also, utilities that serve both retail and wholesale consumers may choose to join at this level.

PSN Sponsor

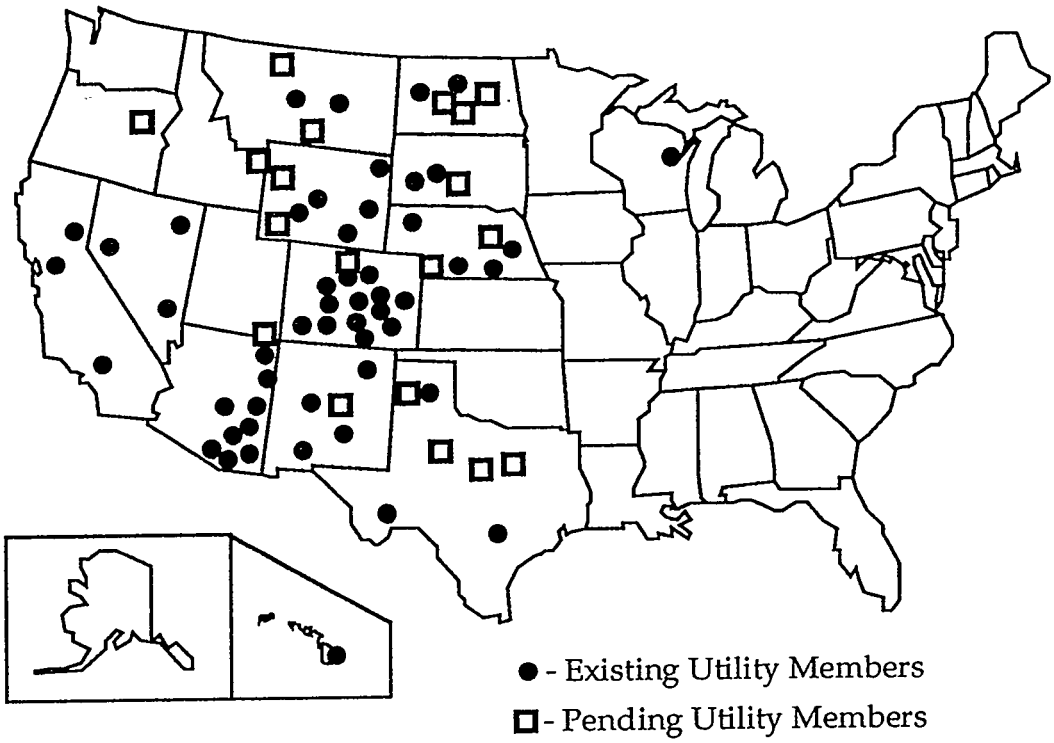
PSN sponsorships are for organizations that wish to support utility involvement in PV by cost-sharing the PSN's service and product support to member utilities. Sponsors of PSN support activities include national laboratories, utility research organizations, state or federal agencies, or non-profit foundations.

PSN Information Subscription

PSN information subscriptions are available to any organization or individual who wishes to keep abreast of PSN activities and opportunities. Companies affiliated with the PV industry are especially encouraged to subscribe, since the PSN anticipates interactions and information exchanges with all sectors of the PV industry to promote development of PV products that meet utility specifications.

Present Utility Participation

Presently, the PSN is comprised of 54 electric utilities of all types including rural electric cooperatives, municipal utilities, public power districts, investor owned utilities, and power marketing agencies. As shown in the following map, these utilities are located in 14 western and midwestern states and include 42 rural electric cooperatives, 10 investor-owned utilities, two power marketing agencies, and one municipality.



PSN Activities To Date

Implementing the PSN's business plan to date can be divided into three primary areas: 1) service support activities, 2) market development activities, and 3) product support activities. It has been the implementation of these business plan elements that have resulted from four of the six tasks identified in the original Commercialization Ventures proposal. These four tasks included: 1) action plan development (CVP Task 1); 2) strategic alliances (CVP Task 3); and 3) marketing strategy implementation (CVP Task 4); and 4) aggregate system purchases (CVP Task 5). Results in these areas have initially demonstrated how the combination of packaged PV systems (as supplied by companies like Golden Photon) combined with packaged PV services (as supplied by the PSN and its member utilities) will reliably lead to greater commercialization of the PV technology.

Service Support Activities

The service support activities have focused on education, information exchange, and training, as these activities are essential for utilities to implement successful PV service programs. The PSN provides PV education and training to utility member employees, board of directors, customers, and local trade allies through series of workshops and other on-site support activities. In addition, the PSN provides support in such areas as service territory audits; PV tariff development; PV vendor qualification; PV system procurement; and PV service program marketing. Examples of such training and education materials are attached.

Market Development Activities

Market development activities have included general market assessment as well as direct marketing support for individual PSN member utilities. The primary market assessment goal is to quantify the benefits of utilities offering PV as an alternative service, while the direct marketing support focuses on 1) developing marketing methods and tools aimed at increasing customer awareness and participation in PV service programs (see attachments); and 2) educating local trade allies, so they can become qualified vendors capable of supporting and promoting the utility PV service program.

Throughout this project, the PSN supported and promoted four "standard" marketing plan elements. Two key objectives of these standard elements were that they be low cost and self-sustaining from the utility's perspective, since most PSN member utilities do not have the resources for costly marketing or promotion campaigns. From these elements, each utility was encouraged to adopt (and adapt) those elements most appropriate to its specific situation. The four standard marketing plan elements supported and promoted by the PSN included marketing alliances; the PSN' Product Lists; customer education; and media promotion. A summary of each element follows:

Marketing Alliances

Since most PSN utility members are rural electric cooperatives with limited personnel and financial resources, establishing marketing alliances with local organizations is an essential marketing plan element. Key marketing alliances have been developed by utilities in this project with local contractors (both well service and electrical), Real Estate developers, and county offices of the Natural Resources Conservation Service (NRCS).

The first two types of allies (i.e., contractors and developers) have a financial incentive to promote the utility's PV service program for various off-grid applications. In the case of contractors, the PSN has worked with several member utilities (e.g., Plumas-Sierra, Northwest Rural PPD, KC Electric, etc.) to establish programs that provide various direct financial incentives for local contractor involvement. Such incentives include commissions for customer identification, discount pricing for direct contractor sales (with utility as local product "wholesaler"), and long-term service and maintenance agreements. In the case of Real Estate developers, the primary incentive is the opportunity to obtain utility-grade power (via PV) in remote locations not previously served. Utility "will serve" letters for such property significantly enhances the developers chances of finding buyers due to better mortgage rates and lower electrical service costs.

The third type of ally (i.e., county NRCS offices) is unique to the PV water pumping application. The NRCS, formerly the Soil Conservation Service, is a federal agency that manages numerous agricultural programs for the U.S. Department of Agriculture. These programs and the associated conservation practices are managed through local NRCS county offices. As a result, when a rancher has a problem or needs a new pasture developed, he regularly goes to the county agent for free consulting support. Additionally, the rancher could possibly obtain cost-sharing through this county agent, if the solution involves an approved

conservation practice. Most often, however, these county agents are simply the preferred source of information for the local ranching community.

Recognizing these county agents as potential marketing allies for utility PV service programs, the PSN has supported utility members with educating their local NRCS offices about utility PV services. Additionally, water pumping systems contained in the PSN's Water Pumping Product List has been "pre-approved" in several states (i.e., Colorado, Nebraska, and Arizona with approval in eight others pending) as satisfying NRCS conservation practice standards.

PSN Product Lists

The PSN's PV Product Lists for water pumping and remote residential systems are an essential element of each utility's marketing program. The systems contained in this catalog are the standard products that each utility is marketing. The Product Lists provide all the information necessary for utilities, their marketing allies, and prospective customers need to make sound purchasing decisions. In particular, the Product List features include:

- Side-by-side comparisons of PV system and supplier attributes - "single-stop shopping;"
- Standard system specifications and warranties - all systems meet strict PSN minimum requirements including 2-year system warranties;
- Simplified procurement - competitive bidding process already completed by PSN; and
- Volume pricing and quantity discounts.

As a result, several "versions" of the standard Product List catalog have been developed with utility-specific pricing so the individual utility can distribute the catalog to their particular marketing allies (see attachments). In this way, the utility's marketing allies could have easy access to standard systems and prices as well.

Customer Education

As with any new technology, customer education is an essential marketing plan element. The PSN has supported each utility with information in a variety of forms that could be used to educate prospective PV service customers. As shown in the example materials contained in Appendix C, the primary objectives of this information is to:

- notify consumers that a PV program exists and how to find out more about it;
- describe how the program will operate from the customer's point-of-view (e.g., costs);
- explain why the utility is promoting such a program;
- provide general information on PV, as well as specific information on PV systems to meet their needs;
- supply a list of PV contractors that are qualified to provide equipment and services for the program; and

- offer case studies and testimonials from satisfied customers.

Media Promotion

Media promotion was another "standard" marketing plan element implemented to varying degrees by each utility. Unlike the previous elements, however, promotional materials were developed primarily by the utilities and their local media (as opposed to the PSN). A wide range of methods have been used by these utilities for promoting including:

- Marketing flyers or brochures for use by participating vendors;
- Bill stuffer notices;
- Notices/feature stories in local newspaper or dedicated magazine regarding program;
- Kick-off press releases and/or press conferences;
- Radio or television ads and/or public service announcements;
- Newspaper and local magazine ads;
- Direct mail letters to most likely customers explaining program;
- Point-of-purchase displays/signs at participating vendor offices;
- Site signs announcing installed projects;
- Exhibit booths for membership meetings, home shows, agricultural shows, etc.; and
- Promotional slide shows/videos for customers.

With these marketing plan elements as the initial focus supported and promoted by the PSN, each utility was encouraged to adopt those elements most appropriate to its specific situation.

Product Support Activities

As of the introduction of the PSN in late 1994, no system hardware standardization existed that addressed utility requirements for cost and performance. As well, no standard means of implementing PV systems had been adopted that would ensure easy customer access, quality customer service, and growing market development.

The concept of offering standard packaged PV systems as a utility service option was first explored by NEOS in this project. Specifically, a packaged system was developed that used readily available commercial AC water pumps powered by a new PV module technology (developed by Golden Photon). With guidance from NEOS, Golden Photon introduced their product exclusively packaged as a complete water pumping system. The systems were offered in a discrete number of packaged sizes and included all required hardware and controls for installation and operation.

Each system was capable of a range of pumping volumes and at a range of pumping heads. By contrast other PV water pumping systems have to be custom designed and integrated to meet specific applications. By limiting the number of available options, Golden Photon was able to lower the cost of integration by bulk ordering and pre-assembling many of the system

components. This product was consistent with the PSN's philosophy of standard packaged systems and served as a test case to demonstrate the validity of the concept.

The success realized by this initial demonstration has lead to the conclusion that the only viable way for utilities to build sustainable PV service programs was to offer standardized PV power systems, much in the same way they offer other energy service products. Below is a short list of the lessons learned that justify the concept of "performance-based" packaged systems:

- Packaged PV systems manufactured in standard configurations lower the cost to the utility and their customers by enabling the manufacturer to bulk order and assemble the necessary components. Bulk ordering not only lowers the administrative costs of manufacturing, but enables relative economies of scale in component costs. Factory assembly likewise lowers production costs by requiring less skilled labor.
- By offering standard system sizes, the utility reduces the need and associated costs of individually designing and specifying the PV system hardware. Rather than "fitting" the hardware to the infinite number of possible load scenarios, the utility service representative can "fit" the customer into one of the standard system sizes.
- Unlike custom systems, which require the stocking of hundreds of individual parts, standard packaged PV systems are easily inventoried by utilities for quick application. This feature also reduces the accounting required for processing a sale or lease.
- Properly designed PV packages can be made modular or expandable to adapt to changing load requirements, thus further reducing the need for carrying excessive inventory.
- Packaged PV systems are easily transported for quick installation. This feature also enables them to be re-deployed for future utility applications, should the initial customer no longer need or desire the system.
- As the markets "aggregate" around standard system sizes, the opportunity for even lower costs through more dedicated system manufacturing increases.

To further validate these lessons and to enable its utility members convenient access to standard packaged systems, the PSN undertook an initiative to produce a catalog of commercially available PV systems. The PSN developed the first two chapters of its "Product List Catalog for two PV applications: water pumping and residential PV power systems (see Product List catalog attached). However, the catalog is intended to include numerous additional applications in the future.

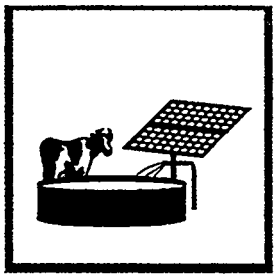
The Product list was intended to provide its utility members a convenient means for making informed purchasing decisions on standard packaged PV power systems. Some PV industry companies distribute catalogs of PV components. The Government Service Agency (GSA) likewise distributes equipment schedules to government agencies. Both sources list a select few "kits" consisting of most necessary system components, but no catalog to date offered completely integrated packaged PV systems. As well, those systems that were available in kit form consisted of many different brands of components with each brand supplied being reflective of the present availability or lowest cost available at the time of ordering. The PSN's

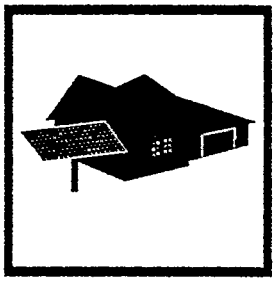
Product List was the first of its kind and has greatly enhanced the ability of utilities to offer PV services.

The catalog includes a small PSN mark-up to each of the included systems. This mark-up was calculated to cover the cost of processing the anticipated volume of sales. The resulting Product List was distributed to all PSN members. Sample product lists were made available to select purchasing groups. The catalog is a living document. Periodic updates will reflect changes in suppliers and prices as the market forces deem them necessary.

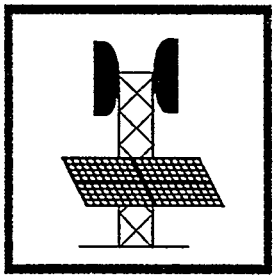
The value of offering standard packaged PV power systems has been hailed by all who have had occasion to use this catalog. Since March 1996 (when the Product List catalog was first published), over $400,000 in sales have resulted, nearly half of which have been for livestock water pumping applications. Additionally, none of these water pumping installations have used AC pumping systems, as neither Golden Photon nor any other manufacturer had commercial systems available during that period.

Photovoltaic Services Network

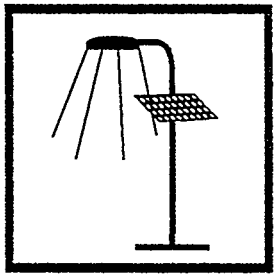


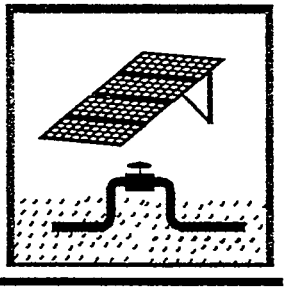


PV Systems



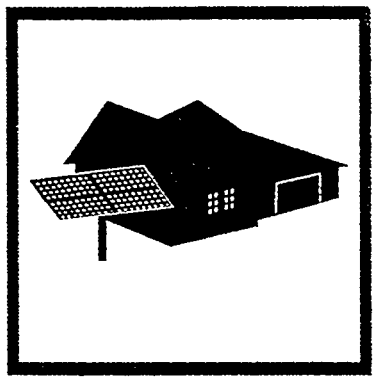
1997 Catalog





PSN

otovoltaic Services Network, Inc.



1997 Residential Product List

PSN

hotovoltaic Services Network, Inc.

Residential Product List

A wide variety of remote residential PV systems were evaluated for inclusion in the Residential Product List. The systems selected for the list represent the best combinations of high quality equipment, price and supplier experience, capabilities and support.

To ensure that the systems on the Residential Product list are of high quality and meet utility needs for performance, reliability and convenience, the PSN used the minimum requirements below as a preliminary screening tool in evaluating proposed pumping systems.

Minimum Requirements

All of the PV-powered residential systems selected for the PSN list meet the following minimum system and supplier requirements:

- ✓ Systems are capable of supplying the design energy for at least 3 days without auxiliary energy based on the low voltage disconnect (LVD) set point during winter temperatures and have a minimum two year battery lifetime under typical cycling.
- ✓ Systems provide 115 VAC, 60 Hz, single phase power.
- ✓ Systems are supplied complete and self contained with all necessary installation hardware. No components are mounted in or on customer structures except the in-house monitor.
- ✓ System are designed for 20 year life with minimum maintenance.
- ✓ Systems are as pre-assembled and wired as is feasible and cost-effective for shipping.
- ✓ Systems are capable of operating in temperature of -20° to 45°C and winds of 100 mph for 20 years.
- ✓ Array structures provide a minimum of two foot ground clearance.
- ✓ Systems meet all applicable National Electric Code requirements to ensure installer/operator safety including: a manual disconnect switch, proper grounding, proper size wire and disconnects, and hazard warning signs. However, all UL (or equivalent) listed components are not required since few PV-powered systems on the market today meet that requirement.
- ✓ PV modules meet IEEE P1262 and UL 1703 standards and include a minimum 10 year, 90% power rating warranty.
- ✓ System components have proven and documented records of field performance in similar applications.
- ✓ Systems have NEC approved means for accepting auxiliary 115 VAC power.
- ✓ Systems are supplied with complete installation, operation and maintenance manuals for utility personnel and a user manual for the customer/member.
- ✓ Systems have adequate protection against lightning and load induced voltage surges.
- ✓ System energy outputs are warranted for a minimum of 2 years. (Utilities process all warranty claims through the PSN)
- ✓ The system manufacturer has documented experience in supplying similar packaged residential systems.
- ✓ The price quotes contained in the Residential Product List are effective through December of 1997.

Residential System Selection

Five sizes of residential systems are included in the Product List: 0.5 kWh/day, 1 kWh/day h/day, 3 kWh/day, 5 kWh/day and 8 kWh/day. These systems were designed to provide the rated energy when exposed to average daily insolation levels of 5.5 kWh/m^2 (consistent with the Boulder, CO TMY site). If your local insolation differs considerably from this design point, refer to the System Information

sheets at the back of this section for monthly system output in two other locations.

When selecting a residential system for a specific application, first estimate the daily energy requirement in kWh/day. Then turn to the appropriate page of the Residential System Comparisons Charts (0.5, 1, 3, 5 or 8 kWh/day) for information about the systems.

The systems on the charts are listed from left to right in order of cost. When reviewing the systems, please remember that there may be significant differences between the listed systems that may justify a higher cost (such as a larger PV array, higher quality batteries or trailer mounting). For additional information on any system (including system energy output by month), refer to the PSN System Specification sheets at the end of the section.

Residential System Comparison Chart

The Residential System Comparison Chart consists of five pages (one page for each system size). Each page is labeled by the system size on the upper right corner and also on the bottom of the page.

The first line on the chart is the PSN identification number for each system on the chart. This is the number you would use to order a system. The next line labeled ***Est. output (5.5 sun hr)*** gives a rough approximation of the daily energy output of each system in kWh/day with an insolation level of 5.5 sun hours (kWh/m^2) per day.

Under the System heading, ***System configuration*** describes how each system is packaged and mounted for portability and ***Enclosure description*** describes the construction materials of the equipment enclosure. ***Foundation required*** describes the necessary site preparation prior to installing the system. ***Maintenance interval*** is the recommended time between periodic maintenance visits. ***In-house monitor*** tells whether the system includes a system monitoring device for use within customer homes.

Under the PV Array heading, ***# modules/PV array size*** gives the number of PV modules in each system and the size of the PV array in peak watts. ***PV make/model*** names the manufacturer and model of the PV modules and ***PV warranty*** lists the manufacturer's warranty on PV power output. ***PV field history*** gives the number of years that the PV module has been commercially available.

Under the Balance of Syst., heading, ***Battery make/model*** lists the manufacturer and model number of the batteries and ***Battery type*** describes the type of battery technology used (such as flooded lead acid and sealed valve regulated). ***Available battery capacity*** is the battery storage capacity that is available in AC watt-hours. The next line ***# batteries/ system volt*** describes the number of batteries in the system and the system DC voltage. ***Estimated battery life*** is the system supplier's estimate of the battery's life when it is used according to recommendations.

Inverter make/model names the inverter manufacturer and model number and ***Inverter volts/waveform*** describes the inverter's nominal output voltage and waveform (square, sine or modified sine wave). ***Inverter contin. rating*** gives the inverter's rated power output for continuous use. ***Controller make/model*** lists the manufacturer and model number of the battery charge controller

Under the Supplier heading, ***Supplier name*** lists the PV system supplier that provides each residential PV system to the PSN. ***System warranty*** lists the supplier's warranty for the packaged system and ***Est. lead time to ship*** describes the time each supplier requires to ship a system after receipt of order. ***Residential PV exper.*** lists the system supplier's experience with residential PV systems.

Under the price heading, ***Battery price*** is the price for batteries and ***$/watt PV*** is the cost of the packaged system divided by the size of the PV array. ***System Price*** is the price for the entire PV system.

Residential System Comparison Chart

Seasonal Cabin Systems

System ID	PSN-PI0.5-R	PSN-PC0.5-R
Est.PV output/5.5 sun hr	0.5 kWh/day	0.8 kWh/day
System		
System configuration	pole mount	skid mount
Enclosure description	Aluminum	powder coat steel
Foundation required	for pole	level site
Maintenance interval	12 months	6 months
In-house monitor	yes	yes
PV Array		
# modules/PV array size	2/160 watts	2/240 watts
PV make/model	Solec or Siemens	Kyocera 120
PV warranty	10 years/90%	12 years/90%
PV field history	5+ years	10 years
Balance of Syst.		
Battery make/model	Concorde B -12/130	Trojan T-105
Battery type	valve regulated	flooded
Avail. battery capacity	1,997 Watt hours	3,379 Watt hours
# batteries/system volt	2/12V	4/12V
Estimated battery life	5 years	3-5 years
Inverter make/model	Trace 812	Trace 812 SB
Inverter volts/waveform	115/modified sine	115/modified sine
Inverter contin. rating	575 watts	575 watts
Controller make/model	Photron PSC2/15A	Trace C-40
Supplier		
Supplier name	Photron, Inc	Photocomm
System warranty	2 years	2 years
Est. lead time to ship	4-8 weeks	6-8 weeks
Residential PV exper.	13 years	14 years
Price		
$/watt PV	$27 / Watt	$22 / Watt
System Price	**$4,395**	**$5,355**

3/14/97

Residential System Comparison Chart — Small Full-Time Home Systems

System ID	PSN-PC1-R	PSN-DP1-R	PSN-BP0.5-R	PSN-SES1-R	PSN-SW1-R
Est.PV output/5.5 sun hr	1.6 kWh/day	1.5 kWh/day	1.0 kWh/day	1.0 kWh/day	1.0 kWh/day
System					
System configuration	skid mount	skid mount	steel box on skid	enclosed trailer	skid mount
Enclosure description	powder coat steel	5052-H32 aluminum	painted steel	aluminum trailer	galv. steel/polyprop.
Foundation required	level site	level site	level site/gravel	level+ground anchors	4-8" gravel
Maintenance interval	6 months	6 months	6 months	12 months	12 months
In-house monitor	yes	yes	yes	yes	no
PV Array					
# modules/PV array size	4/480 watts	6/462 watts	4/300 watts	4/300 watts	4/300 watts
PV make/model	Kyocera 120	Solarex MSX77	BP Solar BP275	Siemens PC4JF	Siemens PC4JF
PV warranty	12 years/90%	20 years/80%	20 years	10 years	10 years
PV field history	10 years	20+ years	15 years	4 years	5 years
Balance of Syst.					
Battery make/model	Deka 8L16	Deka 8C12	BPVC-8D	Deka 12SC92	Trojan L16
Battery type	flooded	flooded	flooded	valve regulated	flooded
Avail. battery capacity	6,927 Watt hours	4,493 Watt hours	4,608 Watt hours	3,011 Watt hours	5,990 Watt hours
# batteries/system volt	4/12V	3/12V	2/24V	4/12V	/24V
Estimated battery life	5-7 years	2.5-4 years	7-10 years	5 years	3 years
Inverter make/model	Trace DR1512	Trace DR1512	BP Trusine 4.0	Trace SW2512	Trace SW4024
Inverter volts/waveform	115/modified sine	115/modified sine	115/230/sine	115/sine	115/sine
Inverter contin. rating	1500 watts	1500 watts	4000 watts	2500 watts	4000 watts
Controller make/model	Ananda/60 A	Ananda/60 A	BP/100 A	Morning Star/30 A	Ananda/60 A
Supplier					
Supplier name	Photocomm	Direct Power & Water	BP Solar	Solar Electric Spec.	SunWize Energy
System warranty	2 years	2 years	3 years	5 years	2 years
Est. lead time to ship	6-8 weeks	5-7 days	2 weeks	2 weeks	8 weeks
Residential PV exper.	14 years	3 years	8 years	15 years	10 years
Price					
$/watt PV	$18 / Watt	$21 / Watt	$33 / Watt	$37 / Watt	$62 / Watt
System Price	**$8,672**	**$9,710**	**$9,827**	**$11,176**	**$18,585**

3/14/97

Residential System Comparison Chart — *Medium Full-Time Home Systems*

System ID	PSN-BP3-R	PSN-SES3-R	PSN-PC3-R	PSN-SW3-R	PSN-DP3-R
Est.PV output/5.5 sun hr	3.0 kWh/day	3.0 kWh/day	4.2 kWh/day	3.0 kWh/day	4.6 kWh/day
System					
System configuration	steel box on skid	enclosed trailer	skid mount	skid mount	skid mount
Enclosure description	painted steel	aluminum trailer	powder coat steel	galv. steel/polyprop.	5052-H32 aluminum
Foundation required	level site/gravel	level+ground anchors	level site	level+4-8" gravel	level site
Maintenance interval	6 months	12 months	6 months	12 months	6 months
In-house monitor	yes	yes	yes	no	yes
PV Array					
# modules/PV array size	12/900 watts	12/900 watts	16/1280 watts	12/900 watts	18/1386 watts
PV make/model	BP Solar BP275	Siemens PC4JF	Kyocera 80	Siemens PC4JF	Solarex MSX77
PV warranty	20 years	10 years	12 years/90%	10 years	20 years/80%
PV field history	15 years	4 years	10 years	5 years	20+ years
Balance of Syst.					
Battery make/model	BPVC-8D	Deka 12SC225	IBE 85N33	Trojan L16	Deka 8L16
Battery type	flooded	valve regulated	flooded	flooded	flooded
Avail. battery capacity	9,216 Watt hours	8,141 Watt hours	14,684 Watt hours	11,950 Watt hours	17,050 Watt hours
# batteries/system volt	4/24V	4/24V	6/12V	8/24V	12/24V
Estimated battery life	7-10 years	5 years	5-7 years	3 years	2.5-4 years
Inverter make/model	BP Trusine 4.0	Trace SW4024	Trace SW2512	Trace SW4024	Trace SW4024
Inverter volts/waveform	115/230/sine	115/sine	115/sine	115/sine	115/sine
Inverter contin. rating	4000 watts	4000 watts	2500 watts	4000 watts	4000 watts
Controller make/model	BP/100 A	Morning Star/30 A	Ananda/60 A	Ananda/60 A	Ananda/120 A
Supplier					
Supplier name	BP Solar	Solar Electric Spec.	Photocomm	SunWize Energy	Direct Power & Water
System warranty	3 years	5 years	2 years	2 years	2 years
Est. lead time to ship	2 weeks	2 weeks	6-8 weeks	8 weeks	5-7 days
Residential PV exper.	8 years	15 years	14 years	10 years	3 years
Price					
$/watt PV	$18 / Watt	$21 / Watt	$15 / Watt	$23 / Watt	$16 / Watt
System Price	**$16,199**	**$18,755**	**$19,626**	**$20,785**	**$21,791**

3/14/97

Residential System Comparison Chart — Large Full-Time Home Systems

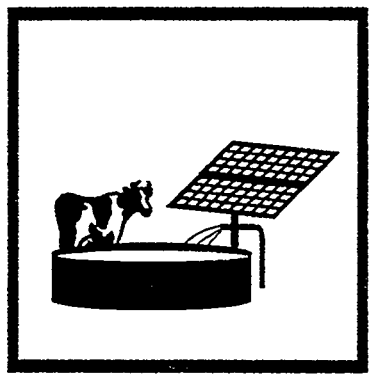
System ID	PSN-BP3a-R	PSN-SW5-R	PSN-SES5-R	PSN-PC5-R	PSN-DP5-R
Est.PV output/5.5 sun hr	5.0 kWh/day	5.0 kWh/day	5.0 kWh/day	7.1 kWh/day	7.1 kWh/day
System					
System configuration	steel box on skid	skid mount	enclosed trailer	skid mount	skid mount
Enclosure description	painted steel	galv. steel/polyprop.	aluminum trailer	powder coat steel	5052-H32 aluminum
Foundation required	level site/gravel	4-8" gravel	level+ground anchors	level site	level site
Maintenance interval	6 months	12 months	12 months	6 months	6 months
In-house monitor	yes	no	yes	yes	yes
PV Array					
# modules/PV array size	20/1500 watts	20/1500 watts	20/1500 watts	18/2160 watts	28/2156 watts
PV make/model	BP Solar BP275	Siemens PC4JF	Siemens PC4JF	Kyocera 120	Solarex MSX77
PV warranty	20 years	10 years	10 years	12 years/90%	20 years/80%
PV field history	15 years	5 years	4years	10 years	20+ years
Balance of Syst.					
Battery make/model	BPVC-8D	Trojan L16	Deka 12SC225	IBE 85N33	Deka 8L16
Battery type	flooded	flooded	valve regulated	flooded	flooded
Avail. battery capacity	13,824 Watt hours	11,950 Watt hours	16,282 Watt hours	31,334 Watt hours	22,733 Watt hours
# batteries/system volt	6/24V	8/24V	8/24V	12/24V	16/48V
Estimated battery life	7-10 years	3 years	5 years	5-7 years	2.5-4 years
Inverter make/model	BP Trusine 4.0	Trace SW4024	Trace SW4024	Trace SW4024	Trace SW4048
Inverter volts/waveform	115/230/sine	115/sine	115/sine	115/sine	115/sine
Inverter contin. rating	4000 watts	4000 watts	4000 watts	4000 watts	4000 watts
Controller make/model	BP/100 A	Ananda/60 A	Morning Star/APT-30A	Ananda/60 A	Ananda/120 A
Supplier					
Supplier name	BP Solar	SunWize Energy	Solar Electric Spec.	Photocomm	Direct Power & Water
System warranty	3 years	2 years	5 years	2 years	2 years
Est. lead time to ship	2 weeks	8 weeks	2 weeks	6-8 weeks	5-7 days
Residential PV exper.	8 years	10 years	15 years	14 years	3 years
Price					
$/watt PV	$15 / Watt	$16 / Watt	$17 / Watt	$15 / Watt	$15 / Watt
System Price	**$22,503**	**$24,195**	**$25,430**	**$31,466**	**$31,901**

3/14/97

Residential System Comparison Chart — *X-Large Full-Time Home Systems*

System ID	PSN-BP8-R	PSN-SW8-R	PSN-SES8-R	PSN-DP8-R	PSN-PC8-R	PSN-BP8a-R
Est.PV output/5.5 sun hr	7.9 kWh/day	7.9 kWh/day	7.4 kWh/day	11.2 kWh/day	11.1 kWh/day	12.4 kWh/day
System						
System configuration	wooden shed on skid	skid mount	enclosed trailer	skid mount	skid mount	wooden shed on skid
Enclosure description	painted wood	galv. steel/polyprop.	aluminum trailer	5052-H32 aluminum	powder coat steel	painted wood
Foundation required	level site/gravel	level+4-8" gravel	level+ground anchors	level site	level site	level site/gravel
Maintenance interval	6 months	12 months	12 months	6 months	6 months	6 months
In-house monitor	yes	no	yes	yes	yes	yes
PV Array						
# modules/PV array size	32/2400 watts	32/2400 watts	30/2250 watts	44/3388 watts	28/3360 watts	50/3750 watts
PV make/model	BP Solar BP275	Siemens PC4JF	Siemens PC4JF	Solarex MSX77	Kyocera 120	BP Solar BP275
PV warranty	20 years	10 years	10 years	20 years/80%	12 years/90%	20 years
PV field history	15 years	5 years	4 years	20+ years	10 years	15 years
Balance of Syst.						
Battery make/model	C&D CP75-25	Trojan 145j-13	Deka 12SC225	Deka 8L16	IBE 85N25	C&D CP75-25
Battery type	flooded	flooded	valve regulated	flooded	flooded	flooded
Avail. battery capacity	27,648 Watt hours	35,328 Watt hours	24,422 Watt hours	34,099 Watt hours	47,002 Watt hours	35,512 Watt hours
# batteries/system volt	12/24V	/24V	12/24V	24/48V	24/24V	24/24V
Estimated battery life	7-10 years	6-7 years	5 years	2.5-4 years	5-7 years	7-10 years
Inverter make/model	BP Trusine 4.0	Trace SW4024	Trace SW4024	Trace SW4048	Trace SW5548	BP Trusine 4.0
Inverter volts/waveform	115/230/sine	115/230/sine	115/230/sine	115/230/sine	115/sine	115/230/sine
Inverter contin. rating	4000 watts	8000 watts	8000 watts	8000 watts	5500 watts	4000 watts
Controller make/model	BP/100 A	Ananda/60 A	Morning Star/APT-30A	Ananda/120 A	Ananda/60 A	BP/100 A
Supplier						
Supplier name	BP Solar	SunWize Energy	Solar Electric Spec.	Direct Power & Water	Photocomm	BP Solar
System warranty	3 years	2 years	5 years	2 years	2 years	3 years
Est. lead time to ship	2 weeks	8 weeks	2 weeks	5-7 days	6-8 weeks	2 weeks
Residential PV exper.	8 years	10 years	15 years	3 years	14 years	8 years
Price						
$/watt PV	$13 / Watt	$15 / Watt	$17 / Watt	$12 / Watt	$13 / Watt	$12 / Watt
System Price	**$30,973**	**$36,295**	**$38,500**	**$42,349**	**$44,453**	**$44,915**

3/14/97



1997 Water Pumping Product List

PSN

hotovoltaic Services Network, Inc.

Water Pumping Product List

A wide variety of PV-powered water pumping systems were evaluated for inclusion on the PSN Water Pumping Product List. The systems finally selected for the list represent the best combinations of high quality equipment, price and supplier experience, capabilities and support. The selection of pumping systems on the Product List was narrowed to include only those with submersible pumps, since that is what the majority of utility pumping applications require. However, the PSN can price and negotiate the purchase of jack and surface pumps as well for any PSN member.

To ensure that the systems on the Pumping Product list are of high quality and meet utility needs for performance, reliability and convenience, the PSN used the minimum requirements below as a preliminary screening tool when evaluating pumping systems.

Minimum Requirements

All of the PV-powered pumping systems selected for the PSN pumping list meet the following minimum system and supplier requirements:

- ✓ Systems include two distinct sub-systems 1) a fully integrated PV power supply with all hardware needed for installation (excluding water pipe and pump cable) and 2) the associated pump/motor unit.
- ✓ Pump/motor units are submersible to a minimum of 50 feet under water.
- ✓ Systems meet all applicable National Electric Code requirements to ensure installer/operator safety including: a manual disconnect switch, proper grounding, proper size wire and disconnects, and hazard warning signs. However, UL (or equivalent) listed components are not required since few PV-powered systems on the market today meet that requirement.
- ✓ PV modules meet IEEE P1262 and UL 1703 standards and include a minimum 10 year, 90% power rating warranty.
- ✓ Power supplies include bypass diodes according to module mfr. recommendations.
- ✓ Systems are capable of operating in temperatures of -20° to 45 °C, withstand winds of 90 mph with the array at 55 ° tilt and have a minimum two foot ground clearance.
- ✓ Systems can withstand exposure to above conditions for 20 years without maintenance.
- ✓ Systems are supplied with complete installation, operation and maintenance manuals for utility personnel and a user manual for the customer/member.
- ✓ The system manufacturer warrants water output for a minimum of two years. (Utilities process all warranty claims through the PSN.)
- ✓ The system manufacturer has documented experience in supplying similar packaged pumping systems.
- ✓ The price quotes contained in the Water Pumping Product List are effective through December of 1997.

Pumping System Selection

When selecting a pumping system for a specific application, first consult Chart 1: Performance Nodes. Use Chart 1 to select a performance node (labeled intersection) that is closest to your combination of pumping head (total vertical lift) and required gallons per day (GPD).

Next turn to Chart 2: Pumping System Comparisons and go to the page labeled with the selected node. This page will give you information about the pumping systems offered by the PSN that are appropriate for that particular combination of head and GPD. If your application is between nodes, also check the nodes immediately before and after your required head and GPD.

The systems on the Chart 2 are listed from left to right in order of system cost. When reviewing pumping systems, please remember that there may be significant differences between systems that may justify a higher cost (such as lower maintenance pumps).

Chart 2: Pumping System Comparisons

Chart 2 consists of 69 pages (one page for each node). Each page is labeled by node on the upper right corner and also on the bottom of the page.

The first line on the chart is the PSN identification number for each system on the chart. This is the number you would use to order a system.

The next line labeled ***Estimated GPD/Max GPM*** gives each system's daily water output (with an insolation level of 6 peak sun hours or kWh/m^2 per day) and the maximum gallons per minute production. These pumping levels can be expected during the summer months in most western states. Actual water delivery will depend on the well's location and season of use. For a more accurate water estimate call the PSN.

Under the Pump heading, the line labeled ***Pump Type*** describes the type of pumping mechanism used to move the water. All the systems on the list are diaphragm, centrifugal or sealed piston pumps. Diaphragm pumps are positive displacement pumps that require periodic replacement of the flexible diaphragms and rebuilding of the brushed DC motors. Centrifugal pumps require no periodic maintenance of the pumping mechanisms and have brushless (maintenance free) motors. The sealed piston pumps are a new entry in this year's Product List. They are similar to diaphragm pumps but they do not require as much maintenance.

The ***Pump Manufacturer*** and ***Pump Model*** lines give the make and model of the pump. ***Minimum well casing*** is the minimum well inside diameter that each pump will fit into. ***Pump field history*** describes how long each pump has been commercially available and installed in the field. ***Rebuild interval/cost*** gives the pump manufacturer's estimated time before the pump needs to be rebuilt and the approximate cost for the rebuild. ***Recommended pipe*** describes the type and size of pipe that the manufacturer recommends for installing each pump. ***Recommended wire*** describes the type and size of pump cable that should be used with the pump.

Under the Power Supply heading, ***# modules/PV array size*** gives the number of PV modules in each system and the size of the PV array in peak watts. ***PV make/model*** names the manufacturer and model number of the PV modules and ***PV warranty*** lists manufacturer's warranty on PV power output. ***PV field history*** gives the number of years that the PV module has been commercially available.

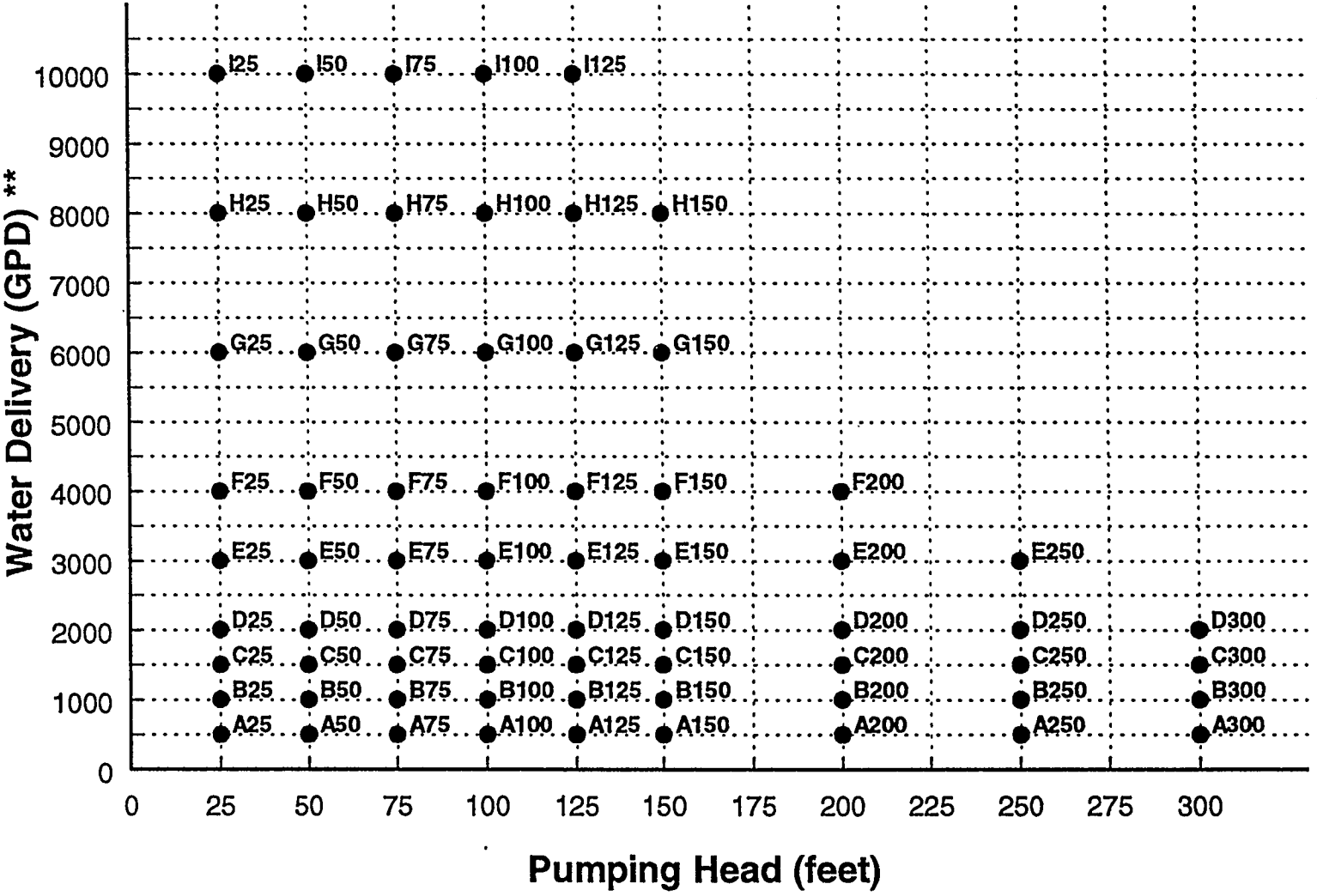
Array mount describes the type of mounting structure used for the PV array and the brand name of the tracker if one is used (either Zomeworks, passive tracker, or Wattsun active tracker). ***Controller make/model*** names the manufacturer of the pump controller and ***Back-up power option*** describes the method used to provide back-up power to the pump (if any).

Under the Supplier heading, ***Supplier name*** gives the name of the PV system supplier that provides each pumping system to the PSN and ***PV pumping experience*** lists the amount of experience each supplier has with PV-powered water pumping. ***System warranty*** lists the system supplier's warranty for the packaged pumping system and ***Est. lead time to ship*** describes the time each system supplier requires to ship a system after receipt of order. ***Estimated ship weight*** is the approximate shipping weight of the system.

Controller price and ***Pump price*** gives the prices for the separate components and ***System Price*** is the price for the entire system.

Pumping System Selection

Chart 1: Performance Nodes *



*** Select a labeled node that is closest to (but not lower than) your required pumping head and daily water requirement. Then turn to Chart 2 to find out what pumping systems suit your needs.**

**** Water delivery based on insolation of 6 sun hours**

Chart 2: Pumping System Comparisons — Node A25 (25 ft., 500 GPD)

System ID	PSN-RB3-P	PSN-DP04-P	PSN-PC01-P	PSN-DP02-P	PSN-SES1-P	PSN-AP01-P
Est. GPD/Max. GPM	540/1.5	605/2	601/1.9	535/1.2	702/2.1	1803/6.1
Pump						
Pump type	Diaphragm	Diaphragm	Diaphragm	Diaphragm	Diaphragm	Centrifugal
Pump manufacturer	Robison	SolarJack	SolarJack	SolarJack	Shurflo	Grundfos
Pump model	RP 24/50	SDS-Q-128	SDS-Q-128	SDS-D-128	9300	SP1.5A-3
Minimum well casing	4 inch	4.5 inch	4.5 inch	4 inch	4 inch	4 inch
Pump field history	10 years	7 years	7 years	7 years	5 years	2 years
Rebuild interval/cost	5 years/$150					up to 20 yr/new pump
Recommended pipe	1/2" or 3/4" poly	3/4" poly	3/4" poly	3/4" poly	1/2" or 3/4" poly	1 1/4" PVC
Recommended wire	14-2 pump cable	12-2/G pump cable	12-2/G pump cable	12-2/G pump cable	10-2 pump cable	10-3/G pump cable
Power Supply						
# modules/PV array size	1/53 watts	1/40 watts	1/40 watts	1/60 watts	1/50 watts	3/150 watts
PV make/model	Solarex VLX-53	Solarex MSX 40	Based on Availability	Solarex MSX 60	Siemens SM50	ASE-50-AL
PV warranty	20 years	20 years	variable	20 years	10 years	10 years
PV field history	10 years	9 years	variable	9 years	10 years	2 years
Array mount	fixed/pole	fixed/pole	fixed/pole	fixed/pole	fixed/pole	fixed/pole
Controller make/model	SPC-1 24 Volt	Solarjack PVA 5-30A	Solarjack PCA 10-30A	Solarjack PVA 5-30A	Atersa M5	Grundfos SA400
Back-up power option	12 volt battery		12V batteries		12 or 24V battery	none
Supplier						
Supplier name	Robison	Direct Power & Water	Photocomm	Direct Power & Water	Solar Electric Spec.	Applied Power
PV pump experience	11 years	5 years	15 years	5 years	16 years	12 years
System warranty	2 years	2 years	2 years	2 years	2 years	2 years
Est. lead time to ship	24-48 hours	2 days	24 hours	2 days	1-2 weeks	48 hours
Estimated ship weight	45 lb		80 lb		47 lb	100 lb
Price						
Controller Price	$215		$165			$738
Pump Price	$468	$710	$572	$732	$550	$660
System Price	$1,027	$1,176	$1,179	$1,324	$1,326	$2,642

Chart 2: Pumping System Comparisons — Node A50 (50 ft., 500 GPD)

System ID	PSN-RB2-P	PSN-PC02-P	PSN-SES2-P	PSN-AP02-P	PSN-DP15-P
Est. GPD/Max. GPM	720/2	581/1.9	684/2	615/2.6	553/1.4
Pump					
Pump type	Diaphragm	Diaphragm	Diaphragm	Centrifugal	Centrifugal
Pump manufacturer	Robison	SolarJack	Shurflo	Grundfos	SolarJack
Pump model	RP 32/50	SDS-Q-128	9300	SP1A-6	SCS 4-140
Minimum well casing	4 inch	4.5 inch	4 inch	4 inch	4 inch
Pump field history	10 years	7 years	5 years	2 years	2 years
Rebuild interval/cost	3 years/$150			up to 20 yr/new pump	
Recommended pipe	1/2" or 3/4" poly	3/4" poly	1/2" or 3/4" poly	1 1/4" PVC	
Recommended wire	14-2 pump cable	12-2/G pump cable	10-2 pump cable	10-3/G pump cable	
Power Supply					
# modules/PV array size	2/106 watts	1/60 watts	1/75 watts	3/150 watts	2/112 watts
PV make/model	Solarex VLX-53	Based on Availability	Siemens SM75	ASE-50-AL	Solarex MSX 56
PV warranty	20 years	variable	10 years	10 years	20 years
PV field history	10 years	variable	4 years	2 years	9 years
Array mount	fixed/pole	fixed/pole	fixed/pole	fixed/pole	fixed/pole
Controller make/model	SPC-1 32 Volt	Solarjack PCA 10-30A	Atersa M5	Grundfos SA400	Solarjack PCA 8-60
Back-up power option	12 or 24 volt battery	12V batteries	12 or 24V battery	none	
Supplier					
Supplier name	Robison	Photocomm	Solar Electric Spec.	Applied Power	Direct Power & Water
PV pump experience	11 years	15 years	16 years	12 years	5 years
System warranty	2 years	2 years	2 years	2 years	2 years
Est. lead time to ship	24-48 hours	24 hours	1-2 weeks	48 hours	2 days
Estimated ship weight	66 lb	120 lb	52 lb	100 lb	
Price					
Controller Price	$215	$165		$738	
Pump Price	$468	$572	$550	$660	$1,678
System Price	$1,249	$1,271	$1,451	$2,642	$2,666

Chart 2: Pumping System Comparisons — Node A75 (75 ft., 500 GPD)

System ID	PSN-RB2-P	PSN-DP23-P	PSN-SES2-P	PSN-PC03-P	PSN-AP03-P
Est. GPD/Max. GPM	612/1.7	700/2	638/2	727/2	525/2.9
Pump					
Pump type	Diaphragm	Diaphragm	Diaphragm	Diaphragm	Centrifugal
Pump manufacturer	Robison	SolarJack	Shurflo	SolarJack	Grundfos
Pump model	RP 32/50	SDS-Q-128	9300	SDS-Q-128	SP1A-6
Minimum well casing	4 inch	4.5 inch	4 inch	4.5 inch	4 inch
Pump field history	10 years	7 years	5 years	7 years	2 years
Rebuild interval/cost	3 years/$150				up to 20 yr/new pump
Recommended pipe	1/2" or 3/4" poly	3/4" poly	1/2" or 3/4" poly	3/4" poly	1 1/4" PVC
Recommended wire	14-2 pump cable	12-2/G pump cable	10-2 pump cable	12-2/G pump cable	10-3/G pump cable
Power Supply					
# modules/PV array size	2/106 watts	2/100 watts	1/75 watts	2/100 watts	4/200 watts
PV make/model	Solarex VLX-53	Solarex MSX 50	Siemens SM75	Based on Availability	ASE-50-AL
PV warranty	20 years	20 years	10 years	variable	10 years
PV field history	10 years	9 years	4 years	variable	2 years
Array mount	fixed/pole	fixed/pole	fixed/pole	fixed/pole	fixed/pole
Controller make/model	SPC-1 32 Volt	Solarjack PCA 10-30	Atersa M5	Solarjack PCA 10-30A	Grundfos SA400
Back-up power option	12 or 24 volt battery		12 or 24V battery	24V batteries	none
Supplier					
Supplier name	Robison	Direct Power & Water	Solar Electric Spec.	Photocomm	Applied Power
PV pump experience	11 years	5 years	16 years	15 years	12 years
System warranty	2 years	2 years	2 years	2 years	2 years
Est. lead time to ship	24-48 hours	2 days	1-2 weeks	24 hours	48 hours
Estimated ship weight	66 lb		52 lb	120 lb	132 lb
Price					
Controller Price	$215			$165	$738
Pump Price	$468	$710	$550	$572	$660
System Price	$1,249	$1,434	$1,451	$1,474	$2,961

Chart 2: Pumping System Comparisons — Node A100 (100 ft., 500 GPD)

System ID	PSN-RB2-P	PSN-RB1-P	PSN-DP31A-P	PSN-SES3-P	PSN-AP04-P	PSN-DP32-P
Est. GPD/Max. GPM	540/1.5	792/2.2	664/1.8	648/1.8	640/2.9	610/2.2
Pump						
Pump type	Diaphragm	Diaphragm	Diaphragm	Diaphragm	Centrifugal	Centrifugal
Pump manufacturer	Robison	Robison	SolarJack	Shurflo	Grundfos	SolarJack
Pump model	RP 32/50	RP 32/50	SDS-Q-128	9300	SP1A-9	SCS 2-280
Minimum well casing	4 inch	4 inch	4.5 inch	4 inch	4 inch	4 inch
Pump field history	10 years	10 years	7 years	5 years	2 years	2 years
Rebuild interval/cost	3 years/$150	3 years/$150			up to 20 yr/new pump	
Recommended pipe	1/2" or 3/4" poly	1/2" or 3/4" poly	3/4" poly	1/2" or 3/4" poly	1 1/4" PVC	
Recommended wire	14-2 pump cable	14-2 pump cable	12-2/G pump cable	10-2 pump cable	10-3/G pump cable	
Power Supply						
# modules/PV array size	2/106 watts	2/154 watts	2/112 watts	2/100 watts	5/250 watts	4/224 watts
PV make/model	Solarex VLX-53	Solarex MSX-77	Solarex MSX 56	Siemens SM50	ASE-50-AL	Solarex MSX 56
PV warranty	20 years	20 years	20 years	10 years	10 years	20 years
PV field history	10 years	10 years	9 years	10 years	2 years	9 years
Array mount	fixed/pole	fixed/pole	fixed/pole	fixed/pole	fixed/pole	fixed/pole
Controller make/model	SPC-1 32 Volt	SPC-1 32 Volt	Solarjack PVA 5-30	Atersa M5	Grundfos SA400	Solarjack PCA 8-60
Back-up power option	12 or 24 volt battery	12 or 24 volt battery		12 or 24V battery	none	
Supplier						
Supplier name	Robison	Robison	Direct Power & Water	Solar Electric Spec.	Applied Power	Direct Power & Water
PV pump experience	11 years	11 years	5 years	16 years	12 years	5 years
System warranty	2 years	2 years	2 years	2 years	2 years	2 years
Est. lead time to ship	24-48 hours	24-48 hours	2 days	1-2 weeks	48 hours	2 days
Estimated ship weight	66 lb	71 lb		74 lb	132 lb	
Price						
Controller Price	$215	$215			$738	
Pump Price	$468	$468	$710	$550	$660	$1,825
System Price	$1,249	$1,568	$1,632	$1,658	$3,480	$3,579

Node A100 (100 ft., 500 GPD)

Chart 2: Pumping System Comparisons — Node A125 (125 ft., 500 GPD)

System ID	PSN-RB1-P	PSN-PC05-P	PSN-DP39-P	PSN-AP05-P
Est. GPD/Max. GPM	720/2	515/1.1	555/1.1	599/3
Pump				
Pump type	Diaphragm	Diaphragm	Diaphragm	Centrifugal
Pump manufacturer	Robison	SolarJack	SolarJack	Grundfos
Pump model	RP 32/50	SDS-D-228	SDS-D-228	SP1A-9
Minimum well casing	4 inch	4 inch	4 inch	4 inch
Pump field history	10 years	7 years	7 years	2 years
Rebuild interval/cost	3 years/$150			up to 20 yr/new pump
Recommended pipe	1/2" or 3/4" poly	1/2" poly	1/2" poly	1 1/4" PVC
Recommended wire	14-2 pump cable	12-2/G pump cable	12-2/G pump cable	10-3/G pump cable
Power Supply				
# modules/PV array size	2/154 watts	2/128 watts	2/154 watts	6/300 watts
PV make/model	Solarex MSX-77	Based on Availability	Solarex MSX 77	ASE-50-AL
PV warranty	20 years	variable	20 years	10 years
PV field history	10 years	variable	9 years	2 years
Array mount	fixed/pole	fixed/pole	fixed/pole	fixed/pole
Controller make/model	SPC-1 32 Volt	Solarjack PCA 10-30A	Solarjack PCA 10-30A	Grundfos SA400
Back-up power option	12 or 24 volt battery	24V batteries		none
Supplier				
Supplier name	Robison	Photocomm	Direct Power & Water	Applied Power
PV pump experience	11 years	15 years	5 years	12 years
System warranty	2 years	2 years	2 years	2 years
Est. lead time to ship	24-48 hours	24 hours	2 days	48 hours
Estimated ship weight	71 lb	140 lb		161 lb
Price				
Controller Price	$215	$165		$738
Pump Price	$468	$523	$655	$660
System Price	$1,568	$1,623	$1,795	$3,802

Node A125 (125 ft., 500 GPD)

Chart 2: Pumping System Comparisons — Node A150 (150 ft., 500 GPD)

System ID	PSN-RB1-P	PSN-SES3-P	PSN-DP39-P	PSN-PC06-P	PSN-DP24-P
Est. GPD/Max. GPM	576/1.6	588/1.8	515/1.1	521/1.1	648/1.7
Pump					
Pump type	Diaphragm	Diaphragm	Diaphragm	Diaphragm	Centrifugal
Pump manufacturer	Robison	Shurflo	SolarJack	SolarJack	SolarJack
Pump model	RP 32/50	9300	SDS-D-228	SDS-D-228	SCS 2-280
Minimum well casing	4 inch	4 inch	4 inch	4 inch	4 inch
Pump field history	10 years	5 years	7 years	7 years	2 years
Rebuild interval/cost	3 years/$150				
Recommended pipe	1/2" or 3/4" poly	1/2" or 3/4" poly	1/2" poly	1/2" poly	
Recommended wire	14-2 pump cable	10-2 pump cable	10-2/G pump cable	10-2/G pump cable	
Power Supply					
# modules/PV array size	2/154 watts	2/100 watts	2/154 watts	2/160 watts	4/240 watts
PV make/model	Solarex MSX-77	Siemens SM50	Solarex MSX 77	Based on Availability	Solarex MSX 60
PV warranty	20 years	10 years	20 years	variable	20 years
PV field history	10 years	10 years	9 years	variable	9 years
Array mount	fixed/pole	fixed/pole	fixed/pole	fixed/pole	Wattsun tracker
Controller make/model	SPC-1 32 Volt	Atersa M5	Solarjack PCA 10-30A	Solarjack PCA 10-30A	Solarjack PCA 8-60
Back-up power option	12 or 24 volt battery	12 or 24V battery		24V batteries	
Supplier					
Supplier name	Robison	Solar Electric Spec.	Direct Power & Water	Photocomm	Direct Power & Water
PV pump experience	11 years	16 years	5 years	15 years	5 years
System warranty	2 years	2 years	2 years	2 years	2 years
Est. lead time to ship	24-48 hours	1-2 weeks	2 days	24 hours	2 days
Estimated ship weight	71 lb	74 lb		160 lb	
Price					
Controller Price	$215			$165	
Pump Price	$468	$550	$655	$545	$1,810
System Price	**$1,568**	**$1,658**	**$1,795**	**$1,815**	**$3,894**

Chart 2: Pumping System Comparisons

Node A200 (200 ft., 500 GPD)

System ID	PSN-PC07-P	PSN-DP50-P	PSN-DP51-P
Est. GPD/Max. GPM	622/1	614/1	565/1.6
Pump			
Pump type	Diaphragm	Diaphragm	Centrifugal
Pump manufacturer	SolarJack	SolarJack	SolarJack
Pump model	SDS-D-228	SDS-D-228	SCS 2-280
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	7 years	7 years	2 years
Rebuild interval/cost			
Recommended pipe	1/2" poly	1/2" poly	
Recommended wire	10-2/G pump cable	10-2/G pump cable	
Power Supply			
# modules/PV array size	2/160 watts	2/154 watts	6/360 watts
PV make/model	Based on Availability	Solarex MSX 77	Solarex MSX 60
PV warranty	variable	20 years	20 years
PV field history	variable	9 years	9 years
Array mount	Zomeworks tracker	Wattsun tracker	Wattsun tracker
Controller make/model	Solarjack PCA 10-30A	Solarjack PCA 10-30A	Solarjack PCB 8-120
Back-up power option	24V batteries		
Supplier			
Supplier name	Photocomm	Direct Power & Water	Direct Power & Water
PV pump experience	15 years	5 years	5 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	2 days
Estimated ship weight	160 lb		
Price			
Controller Price	$165		
Pump Price	$545	$655	$1,810
System Price	$2,054	$2,085	$4,840

Node A200 (200 ft., 500 GPD)

Chart 2: Pumping System Comparisons

Node A250 (250 ft., 500 GPD)

System ID	PSN-PC08-P	PSN-DP55-P	PSN-AP07-P
Est. GPD/Max. GPM	957/2.3	505/1.3	729/5.4
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 4-325	SCS 3-425	SP2A-15
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe	3/4" poly	3/4" poly	2" PVC
Recommended wire	8-2/G pump cable	8-2/G pump cable	6-3/G pump cable
Power Supply			
# modules/PV array size	10/600 watts	10/560 watts	16/800 watts
PV make/model	Based on Availability	Solarex MSX 56	ASE-50-AL
PV warranty	variable	20 years	10 years
PV field history	variable	9 years	2 years
Array mount	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	75V batteries		optional gen. interface
Supplier			
Supplier name	Photocomm	Direct Power & Water	Applied Power
PV pump experience	15 years	5 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	48 hours
Estimated ship weight	300 lb		396 lb
Price			
Controller Price	$351		$1,525
Pump Price	$1,726	$1,898	$1,180
System Price	**$6,508**	**$6,740**	**$8,757**

Chart 2: Pumping System Comparisons — Node A300 (300 ft., 500 GPD)

System ID	PSN-SES9-P	PSN-PC09-P	PSN-DP55-P	PSN-AP08-P
Est. GPD/Max. GPM	645/1.5	589/1.6	500/1.6	525/3.1
Pump				
Pump type	Sealed piston	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	Sunrise	SolarJack	SolarJack	Grundfos
Pump model	5218	SCS 4-325	SCS 3-425	SP1.5A-21
Minimum well casing	4 inch	4 inch	4 inch	4 inch
Pump field history	3 years	2 years	2 years	16 years
Rebuild interval/cost				up to 20 yr/new pump
Recommended pipe	3/4" poly	3/4" poly	3/4" poly	2" PVC
Recommended wire		8-2/G pump cable	8-2/G pump cable	6-3/G pump cable
Power Supply				
# modules/PV array size	4/280 watts	10/600 watts	10/560 watts	16/800 watts
PV make/model	Siemens SM70	Based on Availability	Solarex MSX 56	ASE-50-AL
PV warranty	10 years	variable	20 years	10 years
PV field history	4 years	variable	9 years	2 years
Array mount	Zomeworks tracker	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Sunprimer Mk-1/b	Solarjack PCB 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	12 or 24V battery	75V batteries		optional gen. interface
Supplier				
Supplier name	Solar Electric Spec.	Photocomm	Direct Power & Water	Applied Power
PV pump experience	16 years	15 years	5 years	12 years
System warranty	2 years	2 years	2 years	2 years
Est. lead time to ship	1-2 weeks	24 hours	2 days	48 hours
Estimated ship weight	152 lb	300 lb		396 lb
Price				
Controller Price		$351		$1,525
Pump Price	$1,628	$1,726	$1,898	$1,398
System Price	$4,055	$6,508	$6,740	$8,975

Node A300 (300 ft., 500 GPD)

Chart 2: Pumping System Comparisons — Node B25 (25 ft., 1000 GPD)

System ID	PSN-DP06-P	PSN-PC10-P	PSN-DP05-P	PSN-SES4-P	PSN-DP03-P	PSN-AP01-P
Est. GPD/Max. GPM	1080/2.4	1044/2.8	1052/1.8	980/2	1130/2.8	1803/6.1
Pump						
Pump type	Diaphragm	Diaphragm	Diaphragm	Diaphragm	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	SolarJack	Shurflo	SolarJack	Grundfos
Pump model	SDS-Q-128	SDS-Q-128	SDS-D-128	9300	SCS 5-115	SP1.5A-3
Minimum well casing	4.5 inch	4.5 inch	4 inch	4 inch	4 inch	4 inch
Pump field history	7 years	7 years	7 years	5 years	2 years	2 years
Rebuild interval/cost						up to 20 yr/new pump
Recommended pipe	3/4" poly	3/4" poly	3/4" poly	1/2" or 3/4" poly		1 1/4" PVC
Recommended wire	12-2/G pump cable	12-2/G pump cable	12-2/G pump cable	10-2 pump cable		10-3/G pump cable
Power Supply						
# modules/PV array size	1/77 watts	2/64 watts	2/154 watts	2/100 watts	2/112 watts	3/150 watts
PV make/model	Solarex MSX 77	Based on Availability	Solarex MSX 77	Siemens SM50	Solarex MSX 56	ASE-50-AL
PV warranty	20 years	variable	20 years	10 years	20 years	10 years
PV field history	9 years	variable	9 years	10 years	9 years	2 years
Array mount	fixed/pole	fixed/pole	fixed/pole	Zomeworks tracker	fixed/pole	fixed/pole
Controller make/model	Solarjack PVA 5-30A	Solarjack PCA 10-30A	Solarjack PCA 8-30	Atersa M5	Solarjack PCA 8-60	Grundfos SA400
Back-up power option		24V batteries		12 or 24V battery		none
Supplier						
Supplier name	Direct Power & Water	Photocomm	Direct Power & Water	Solar Electric Spec.	Direct Power & Water	Applied Power
PV pump experience	5 years	15 years	5 years	16 years	5 years	12 years
System warranty	2 years	2 years	2 years	2 years	2 years	2 years
Est. lead time to ship	2 days	24 hours	2 days	1-2 weeks	2 days	48 hours
Estimated ship weight		80 lb		74 lb		100 lb
Price						
Controller Price		$165				$738
Pump Price	$710	$572	$655	$550	$1,645	$660
System Price	$1,390	$1,407	$1,687	$1,882	$2,545	$2,642

Chart 2: Pumping System Comparisons — Node B50 (50 ft., 1000 GPD)

System ID	PSN-DP16-P	PSN-PC11-P	PSN-SES4-P	PSN-AP03-P	PSN-DP17-P	PSN-SES10-P
Est. GPD/Max. GPM	1044/3.2	1073/2.8	960/2	1204/4	1200/3.5	1770/3.4
Pump						
Pump type	Diaphragm	Diaphragm	Diaphragm	Centrifugal	Centrifugal	Sealed piston
Pump manufacturer	SolarJack	SolarJack	Shurflo	Grundfos	SolarJack	Sunrise
Pump model	SDS-Q-128	SDS-Q-128	9300	SP1A-6	SCS 8-90	5218
Minimum well casing	4.5 inch	4.5 inch	4 inch	4 inch	4 inch	4 inch
Pump field history	7 years	7 years	5 years	2 years	2 years	3 years
Rebuild interval/cost				up to 20 yr/new pump		
Recommended pipe	3/4" poly	3/4" poly	1/2" or 3/4" poly	1 1/4" PVC		3/4" poly
Recommended wire	12-2/G pump cable	12-2/G pump cable	10-2 pump cable	10-3/G pump cable		
Power Supply						
# modules/PV array size	2/100 watts	2/100 watts	2/100 watts	4/200 watts	2/154 watts	4/280 watts
PV make/model	Solarex MSX 50	Based on Availability	Siemens SM50	ASE-50-AL	Solarex MSX 77	Siemens SM70
PV warranty	20 years	variable	10 years	10 years	20 years	10 years
PV field history	9 years	variable	10 years	2 years	9 years	4 years
Array mount	fixed/pole	fixed/pole	Zomeworks tracker	fixed/pole	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCA 10-30	Solarjack PCA 10-30A	Atersa M5	Grundfos SA400	Solarjack PCA 8-60	Sunprimer Mk-1/b
Back-up power option		24V batteries	12 or 24V battery	none		12 or 24V battery
Supplier						
Supplier name	Direct Power & Water	Photocomm	Solar Electric Spec.	Applied Power	Direct Power & Water	Solar Electric Spec.
PV pump experience	5 years	15 years	16 years	12 years	5 years	16 years
System warranty	2 years	2 years	2 years	2 years	2 years	2 years
Est. lead time to ship	2 days	24 hours	1-2 weeks	48 hours	2 days	1-2 weeks
Estimated ship weight		100 lb	74 lb	132 lb		152 lb
Price						
Controller Price		$165		$738		
Pump Price	$710	$572	$550	$660	$1,865	$1,628
System Price	$1,480	$1,544	$1,882	$2,961	$3,220	$4,055

Chart 2: Pumping System Comparisons — Node B75 (75 ft., 1000 GPD)

System ID	PSN-DP24A-P	PSN-PC12-P	PSN-SES5-P	PSN-AP04-P	PSN-DP24-P	PSN-SES10-P
Est. GPD/Max. GPM	1280/3	1273/2.6	960/2	1055/3.6	1150/2.7	1700/3.3
Pump						
Pump type	Diaphragm	Diaphragm	Diaphragm	Centrifugal	Centrifugal	Sealed piston
Pump manufacturer	SolarJack	SolarJack	Shurflo	Grundfos	SolarJack	Sunrise
Pump model	SDS-Q-128	SDS-Q-128	9300	SP1A-9	SCS 2-280	5218
Minimum well casing	4.5 inch	4.5 inch	4 inch	4 inch	4 inch	4 inch
Pump field history	7 years	7 years	5 years	2 years	2 years	3 years
Rebuild interval/cost				up to 20 yr/new pump		
Recommended pipe			1/2" or 3/4" poly	1 1/4" PVC		3/4" poly
Recommended wire	12-2/G pump cable	12-2/G pump cable	10-2 pump cable	10-3/G pump cable		
Power Supply						
# modules/PV array size	2/154 watts	2/120 watts	2/150 watts	5/250 watts	4/240 watts	4/280 watts
PV make/model	Solarex MSX 77	Based on Availability	Siemens SM75	ASE-50-AL	Solarex MSX 60	Siemens SM70
PV warranty	20 years	variable	10 years	10 years	20 years	10 years
PV field history	9 years	variable	10 years	2 years	9 years	4 years
Array mount	fixed/pole	Zomeworks tracker	Zomeworks tracker	fixed/pole	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCA 8-60	Solarjack PCA 10-30A	Atersa M5	Grundfos SA400	Solarjack PCA 8-60	Sunprimer Mk-1/b
Back-up power option		24V batteries	12 or 24V battery	none		12 or 24V battery
Supplier						
Supplier name	Direct Power & Water	Photocomm	Solar Electric Spec.	Applied Power	Direct Power & Water	Solar Electric Spec.
PV pump experience	5 years	15 years	16 years	12 years	5 years	16 years
System warranty	2 years	2 years	2 years	2 years	2 years	2 years
Est. lead time to ship	2 days	24 hours	1-2 weeks	48 hours	2 days	1-2 weeks
Estimated ship weight		100 lb	93 lb	132 lb		152 lb
Price						
Controller Price		$165		$738		
Pump Price	$710	$572	$550	$660	$1,810	$1,628
System Price	$1,832	$1,902	$2,116	$3,480	$3,894	$4,055

Chart 2: Pumping System Comparisons — Node B100 (100 ft., 1000 GPD)

System ID	PSN-DP18-P	PSN-SES5-P	PSN-PC13-P	PSN-AP05-P	PSN-SES10-P
Est. GPD/Max. GPM	1310/2.8	950/2	1378/2.8	1000/3.7	1550/3.2
Pump					
Pump type	Diaphragm	Diaphragm	Diaphragm	Centrifugal	Sealed piston
Pump manufacturer	SolarJack	Shurflo	SolarJack	Grundfos	Sunrise
Pump model	SDS-Q-128	9300	SDS-Q-128	SP1A-9	5218
Minimum well casing	4.5 inch	4 inch	4.5 inch	4 inch	4 inch
Pump field history	7 years	5 years	7 years	2 years	3 years
Rebuild interval/cost				up to 20 yr/new pump	
Recommended pipe		1/2" or 3/4" poly		1 1/4" PVC	3/4" poly
Recommended wire	12-2/G pump cable	10-2 pump cable	12-2/G pump cable	10-3/G pump cable	
Power Supply					
# modules/PV array size	2/154 watts	2/150 watts	2/160 watts	6/300 watts	4/280 watts
PV make/model	Solarex MSX 77	Siemens SM75	Based on Availability	ASE-50-AL	Siemens SM70
PV warranty	20 years	10 years	variable	10 years	10 years
PV field history	9 years	10 years	variable	2 years	4 years
Array mount	Wattsun tracker	Zomeworks tracker	Zomeworks tracker	fixed/pole	fixed/pole
Controller make/model	Solarjack PCA 10-30	Atersa M5	Solarjack PCA 10-30A	Grundfos SA400	Sunprimer Mk-1/b
Back-up power option		12 or 24V battery	24V batteries	none	12 or 24V battery
Supplier					
Supplier name	Direct Power & Water	Solar Electric Spec.	Photocomm	Applied Power	Solar Electric Spec.
PV pump experience	5 years	16 years	15 years	12 years	16 years
System warranty	2 years	2 years	2 years	2 years	2 years
Est. lead time to ship	2 days	1-2 weeks	24 hours	48 hours	1-2 weeks
Estimated ship weight		93 lb	120 lb	161 lb	152 lb
Price					
Controller Price			$165	$738	
Pump Price	$710	$550	$572	$660	$1,628
System Price	$2,112	$2,116	$2,218	$3,802	$4,055

Node B100 (100 ft., 1000 GPD)

Chart 2: Pumping System Comparisons — Node B125 (125 ft., 1000 GPD)

System ID	PSN-SES5-P	PSN-SES10-P	PSN-PC14-P	PSN-DP40-P	PSN-AP28-P
Est. GPD/Max. GPM	950/2	1405/3.1	1202/3	1031/4.1	1070/5.9
Pump					
Pump type	Diaphragm	Sealed piston	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	Shurflo	Sunrise	SolarJack	SolarJack	Grundfos
Pump model	9300	5218	SCS 3-150	SCS 4-140	SP3A-10
Minimum well casing	4 inch	4 inch	4 inch	4 inch	4 inch
Pump field history	5 years	3 years	2 years	2 years	16 years
Rebuild interval/cost					up to 20 yr/new pump
Recommended pipe	1/2" or 3/4" poly	3/4" poly			2" PVC
Recommended wire	10-2 pump cable		12-2/G pump cable	12-2/G pump cable	8-3/G pump cable
Power Supply					
# modules/PV array size	2/150 watts	4/280 watts	6/420 watts	6/384 watts	8/512 watts
PV make/model	Siemens SM75	Siemens SM70	Based on Availability	Solarex MSX 64	Solarex MSX-64
PV warranty	10 years	10 years	variable	20 years	20 years
PV field history	10 years	4 years	variable	9 years	9 years
Array mount	Zomeworks tracker	fixed/pole	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Atersa M5	Sunprimer Mk-1/b	Solarjack PCA 8-60	Solarjack PCA 8-60	Grundfos SA-1500
Back-up power option	12 or 24V battery	12 or 24V battery	45V batteries		optional gen. interface
Supplier					
Supplier name	Solar Electric Spec.	Solar Electric Spec.	Photocomm	Direct Power & Water	Applied Power
PV pump experience	16 years	16 years	15 years	5 years	12 years
System warranty	2 years	2 years	2 years	2 years	2 years
Est. lead time to ship	1-2 weeks	1-2 weeks	24 hours	2 days	1-2 weeks
Estimated ship weight	93 lb	152 lb	240 lb		277 lb
Price					
Controller Price			$241		$1,525
Pump Price	$550	$1,628	$1,484	$1,678	$1,063
System Price	**$2,116**	**$4,055**	**$5,158**	**$5,174**	**$6,450**

Chart 2: Pumping System Comparisons — Node B150 (150 ft., 1000 GPD)

System ID	PSN-SES10-P	PSN-PC15-P	PSN-DP44-P	PSN-AP33-P
Est. GPD/Max. GPM	1220/2.9	1262/3.1	1046/2.6	1585/9.2
Pump				
Pump type	Sealed piston	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	Sunrise	SolarJack	SolarJack	Grundfos
Pump model	5218	SCS 3-150	SCS 4-325	SP3A-10
Minimum well casing	4 inch	4 inch	4 inch	4 inch
Pump field history	3 years	2 years	2 years	16 years
Rebuild interval/cost				up to 20 yr/new pump
Recommended pipe	3/4" poly			2" PVC
Recommended wire		10-2/G pump cable	10-2/G pump cable	8-3/G pump cable
Power Supply				
# modules/PV array size	4/280 watts	6/480 watts	8/448 watts	14/700 watts
PV make/model	Siemens SM70	Based on Availability	Solarex MSX 56	ASE-50-AL
PV warranty	10 years	variable	20 years	10 years
PV field history	4 years	variable	9 years	2 years
Array mount	fixed/pole	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Sunprimer Mk-1/b	Solarjack PCA 8-60	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	12 or 24V battery	45V batteries		optional gen. interface
Supplier				
Supplier name	Solar Electric Spec.	Photocomm	Direct Power & Water	Applied Power
PV pump experience	16 years	15 years	5 years	12 years
System warranty	2 years	2 years	2 years	2 years
Est. lead time to ship	1-2 weeks	24 hours	2 days	48 hours
Estimated ship weight	152 lb	260 lb		360 lb
Price				
Controller Price		$241		$1,525
Pump Price	$1,628	$1,484	$1,898	$1,063
System Price	**$4,055**	**$5,365**	**$5,804**	**$8,009**

Node B150 (150 ft., 1000 GPD)

Chart 2: Pumping System Comparisons — Node B200 (200 ft., 1000 GPD)

System ID	PSN-SES6-P	PSN-PC16-P	PSN-DP52-P	PSN-AP34-P
Est. GPD/Max. GPM	1060/2.7	1120/2.4	1070/2.8	1057/6.6
Pump				
Pump type	Sealed piston	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	Sunrise	SolarJack	SolarJack	Grundfos
Pump model	5226	SCS 3-200	SCS 4-325	SP2A-15
Minimum well casing	4 inch	4 inch	4 inch	4 inch
Pump field history	3 years	2 years	2 years	16 years
Rebuild interval/cost				up to 20 yr/new pump
Recommended pipe	3/4" poly			2" PVC
Recommended wire		10-2/G pump cable	10-2/G pump cable	8-3/G pump cable
Power Supply				
# modules/PV array size	4/280 watts	6/480 watts	8/616 watts	14/700 watts
PV make/model	Siemens SM70	Based on Availability	Solarex MSX 77	ASE-50-AL
PV warranty	10 years	variable	20 years	10 years
PV field history	4 years	variable	9 years	2 years
Array mount	Zomeworks tracker	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Sunprimer Mk-1/b	Solarjack PCA 8-60	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	12 or 24V battery	45V batteries		optional gen. interface
Supplier				
Supplier name	Solar Electric Spec.	Photocomm	Direct Power & Water	Applied Power
PV pump experience	16 years	15 years	5 years	12 years
System warranty	2 years	2 years	2 years	2 years
Est. lead time to ship	1-2 weeks	24 hours	2 days	48 hours
Estimated ship weight	152 lb	260 lb		360 lb
Price				
Controller Price		$241		$1,525
Pump Price	$1,628	$1,484	$1,898	$1,180
System Price	**$4,440**	**$5,365**	**$6,701**	**$8,127**

Chart 2: Pumping System Comparisons

Node B250 (250 ft., 1000 GPD)

System ID	PSN-PC17-P	PSN-DP56-P	PSN-AP25-P
Est. GPD/Max. GPM	1295/3.2	1189/3.1	1440/6
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 4-325	SCS 4-325	SP1.5A-21
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	8-2/G pump cable	8-2/G pump cable	6-3/G pump cable
Power Supply			
# modules/PV array size	6/720 watts	12/672 watts	16/1024 watts
PV make/model	Based on Availability	Solarex MSX 56	Solarex MSX-64
PV warranty	variable	20 years	20 years
PV field history	variable	9 years	9 years
Array mount	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	90V batteries		optional gen. interface
Supplier			
Supplier name	Photocomm	Direct Power & Water	Applied Power
PV pump experience	15 years	5 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	1-2 weeks
Estimated ship weight	500 lb		430 lb
Price			
Controller Price	$351		$1,525
Pump Price	$1,726	$1,898	$1,398
System Price	$7,318	$7,482	$10,536

Node B250 (250 ft., 1000 GPD)

Chart 2: Pumping System Comparisons

Node B300 (300 ft, 1000 GPD)

System ID	PSN-PC18-P	PSN-DP58-P	PSN-AP09-P
Est. GPD/Max. GPM	1139/2.9	1220/3.1	1614/7.7
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 4-325	SCS 4-325	SP2A-15
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	8-2/G pump cable	8-2/G pump cable	6-3/G pump cable
Power Supply			
# modules/PV array size	14/840 watts	16/896 watts	24/1200 watts
PV make/model	Based on Availability	Solarex MSX 56	ASE-50-AL
PV warranty	variable	20 years	10 years
PV field history	variable	9 years	2 years
Array mount	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	105V batteries		optional gen. interface
Supplier			
Supplier name	Photocomm	Direct Power & Water	Applied Power
PV pump experience	15 years	5 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	48 hours
Estimated ship weight	500 lb		555 lb
Price			
Controller Price	$351		$1,525
Pump Price	$1,726	$1,898	$1,180
System Price	**$8,161**	**$9,382**	**$11,727**

Node B300 (300 ft, 1000 GPD)

Chart 2: Pumping System Comparisons — Node C25 (25 ft., 1500 GPD)

System ID	PSN-PC19-P	PSN-DP60-P	PSN-AP01-P	PSN-SES10-P
Est. GPD/Max. GPM	1611/3.5	1622/3	1803/6.1	1880/3.6
Pump				
Pump type	Diaphragm	Diaphragm	Centrifugal	Sealed piston
Pump manufacturer	SolarJack	SolarJack	Grundfos	Sunrise
Pump model	SDS-Q-128	SDS-Q-128	SP1.5A-3	5218
Minimum well casing	4.5 inch	4.5 inch	4 inch	4 inch
Pump field history	7 years	7 years	2 years	3 years
Rebuild interval/cost			up to 20 yr/new pump	
Recommended pipe	3/4" poly	3/4" poly	1 1/4" PVC	3/4" poly
Recommended wire	12-2/G pump cable	12-2/G pump cable	10-3/G pump cable	
Power Supply				
# modules/PV array size	2/100 watts	2/100 watts	3/150 watts	4/280 watts
PV make/model	Based on Availability	Solarex MSX 50	ASE-50-AL	Siemens SM70
PV warranty	variable	20 years	10 years	10 years
PV field history	variable	9 years	2 years	4 years
Array mount	fixed/pole	fixed/pole	fixed/pole	fixed/pole
Controller make/model	Solarjack PCA 10-30A	Solarjack PCA 10-30	Grundfos SA400	Sunprimer Mk-1/b
Back-up power option	24V batteries		none	12 or 24V battery
Supplier				
Supplier name	Photocomm	Direct Power & Water	Applied Power	Solar Electric Spec.
PV pump experience	15 years	5 years	12 years	16 years
System warranty	2 years	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	48 hours	1-2 weeks
Estimated ship weight	80 lb		100 lb	152 lb
Price				
Controller Price	$165		$738	
Pump Price	$572	$710	$660	$1,628
System Price	**$1,485**	**$1,815**	**$2,642**	**$4,055**

Chart 2: Pumping System Comparisons — Node C50 (50 ft., 1500 GPD)

System ID	PSN-PC20-P	PSN-DP61-P	PSN-AP11-P	PSN-SES10-P
Est. GPD/Max. GPM	1610/3.2	1546/3	1834/7.7	1770/3.4
Pump				
Pump type	Diaphragm	Diaphragm	Centrifugal	Sealed piston
Pump manufacturer	SolarJack	SolarJack	Grundfos	Sunrise
Pump model	SDS-Q-128	SDS-Q-128	SP3A-3	5218
Minimum well casing	4.5 inch	4.5 inch	4 inch	4 inch
Pump field history	7 years	7 years	2 years	3 years
Rebuild interval/cost			up to 20 yr/new pump	
Recommended pipe	3/4" poly	3/4" poly	1 1/4" PVC	3/4" poly
Recommended wire	12-2/G pump cable	12-2/G pump cable	10-3/G pump cable	
Power Supply				
# modules/PV array size	2/160 watts	2/112 watts	5/250 watts	4/280 watts
PV make/model	Based on Availability	Solarex MSX 56	ASE-50-AL	Siemens SM70
PV warranty	variable	20 years	10 years	10 years
PV field history	variable	9 years	2 years	4 years
Array mount	fixed/pole	fixed/pole	fixed/pole	fixed/pole
Controller make/model	Solarjack PCA 10-30A	Solarjack PCA 10-30	Grundfos SA400	Sunprimer Mk-1/b
Back-up power option	24V batteries		none	12 or 24V battery
Supplier				
Supplier name	Photocomm	Direct Power & Water	Applied Power	Solar Electric Spec.
PV pump experience	15 years	5 years	12 years	16 years
System warranty	2 years	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	48 hours	1-2 weeks
Estimated ship weight	120 lb		150 lb	152 lb
Price				
Controller Price	$165		$738	
Pump Price	$572	$710	$660	$1,628
System Price	$1,854	$1,863	$3,480	$4,055

Chart 2: Pumping System Comparisons

Node C75 (75 ft., 1500 GPD)

System ID	PSN-PC21-P	PSN-AP14-P	PSN-SES10-P
Est. GPD/Max. GPM	1469/3	1585/9.7	1700/3.3
Pump			
Pump type	Diaphragm	Centrifugal	Sealed piston
Pump manufacturer	SolarJack	Grundfos	Sunrise
Pump model	SDS-Q-128	SP2A-4	5218
Minimum well casing	4.5 inch	4 inch	4 inch
Pump field history	7 years	2 years	3 years
Rebuild interval/cost		up to 20 yr/new pump	
Recommended pipe	3/4" poly	1 1/4" PVC	3/4" poly
Recommended wire	12-2/G pump cable	10-3/G pump cable	
Power Supply			
# modules/PV array size	4/200 watts	6/300 watts	4/280 watts
PV make/model	Based on Availability	ASE-50-AL	Siemens SM70
PV warranty	variable	10 years	10 years
PV field history	variable	2 years	4 years
Array mount	fixed/pole	fixed/pole	fixed/pole
Controller make/model	Solarjack PCA 10-30A	Grundfos SA400	Sunprimer Mk-1/b
Back-up power option	24V batteries	none	12 or 24V battery
Supplier			
Supplier name	Photocomm	Applied Power	Solar Electric Spec.
PV pump experience	15 years	12 years	16 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	48 hours	1-2 weeks
Estimated ship weight	140 lb	161 lb	152 lb
Price			
Controller Price	$165	$738	
Pump Price	$572	$660	$1,628
System Price	**$2,072**	**$3,802**	**$4,055**

Node C75 (75 ft., 1500 GPD)

Chart 2: Pumping System Comparisons — Node C100 (100 ft., 1500 GPD)

System ID	PSN-DP62-P	PSN-PC22-P	PSN-SES10-P	PSN-AP31-P
Est. GPD/Max. GPM	1254/2.8	1673/2.8	1550/3.2	1585/7.5
Pump				
Pump type	Diaphragm	Diaphragm	Sealed piston	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Sunrise	Grundfos
Pump model	SDS-Q-128	SDS-Q-128	5218	SP5A-7
Minimum well casing	4.5 inch	4.5 inch	4 inch	4 inch
Pump field history	7 years	7 years	3 years	16 years
Rebuild interval/cost				up to 20 yr/new pump
Recommended pipe	3/4" poly	3/4" poly	3/4" poly	2" PVC
Recommended wire	12-2/G pump cable	12-2/G pump cable		8-3/G pump cable
Power Supply				
# modules/PV array size	2/166 watts	4/200 watts	4/280 watts	8/512 watts
PV make/model	Solarex MSX 83	Based on Availability	Siemens SM70	Solarex MSX-64
PV warranty	20 years	variable	10 years	20 years
PV field history	9 years	variable	4 years	9 years
Array mount	fixed/pole	Zomeworks tracker	fixed/pole	fixed/pole
Controller make/model	Solarjack PCA 10-30	Solarjack PCA 10-30A	Sunprimer Mk-1/b	Grundfos SA-1500
Back-up power option		24V batteries	12 or 24V battery	optional gen. interface
Supplier				
Supplier name	Direct Power & Water	Photocomm	Solar Electric Spec.	Applied Power
PV pump experience	5 years	15 years	16 years	12 years
System warranty	2 years	2 years	2 years	2 years
Est. lead time to ship	2 days	24 hours	1-2 weeks	1-2 weeks
Estimated ship weight		140 lb	152 lb	227 lb
Price				
Controller Price		$165		$1,525
Pump Price	$710	$572	$1,628	$1,099
System Price	**$2,193**	**$2,453**	**$4,055**	**$6,487**

Node C100 (100 ft., 1500 GPD)

Chart 2: Pumping System Comparisons — Node C125 (125 ft., 1500 GPD)

System ID	PSN-PC23-P	PSN-AP33-P
Est. GPD/Max. GPM	1740/3.5	2378/12.8
Pump		
Pump type	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	Grundfos
Pump model	SCS 3-200	SP3A-10
Minimum well casing	4 inch	4 inch
Pump field history	2 years	16 years
Rebuild interval/cost		up to 20 yr/new pump
Recommended pipe		2" PVC
Recommended wire	12-2/G pump cable	8-3/G pump cable
Power Supply		
# modules/PV array size	6/480 watts	14/700 watts
PV make/model	Based on Availability	ASE-50-AL
PV warranty	variable	10 years
PV field history	variable	2 years
Array mount	Zomeworks tracker	fixed/pole
Controller make/model	Solarjack PCA 8-60	Grundfos SA-1500
Back-up power option	45V batteries	optional gen. interface
Supplier		
Supplier name	Photocomm	Applied Power
PV pump experience	15 years	12 years
System warranty	2 years	2 years
Est. lead time to ship	24 hours	48 hours
Estimated ship weight	200 lb	360 lb
Price		
Controller Price	$241	$1,525
Pump Price	$1,484	$1,063
System Price	$5,365	$8,009

Node C125 (125 ft., 1500 GPD)

Chart 2: Pumping System Comparisons — Node C150 (150 ft., 1500 GPD)

System ID	PSN-PC24-P	PSN-AP33-P
Est. GPD/Max. GPM	1783/3.7	1500/9
Pump		
Pump type	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	Grundfos
Pump model	SCS 3-200	SP3A-10
Minimum well casing	4 inch	4 inch
Pump field history	2 years	16 years
Rebuild interval/cost		up to 20 yr/new pump
Recommended pipe		2" PVC
Recommended wire	10-2/G pump cable	8-3/G pump cable
Power Supply		
# modules/PV array size	6/540 watts	14/700 watts
PV make/model	Based on Availability	ASE-50-AL
PV warranty	variable	10 years
PV field history	variable	2 years
Array mount	Zomeworks tracker	fixed/pole
Controller make/model	Solarjack PCA 8-60	Grundfos SA-1500
Back-up power option	45V batteries	optional gen. interface
Supplier		
Supplier name	Photocomm	Applied Power
PV pump experience	15 years	12 years
System warranty	2 years	2 years
Est. lead time to ship	24 hours	48 hours
Estimated ship weight	250 lb	360 lb
Price		
Controller Price	$241	$1,525
Pump Price	$1,484	$1,063
System Price	**$5,728**	**$8,009**

Chart 2: Pumping System Comparisons — Node C200 (200 ft., 1500 GPD)

System ID	PSN-PC25-P	PSN-AP42-P
Est. GPD/Max. GPM	1595/3.3	1500/6.8
Pump		
Pump type	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	Grundfos
Pump model	SCS 3-200	SP2A-15
Minimum well casing	4 inch	4 inch
Pump field history	2 years	16 years
Rebuild interval/cost		up to 20 yr/new pump
Recommended pipe		2" PVC
Recommended wire	10-2/G pump cable	6-3/G pump cable
Power Supply		
# modules/PV array size	12/600 watts	14/840 watts
PV make/model	Based on Availability	Solarex MSX-60
PV warranty	variable	20 years
PV field history	variable	9 years
Array mount	Zomeworks tracker	fixed/pole
Controller make/model	Solarjack PCA 8-60	Grundfos SA-1500
Back-up power option	45V batteries	optional gen. interface
Supplier		
Supplier name	Photocomm	Applied Power
PV pump experience	15 years	12 years
System warranty	2 years	2 years
Est. lead time to ship	24 hours	1-2 weeks
Estimated ship weight	300 lb	394 lb
Price		
Controller Price	$241	$1,525
Pump Price	$1,484	$1,180
System Price	$6,344	$8,952

Node C200 (200 ft., 1500 GPD)

Chart 2: Pumping System Comparisons — Node C250 (250 ft., 1500 GPD)

System ID	PSN-PC26-P	PSN-AP36-P
Est. GPD/Max. GPM	1655/3.6	1510/6.6
Pump		
Pump type	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	Grundfos
Pump model	SCS 4-325	SP2A-15
Minimum well casing	4 inch	4 inch
Pump field history	2 years	16 years
Rebuild interval/cost		up to 20 yr/new pump
Recommended pipe		2" PVC
Recommended wire	8-2/G pump cable	6-3/G pump cable
Power Supply		
# modules/PV array size	12/840 watts	16/1024 watts
PV make/model	Based on Availability	Solarex MSX-64
PV warranty	variable	20 years
PV field history	variable	9 years
Array mount	Zomeworks tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	90V batteries	optional gen. interface
Supplier		
Supplier name	Photocomm	Applied Power
PV pump experience	15 years	12 years
System warranty	2 years	2 years
Est. lead time to ship	24 hours	1-2 weeks
Estimated ship weight	400 lb	430 lb
Price		
Controller Price	$351	$1,525
Pump Price	$1,726	$1,180
System Price	**$8,510**	**$10,318**

Chart 2: Pumping System Comparisons

Node C300 (300 ft, 1500 GPD)

System ID	PSN-PC27-P	PSN-AP35-P
Est. GPD/Max. GPM	1770/4	1500/7.7
Pump		
Pump type	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	Grundfos
Pump model	SCS 4-325	SP2A-15
Minimum well casing	4 inch	4 inch
Pump field history	2 years	16 years
Rebuild interval/cost		up to 20 yr/new pump
Recommended pipe		2" PVC
Recommended wire	8-2/G pump cable	6-3/G pump cable
Power Supply		
# modules/PV array size	16/1120 watts	16/1328 watts
PV make/model	Based on Availability	Solarex MSX-83
PV warranty	variable	20 years
PV field history	variable	9 years
Array mount	Zomeworks tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	120V batteries	optional gen. interface
Supplier		
Supplier name	Photocomm	Applied Power
PV pump experience	15 years	12 years
System warranty	2 years	2 years
Est. lead time to ship	24 hours	1-2 weeks
Estimated ship weight	600 lb	510 lb
Price		
Controller Price	$351	$1,525
Pump Price	$1,726	$1,180
System Price	$11,223	$12,839

Chart 2: Pumping System Comparisons — Node D25 (25 ft., 2000 GPD)

System ID	PSN-PC28-P	PSN-DP07-P	PSN-DP08-P	PSN-AP10-P	PSN-SES7-P
Est. GPD/Max. GPM	2320/3.5	2260/3.5	2605/5.1	3192/12	2305/6.6
Pump					
Pump type	Diaphragm	Diaphragm	Centrifugal	Centrifugal	Sealed piston
Pump manufacturer	SolarJack	SolarJack	SolarJack	Grundfos	Sunrise
Pump model	SDS-Q-128	SDS-Q-128	SCS 14-70	SP3A-2	5230
Minimum well casing	4.5 inch	4.5 inch	4 inch	4 inch	4 inch
Pump field history	7 years	7 years	2 years	2 years	3 years
Rebuild interval/cost				up to 20 yr/new pump	
Recommended pipe	3/4" poly	3/4" poly		1 1/4" PVC	3/4" poly
Recommended wire	12-2/G pump cable	12-2/G pump cable	12-2/G pump cable	10-3/G pump cable	
Power Supply					
# modules/PV array size	2/120 watts	2/112 watts	2/112 watts	4/200 watts	4/300 watts
PV make/model	Based on Availability	Solarex MSX 56	Solarex MSX 56	ASE-50-AL	Siemens SM75
PV warranty	variable	20 years	20 years	10 years	10 years
PV field history	variable	9 years	9 years	2 years	4 years
Array mount	Zomeworks tracker	Wattsun tracker	Wattsun tracker	fixed/pole	fixed/pole
Controller make/model	Solarjack PCA 10-30A	Solarjack PCA 10-30	Solarjack PCA 8-60	Grundfos SA400	Sunprimer Mk-1/b
Back-up power option	24V batteries			none	12 or 24V battery
Supplier					
Supplier name	Photocomm	Direct Power & Water	Direct Power & Water	Applied Power	Solar Electric Spec.
PV pump experience	15 years	5 years	5 years	12 years	16 years
System warranty	2 years	2 years	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	2 days	48 hours	1-2 weeks
Estimated ship weight	100 lb			132 lb	152 lb
Price					
Controller Price	$165			$738	
Pump Price	$572	$710	$1,568	$660	$1,892
System Price	**$1,902**	**$1,956**	**$2,833**	**$2,961**	**$4,450**

Chart 2: Pumping System Comparisons

Node D50 (50 ft., 2000 GPD)

System ID	PSN-DP18-P	PSN-PC29-P	PSN-AP11-P
Est. GPD/Max. GPM	2109/3.2	2132/3.2	1834/7.7
Pump			
Pump type	Diaphragm	Diaphragm	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SDS-Q-128	SDS-Q-128	SP3A-3
Minimum well casing	4.5 inch	4.5 inch	4 inch
Pump field history	7 years	7 years	2 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe	3/4" poly	3/4" poly	1 1/4" PVC
Recommended wire	12-2/G pump cable	12-2/G pump cable	10-3/G pump cable
Power Supply			
# modules/PV array size	2/154 watts	2/160 watts	5/250 watts
PV make/model	Solarex MSX 77	Based on Availability	ASE-50-AL
PV warranty	20 years	variable	10 years
PV field history	9 years	variable	2 years
Array mount	Wattsun tracker	Zomeworks tracker	fixed/pole
Controller make/model	Solarjack PCA 10-30	Solarjack PCA 10-30A	Grundfos SA400
Back-up power option		24V batteries	none
Supplier			
Supplier name	Direct Power & Water	Photocomm	Applied Power
PV pump experience	5 years	15 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	2 days	24 hours	48 hours
Estimated ship weight		120 lb	150 lb
Price			
Controller Price		$165	$738
Pump Price	$710	$572	$660
System Price	$2,112	$2,116	$3,480

Node D50 (50 ft., 2000 GPD)

Chart 2: Pumping System Comparisons — Node D75 (75 ft., 2000 GPD)

System ID	PSN-DP25-P	PSN-AP05-P	PSN-SES8-P	PSN-PC30-P
Est. GPD/Max. GPM	2160/3	1443/4.6	2065/5.5	2183/4.1
Pump				
Pump type	Diaphragm	Centrifugal	Sealed piston	Centrifugal
Pump manufacturer	SolarJack	Grundfos	Sunrise	SolarJack
Pump model	SDS-Q-128	SP1A-9	5230	SCS 4-110
Minimum well casing	4.5 inch	4 inch	4 inch	4 inch
Pump field history	7 years	2 years	3 years	2 years
Rebuild interval/cost		up to 20 yr/new pump		
Recommended pipe	3/4" poly	1 1/4" PVC	3/4" poly	
Recommended wire	12-2/G pump cable	10-3/G pump cable		12-2/G pump cable
Power Supply				
# modules/PV array size	4/308 watts	6/300 watts	4/300 watts	6/384 watts
PV make/model	Solarex MSX 77	ASE-50-AL	Siemens SM75	Based on Availability
PV warranty	20 years	10 years	10 years	variable
PV field history	9 years	2 years	4 years	variable
Array mount	Wattsun tracker	fixed/pole	Zomeworks tracker	Zomeworks tracker
Controller make/model	Solarjack PCB 8-120	Grundfos SA400	Sunprimer Mk-1/b	Solarjack PCA 8-60
Back-up power option		none	12 or 24V battery	45V batteries
Supplier				
Supplier name	Direct Power & Water	Applied Power	Solar Electric Spec.	Photocomm
PV pump experience	5 years	12 years	16 years	15 years
System warranty	2 years	2 years	2 years	2 years
Est. lead time to ship	2 days	48 hours	1-2 weeks	24 hours
Estimated ship weight		161 lb	152 lb	200 lb
Price				
Controller Price		$738		$241
Pump Price	$710	$660	$1,892	$1,484
System Price	$3,399	$3,802	$4,775	$5,155

Chart 2: Pumping System Comparisons — Node D100 (100 ft., 2000 GPD)

System ID	PSN-SES6-P	PSN-PC31-P	PSN-DP33-P	PSN-AP38-P
Est. GPD/Max. GPM	2000/3.2	2237/5	2740/6.13	3434/13.7
Pump				
Pump type	Sealed piston	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	Sunrise	SolarJack	SolarJack	Grundfos
Pump model	5226	SCS 5-115	SCS 8-90	SP5A-7
Minimum well casing	4 inch	4 inch	4 inch	4 inch
Pump field history	3 years	2 years	2 years	16 years
Rebuild interval/cost				up to 20 yr/new pump
Recommended pipe	3/4" poly			2" PVC
Recommended wire		12-2/G pump cable	12-2/G pump cable	8-3/G pump cable
Power Supply				
# modules/PV array size	4/280 watts	6/480 watts	6/462 watts	14/700 watts
PV make/model	Siemens SM70	Based on Availability	Solarex MSX 77	ASE-50-AL
PV warranty	10 years	variable	20 years	10 years
PV field history	4 years	variable	9 years	2 years
Array mount	Zomeworks tracker	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Sunprimer Mk-1/b	Solarjack PCA 8-60	Solarjack PCA 8-60	Grundfos SA-1500
Back-up power option	12 or 24V battery	45V batteries		optional gen. interface
Supplier				
Supplier name	Solar Electric Spec.	Photocomm	Direct Power & Water	Applied Power
PV pump experience	16 years	15 years	5 years	12 years
System warranty	2 years	2 years	2 years	2 years
Est. lead time to ship	1-2 weeks	24 hours	2 days	48 hours
Estimated ship weight	152 lb	230 lb		360 lb
Price				
Controller Price		$241		$1,525
Pump Price	$1,628	$1,484	$1,865	$1,099
System Price	$4,440	$5,365	$5,705	$8,045

Node D100 (100 ft., 2000 GPD)

Chart 2: Pumping System Comparisons — Node D125 (125 ft., 2000 GPD)

System ID	PSN-PC32-P	PSN-DP41-P	PSN-AP33-P
Est. GPD/Max. GPM	2173/4.8	2466/7	2378/11
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 4-140	SCS 8-185	SP3A-10
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	12-2/G pump cable	12-2/G pump cable	8-3/G pump cable
Power Supply			
# modules/PV array size	6/540 watts	10/600 watts	14/700 watts
PV make/model	Based on Availability	Solarex MSX 60	ASE-50-AL
PV warranty	variable	20 years	10 years
PV field history	variable	9 years	2 years
Array mount	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCA 8-60	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	45V batteries		optional gen. interface
Supplier			
Supplier name	Photocomm	Direct Power & Water	Applied Power
PV pump experience	15 years	5 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	48 hours
Estimated ship weight	280 lb		360 lb
Price			
Controller Price	$241		$1,525
Pump Price	$1,484	$1,700	$1,063
System Price	**$5,728**	**$6,809**	**$8,009**

Node D125 (125 ft., 2000 GPD)

Chart 2: Pumping System Comparisons — Node D150 (150 ft., 2000 GPD)

System ID	PSN-PC33-P	PSN-DP45-P	PSN-AP06-P
Est. GPD/Max. GPM	2303/5.1	2703/7.9	2202/11
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 5-250	SCS 11-210	SP3A-10
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	10-2/G pump cable	10-2/G pump cable	8-3/G pump cable
Power Supply			
# modules/PV array size	6/720 watts	12/672 watts	16/800 watts
PV make/model	Based on Availability	Solarex MSX 56	ASE-50-AL
PV warranty	variable	20 years	10 years
PV field history	variable	9 years	2 years
Array mount	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	90V batteries		optional gen. interface
Supplier			
Supplier name	Photocomm	Direct Power & Water	Applied Power
PV pump experience	15 years	5 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	48 hours
Estimated ship weight	350 lb		396 lb
Price			
Controller Price	$351		$1,525
Pump Price	$1,484	$1,975	$1,063
System Price	$7,076	$7,272	$8,639

Node D150 (150 ft., 2000 GPD)

Chart 2: Pumping System Comparisons

Node D200 (200 ft., 2000 GPD)

System ID	PSN-PC34-P	PSN-DP53-P	PSN-AP37-P
Est. GPD/Max. GPM	2254/4.9	2397/4.6	2140/9.5
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 5-250	SCS 4-325	SP2A-15
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	10-2/G pump cable	10-2/G pump cable	6-3/G pump cable
Power Supply			
# modules/PV array size	12/960 watts	12/924 watts	21/1050 watts
PV make/model	Based on Availability	Solarex MSX 77	ASE-50-AL
PV warranty	variable	20 years	10 years
PV field history	variable	9 years	2 years
Array mount	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	90V batteries		optional gen. interface
Supplier			
Supplier name	Photocomm	Direct Power & Water	Applied Power
PV pump experience	15 years	5 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	48 hours
Estimated ship weight	420 lb		508 lb
Price			
Controller Price	$351		$1,525
Pump Price	$1,484	$2,030	$1,180
System Price	**$8,726**	**$9,247**	**$10,769**

Chart 2: Pumping System Comparisons

Node D250 (250 ft, 2000 GPD)

System ID	PSN-PC35-P	PSN-DP57-P	PSN-AP09-P
Est. GPD/Max. GPM	2409/4.9	2666/5.2	2184/8.6
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 4-325	SCS 4-325	SP2A-15
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	8-2/G pump cable	8-2/G pump cable	6-3/G pump cable
Power Supply			
# modules/PV array size	14/1120 watts	16/1232 watts	24/1200 watts
PV make/model	Based on Availability	Solarex MSX 77	ASE-50-AL
PV warranty	variable	20 years	10 years
PV field history	variable	9 years	2 years
Array mount	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	105V batteries		optional gen. interface
Supplier			
Supplier name	Photocomm	Direct Power & Water	Applied Power
PV pump experience	15 years	5 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	48 hours
Estimated ship weight	550 lb		555 lb
Price			
Controller Price	$351		$1,525
Pump Price	$1,726	$1,920	$1,180
System Price	**$10,100**	**$10,714**	**$11,727**

Node D250 (250 ft, 2000 GPD)

Chart 2: Pumping System Comparisons

Node D300 (300 ft, 2000 GPD)

System ID	PSN-DP59-P	PSN-PC36-P	PSN-AP13-P
Est. GPD/Max. GPM	2240/5.2	2282/4.9	2783/9.7
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 4-325	SCS 4-325	SP2A-15
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	8-2/G pump cable	8-2/G pump cable	6-3/G pump cable
Power Supply			
# modules/PV array size	16/1232 watts	16/1280 watts	32/1600 watts
PV make/model	Solarex MSX 77	Based on Availability	ASE-50-AL
PV warranty	20 years	variable	10 years
PV field history	9 years	variable	2 years
Array mount	Wattsun tracker	Zomeworks tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option		120V batteries	optional gen. interface
Supplier			
Supplier name	Direct Power & Water	Photocomm	Applied Power
PV pump experience	5 years	15 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	2 days	24 hours	48 hours
Estimated ship weight		600 lb	1722 lb
Price			
Controller Price		$351	$1,525
Pump Price	$1,920	$1,726	$1,180
System Price	**$11,146**	**$11,223**	**$14,697**

Chart 2: Pumping System Comparisons

Node E25 (25 ft., 3000 GPD)

System ID	PSN-PC37-P	PSN-AP10-P	PSN-DP09-P
Est. GPD/Max. GPM	3250/5.8	3192/12	3780/8
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	Grundfos	SolarJack
Pump model	SCS 8-90	SP3A-2	SCS 14-70
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	2 years
Rebuild interval/cost		up to 20 yr/new pump	
Recommended pipe		1 1/4" PVC	
Recommended wire	12-2/G pump cable	10-3/G pump cable	12-2/G pump cable
Power Supply			
# modules/PV array size	2/160 watts	4/200 watts	2/154 watts
PV make/model	Based on Availability	ASE-50-AL	Solarex MSX 77
PV warranty	variable	10 years	20 years
PV field history	variable	2 years	9 years
Array mount	Zomeworks tracker	fixed/pole	Wattsun tracker
Controller make/model	Solarjack PCA 8-60	Grundfos SA400	Solarjack PCA 8-60
Back-up power option	30V batteries	none	
Supplier			
Supplier name	Photocomm	Applied Power	Direct Power & Water
PV pump experience	15 years	12 years	5 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	48 hours	2 days
Estimated ship weight	140 lb	132 lb	
Price			
Controller Price	$241	$738	
Pump Price	$572	$660	$1,645
System Price	**$2,116**	**$2,961**	**$3,101**

Node E25 (25 ft., 3000 GPD)

Chart 2: Pumping System Comparisons — Node E50 (50 ft., 3000 GPD)

System ID	PSN-AP14-P	PSN-PC38-P	PSN-DP20-P
Est. GPD/Max. GPM	3024/9.7	3462/7.1	3600/7.6
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	Grundfos	SolarJack	SolarJack
Pump model	SP2A-4	SCS 8-90	SCS 8-90
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	2 years
Rebuild interval/cost	up to 20 yr/new pump		
Recommended pipe	1 1/4" PVC		
Recommended wire	10-3/G pump cable	12-2/G pump cable	12-2/G pump cable
Power Supply			
# modules/PV array size	6/300 watts	6/300 watts	4/308 watts
PV make/model	ASE-50-AL	Based on Availability	Solarex MSX 77
PV warranty	10 years	variable	20 years
PV field history	2 years	variable	9 years
Array mount	fixed/pole	Zomeworks tracker	Wattsun tracker
Controller make/model	Grundfos SA400	Solarjack PCA 8-60	Solarjack PCA 8-60
Back-up power option	none	30V batteries	
Supplier			
Supplier name	Applied Power	Photocomm	Direct Power & Water
PV pump experience	12 years	15 years	5 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	48 hours	24 hours	2 days
Estimated ship weight	161 lb	180 lb	
Price			
Controller Price	$738	$241	
Pump Price	$660	$1,385	$1,755
System Price	$3,802	$4,136	$4,373

Chart 2: Pumping System Comparisons

Node E75 (75 ft., 3000 GPD)

System ID	PSN-PC39-P	PSN-DP26-P	PSN-AP32-P
Est. GPD/Max. GPM	3504/8	3480/12.4	3060/17.2
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 18-160	SCS 18-160	SP5A-7
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	12-2/G pump cable	12-2/G pump cable	8-3/G pump cable
Power Supply			
# modules/PV array size	8/400 watts	8/512 watts	8/616 watts
PV make/model	Based on Availability	Solarex MSX 64	Solarex MSX-77
PV warranty	variable	20 years	20 years
PV field history	variable	9 years	9 years
Array mount	Zomeworks tracker	fixed/pole	fixed/pole
Controller make/model	Solarjack PCA 8-60	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	60V batteries		optional gen. interface
Supplier			
Supplier name	Photocomm	Direct Power & Water	Applied Power
PV pump experience	15 years	5 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	1-2 weeks
Estimated ship weight	200 lb		266 lb
Price			
Controller Price	$241		$1,525
Pump Price	$1,590	$1,755	$1,099
System Price	**$5,083**	**$5,432**	**$7,747**

Node E75 (75 ft., 3000 GPD)

Chart 2: Pumping System Comparisons

Node E100 (100 ft., 3000 GPD)

System ID	PSN-PC40-P	PSN-DP34-P	PSN-AP38-P
Est. GPD/Max. GPM	3711/7.9	3720/10	3434/13.7
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 10-230	SCS 9-100	SP5A-7
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	10-2/G pump cable	10-2/G pump cable	8-3/G pump cable
Power Supply			
# modules/PV array size	8/480 watts	8/616 watts	14/700 watts
PV make/model	Based on Availability	Solarex MSX 77	ASE-50-AL
PV warranty	variable	20 years	10 years
PV field history	variable	9 years	2 years
Array mount	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCA 8-60	Solarjack PCA 8-60	Grundfos SA-1500
Back-up power option	60V batteries		optional gen. interface
Supplier			
Supplier name	Photocomm	Direct Power & Water	Applied Power
PV pump experience	15 years	5 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	48 hours
Estimated ship weight	220 lb		360 lb
Price			
Controller Price	$241		$1,525
Pump Price	$1,590	$1,865	$1,099
System Price	**$5,470**	**$6,635**	**$8,045**

Node E100 (100 ft., 3000 GPD)

Chart 2: Pumping System Comparisons — Node E125 (125 ft., 3000 GPD)

System ID	PSN-PC41-P	PSN-AP06-P
Est. GPD/Max. GPM	3346/7.5	3275/12.8
Pump		
Pump type	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	Grundfos
Pump model	SCS 10-230	SP3A-10
Minimum well casing	4 inch	4 inch
Pump field history	2 years	16 years
Rebuild interval/cost		up to 20 yr/new pump
Recommended pipe		2" PVC
Recommended wire	10-2/G pump cable	8-3/G pump cable
Power Supply		
# modules/PV array size	8/480 watts	16/800 watts
PV make/model	Based on Availability	ASE-50-AL
PV warranty	variable	10 years
PV field history	variable	2 years
Array mount	Zomeworks tracker	fixed/pole
Controller make/model	Solarjack PCA 8-60	Grundfos SA-1500
Back-up power option	60V batteries	optional gen. interface
Supplier		
Supplier name	Photocomm	Applied Power
PV pump experience	15 years	12 years
System warranty	2 years	2 years
Est. lead time to ship	24 hours	48 hours
Estimated ship weight	250 lb	396 lb
Price		
Controller Price	$241	$1,525
Pump Price	$1,590	$1,063
System Price	**$5,470**	**$8,639**

Chart 2: Pumping System Comparisons — Node E150 (150 ft., 3000 GPD)

System ID	PSN-PC42-P	PSN-DP46-P	PSN-AP27-P
Est. GPD/Max. GPM	3563/7.5	3120/8.7	3220/14.1
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 10-230	SCS 11-210	SP3A-10
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	10-2/G pump cable	10-2/G pump cable	10-3/G pump cable
Power Supply			
# modules/PV array size	10/600 watts	12/720 watts	16/1024 watts
PV make/model	Based on Availability	Solarex MSX 60	Solarex MSX-64
PV warranty	variable	20 years	20 years
PV field history	variable	9 years	9 years
Array mount	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCA 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	75V batteries		optional gen. interface
Supplier			
Supplier name	Photocomm	Direct Power & Water	Applied Power
PV pump experience	15 years	5 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	1-2 weeks
Estimated ship weight	300 lb		430 lb
Price			
Controller Price	$351		$1,525
Pump Price	$1,590	$1,865	$1,063
System Price	**$6,371**	**$7,739**	**$10,200**

Node E150 (150 ft., 3000 GPD)

Chart 2: Pumping System Comparisons

Node E200 (200 ft, 3000 GPD)

System ID	PSN-PC43-P	PSN-DP54-P	PSN-AP09-P
Est. GPD/Max. GPM	3130/7.5	4046/9.3	3116/12.8
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 11-210	SCS 11-210	SP2A-15
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	10-2/G pump cable	10-2/G pump cable	6-3/G pump cable
Power Supply			
# modules/PV array size	12/960 watts	14/896 watts	24/1200 watts
PV make/model	Based on Availability	Solarex MSX 64	ASE-50-AL
PV warranty	variable	20 years	10 years
PV field history	variable	9 years	2 years
Array mount	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCA 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	90V batteries		optional gen. interface
Supplier			
Supplier name	Photocomm	Direct Power & Water	Applied Power
PV pump experience	15 years	5 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	48 hours
Estimated ship weight	400 lb		555 lb
Price			
Controller Price	$351		$1,525
Pump Price	$1,590	$1,865	$1,180
System Price	**$8,832**	**$9,528**	**$11,727**

Node E200 (200 ft, 3000 GPD)

Chart 2: Pumping System Comparisons

Node E250 (250 ft, 3000 GPD)

System ID	PSN-DP49-P	PSN-PC44-P	PSN-AP13-P
Est. GPD/Max. GPM	3240/9.9	3898/8.3	3463/11.2
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 11-210	SCS 10-230	SP2A-15
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	8-2/G pump cable	8-2/G pump cable	6-3/G pump cable
Power Supply			
# modules/PV array size	16/1328 watts	16/1280 watts	32/1600 watts
PV make/model	Solarex MSX 83	Based on Availability	ASE-50-AL
PV warranty	20 years	variable	10 years
PV field history	9 years	variable	2 years
Array mount	Wattsun tracker	Zomeworks tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCA 8-120	Grundfos SA-1500
Back-up power option		120V batteries	optional gen. interface
Supplier			
Supplier name	Direct Power & Water	Photocomm	Applied Power
PV pump experience	5 years	15 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	2 days	24 hours	48 hours
Estimated ship weight		650 lb	1722 lb
Price			
Controller Price		$351	$1,525
Pump Price	$1,975	$1,590	$1,180
System Price	**$11,844**	**$13,329**	**$14,697**

Node E250 (250 ft, 3000 GPD)

Chart 2: Pumping System Comparisons

Node F25 (25 ft., 4000 GPD)

System ID	PSN-AP16-P	PSN-PC45-P	PSN-DP10-P
Est. GPD/Max. GPM	4962/16	4796/8.6	4640/11.3
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	Grundfos	SolarJack	SolarJack
Pump model	SP3A-2	SCS 8-90	SCS 14-70
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	2 years
Rebuild interval/cost	up to 20 yr/new pump		
Recommended pipe	1 1/4" PVC		
Recommended wire	10-3/G pump cable	12-2/G pump cable	12-2/G pump cable
Power Supply			
# modules/PV array size	5/250 watts	2/240 watts	4/224 watts
PV make/model	ASE-50-AL	Based on Availability	Solarex MSX 56
PV warranty	10 years	variable	20 years
PV field history	2 years	variable	9 years
Array mount	fixed/pole	Zomeworks tracker	Wattsun tracker
Controller make/model	Grundfos SA400	Solarjack PCA 8-60	Solarjack PCA 8-60
Back-up power option	none	30V batteries	
Supplier			
Supplier name	Applied Power	Photocomm	Direct Power & Water
PV pump experience	12 years	15 years	5 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	48 hours	24 hours	2 days
Estimated ship weight	150 lb	100 lb	
Price			
Controller Price	$738	$241	
Pump Price	$660	$1,385	$1,678
System Price	**$3,480**	**$3,508**	**$3,872**

Node F25 (25 ft., 4000 GPD)

Chart 2: Pumping System Comparisons

Node F50 (50 ft., 4000 GPD)

System ID	PSN-DP20A-P	PSN-PC46-P	PSN-AP39-P
Est. GPD/Max. GPM	4297/12.6	4675/9.2	3963/15
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 14-70	SCS 8-90	SP5A-7
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	12-2/G pump cable	12-2/G pump cable	8-3/G pump cable
Power Supply			
# modules/PV array size	6/360 watts	6/384 watts	8/400 watts
PV make/model	Solarex MSX 60	Based on Availability	ASE-50-AL
PV warranty	20 years	variable	10 years
PV field history	9 years	variable	2 years
Array mount	Wattsun tracker	Zomeworks tracker	fixed/pole
Controller make/model	Solarjack PCA 8-60	Solarjack PCA 8-60	Grundfos SA-1500
Back-up power option		45V batteries	optional gen. interface
Supplier			
Supplier name	Direct Power & Water	Photocomm	Applied Power
PV pump experience	5 years	15 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	2 days	24 hours	48 hours
Estimated ship weight		200 lb	232 lb
Price			
Controller Price		$241	$1,525
Pump Price	$1,678	$1,385	$1,099
System Price	**$4,733**	**$5,056**	**$5,705**

Node F50 (50 ft., 4000 GPD)

Chart 2: Pumping System Comparisons

Node F75 (75 ft., 4000 GPD)

System ID	PSN-PC47-P	PSN-DP28-P	PSN-AP32-P
Est. GPD/Max. GPM	4855/7.4	4611/10.2	4000/17.2
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 10-230	SCS 18-160	SP5A-7
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	12-2/G pump cable	12-2/G pump cable	8-3/G pump cable
Power Supply			
# modules/PV array size	8/480 watts	8/480 watts	8/616 watts
PV make/model	Based on Availability	Solarex MSX 60	Solarex MSX-77
PV warranty	variable	20 years	20 years
PV field history	variable	9 years	9 years
Array mount	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	60V batteries		optional gen. interface
Supplier			
Supplier name	Photocomm	Direct Power & Water	Applied Power
PV pump experience	15 years	5 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	1-2 weeks
Estimated ship weight	220 lb		266 lb
Price			
Controller Price	$241		$1,525
Pump Price	$1,590	$1,755	$1,099
System Price	**$5,470**	**$6,130**	**$7,747**

Node F75 (75 ft., 4000 GPD)

Chart 2: Pumping System Comparisons

Node F100 (100 ft., 4000 GPD)

System ID	PSN-PC48-P	PSN-DP35-P	PSN-AP12-P
Est. GPD/Max. GPM	4700/9.2	4206/10.3	3940/15.4
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 10-230	SCS 18-160	SP5A-7
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	10-2/G pump cable	10-2/G pump cable	8-3/G pump cable
Power Supply			
# modules/PV array size	10/600 watts	10/600 watts	16/800 watts
PV make/model	Based on Availability	Solarex MSX 60	ASE-50-AL
PV warranty	variable	20 years	10 years
PV field history	variable	9 years	2 years
Array mount	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	75V batteries		optional gen. interface
Supplier			
Supplier name	Photocomm	Direct Power & Water	Applied Power
PV pump experience	15 years	5 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	48 hours
Estimated ship weight	300 lb		396 lb
Price			
Controller Price	$351		$1,525
Pump Price	$1,590	$1,700	$1,099
System Price	**$6,371**	**$6,809**	**$8,676**

Node F100 (100 ft., 4000 GPD)

Chart 2: Pumping System Comparisons — Node F125 (125 ft, 4000 GPD)

System ID	PSN-PC49-P	PSN-DP42-P	PSN-DP30-P	PSN-AP15-P
Est. GPD/Max. GPM	4412/8.7	3343/9.6	4120/13.5	5886/17.6
Pump				
Pump type	Centrifugal	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	SolarJack	Grundfos
Pump model	SCS 10-230	SCS 18-160	SCS 18-160	SP3A-10
Minimum well casing	4 inch	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	2 years	16 years
Rebuild interval/cost				up to 20 yr/new pump
Recommended pipe				2" PVC
Recommended wire	10-2/G pump cable	10-2/G pump cable	10-2/G pump cable	6-3/G pump cable
Power Supply				
# modules/PV array size	10/600 watts	10/770 watts	12/768 watts	24/1200 watts
PV make/model	Based on Availability	Solarex MSX 77	Solarex MSX 64	ASE-50-AL
PV warranty	variable	20 years	20 years	10 years
PV field history	variable	9 years	9 years	2 years
Array mount	Zomeworks tracker	Wattsun tracker	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCB 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	75V batteries			optional gen. interface
Supplier				
Supplier name	Photocomm	Direct Power & Water	Direct Power & Water	Applied Power
PV pump experience	15 years	5 years	5 years	12 years
System warranty	2 years	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	2 days	48 hours
Estimated ship weight	300 lb			555 lb
Price				
Controller Price	$351			$1,525
Pump Price	$1,590	$1,810	$1,645	$1,063
System Price	$6,371	$7,997	$8,131	$11,609

Node F125 (125 ft, 4000 GPD)

Chart 2: Pumping System Comparisons

Node F150 (150 ft, 4000 GPD)

System ID	PSN-PC50-P	PSN-DP47-P	PSN-AP15-P
Est. GPD/Max. GPM	4010/7.6	4320/11.3	4671/16.3
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 10-230	SCS 11-210	SP3A-10
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	10-2/G pump cable	10-2/G pump cable	6-3/G pump cable
Power Supply			
# modules/PV array size	6/720 watts	16/960 watts	24/1200 watts
PV make/model	Based on Availability	Solarex MSX 60	ASE-50-AL
PV warranty	variable	20 years	10 years
PV field history	variable	9 years	2 years
Array mount	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	90V batteries		optional gen. interface
Supplier			
Supplier name	Photocomm	Direct Power & Water	Applied Power
PV pump experience	15 years	5 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	48 hours
Estimated ship weight	340 lb		555 lb
Price			
Controller Price	$351		$1,525
Pump Price	$1,590	$1,865	$1,063
System Price	**$6,371**	**$9,477**	**$11,609**

Node F150 (150 ft, 4000 GPD)

Chart 2: Pumping System Comparisons — Node F200 (200 ft, 4000 GPD)

System ID	PSN-PC51-P	PSN-AP13-P
Est. GPD/Max. GPM	4665/9.5	4441/11.2
Pump		
Pump type	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	Grundfos
Pump model	SCS 10-230	SP2A-15
Minimum well casing	4 inch	4 inch
Pump field history	2 years	16 years
Rebuild interval/cost		up to 20 yr/new pump
Recommended pipe		2" PVC
Recommended wire	8-2/G pump cable	6-3/G pump cable
Power Supply		
# modules/PV array size	14/1120 watts	32/1600 watts
PV make/model	Based on Availability	ASE-50-AL
PV warranty	variable	10 years
PV field history	variable	2 years
Array mount	Zomeworks tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	105V batteries	optional gen. interface
Supplier		
Supplier name	Photocomm	Applied Power
PV pump experience	15 years	12 years
System warranty	2 years	2 years
Est. lead time to ship	24 hours	48 hours
Estimated ship weight	550 lb	1722 lb
Price		
Controller Price	$351	$1,525
Pump Price	$1,590	$1,180
System Price	**$11,087**	**$14,697**

Chart 2: Pumping System Comparisons

Node G25 (25 ft., 6000 GPD)

System ID	PSN-PC52-P	PSN-AP17-P	PSN-DP11-P
Est. GPD/Max. GPM	6260/12.1	6192/19	6360/
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	Grundfos	SolarJack
Pump model	SCS 14-70	SP3A-6	SCS 14-70
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	2 years
Rebuild interval/cost		up to 20 yr/new pump	
Recommended pipe		1 1/4" PVC	
Recommended wire	12-2/G pump cable	10-3/G pump cable	12-2/G pump cable
Power Supply			
# modules/PV array size	2/240 watts	6/300 watts	4/240 watts
PV make/model	Based on Availability	ASE-50-AL	Solarex MSX 60
PV warranty	variable	10 years	20 years
PV field history	variable	2 years	9 years
Array mount	Zomeworks tracker	fixed/pole	Wattsun tracker
Controller make/model	Solarjack PCA 8-60	Grundfos SA400	Solarjack PCA 8-60
Back-up power option	30V batteries	none	
Supplier			
Supplier name	Photocomm	Applied Power	Direct Power & Water
PV pump experience	15 years	12 years	5 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	48 hours	2 days
Estimated ship weight	110 lb	161 lb	
Price			
Controller Price	$241	$738	
Pump Price	$1,484	$660	$1,678
System Price	**$3,607**	**$3,802**	**$3,872**

Node G25 (25 ft., 6000 GPD)

Chart 2: Pumping System Comparisons

Node G50 (50 ft., 6000 GPD)

System ID	PSN-DP13-P	PSN-PC53-P	PSN-AP30-P
Est. GPD/Max. GPM	6789/16	6687/13.3	6300/20.7
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 14-70	SCS 14-70	SP5A-7
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	12-2/G pump cable	12-2/G pump cable	8-3/G pump cable
Power Supply			
# modules/PV array size	6/462 watts	4/480 watts	7/539 watts
PV make/model	Solarex MSX 77	Based on Availability	Solarex MSX-77
PV warranty	20 years	variable	20 years
PV field history	9 years	variable	9 years
Array mount	Wattsun tracker	Zomeworks tracker	fixed/pole
Controller make/model	Solarjack PCA 8-60	Solarjack PCA 8-60	Grundfos SA-1500
Back-up power option		30V batteries	optional gen. interface
Supplier			
Supplier name	Direct Power & Water	Photocomm	Applied Power
PV pump experience	5 years	15 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	2 days	24 hours	1-2 weeks
Estimated ship weight		210 lb	243 lb
Price			
Controller Price		$241	$1,525
Pump Price	$1,678	$1,484	$1,099
System Price	$5,243	$5,365	$7,190

Node G50 (50 ft., 6000 GPD)

Chart 2: Pumping System Comparisons

Node G75 (75 ft., 6000 GPD)

System ID	PSN-PC54-P	PSN-DP29-P	PSN-AP12-P
Est. GPD/Max. GPM	6428/12.5	7080/15.1	6563/20.2
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 18-160	SCS 18-160	SP5A-7
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	12-2/G pump cable	12-2/G pump cable	8-3/G pump cable
Power Supply			
# modules/PV array size	8/640 watts	12/672 watts	16/800 watts
PV make/model	Based on Availability	Solarex MSX 56	ASE-50-AL
PV warranty	variable	20 years	10 years
PV field history	variable	9 years	2 years
Array mount	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	60V batteries		optional gen. interface
Supplier			
Supplier name	Photocomm	Direct Power & Water	Applied Power
PV pump experience	15 years	5 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	48 hours
Estimated ship weight	300 lb		396 lb
Price			
Controller Price	$241		$1,525
Pump Price	$1,590	$1,810	$1,099
System Price	$6,689	$7,107	$8,676

Node G75 (75 ft., 6000 GPD)

Chart 2: Pumping System Comparisons

Node G100 (100 ft., 6000 GPD)

System ID	PSN-PC55-P	PSN-DP35A-P	PSN-AP40-P
Est. GPD/Max. GPM	6193/13	7860/15.7	6578/22.5
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 18-160	SCS 18-160	SP5A-7
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	10-2/G pump cable	10-2/G pump cable	6-3/G pump cable
Power Supply			
# modules/PV array size	10/800 watts	12/924 watts	21/1050 watts
PV make/model	Based on Availability	Solarex MSX 77	ASE-50-AL
PV warranty	variable	20 years	10 years
PV field history	variable	9 years	2 years
Array mount	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	75V batteries		optional gen. interface
Supplier			
Supplier name	Photocomm	Direct Power & Water	Applied Power
PV pump experience	15 years	5 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	48 hours
Estimated ship weight	400 lb		508 lb
Price			
Controller Price	$351		$1,525
Pump Price	$1,590	$1,700	$1,099
System Price	**$7,718**	**$8,697**	**$10,689**

Node G100 (100 ft., 6000 GPD)

Chart 2: Pumping System Comparisons

Node G125 (125 ft, 6000 GPD)

System ID	PSN-PC56-P	PSN-DP43-P	PSN-AP15-P
Est. GPD/Max. GPM	6157/14.2	6265/18.2	5886/17.6
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 18-160	SCS 18-160	SP3A-10
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	10-2/G pump cable	10-2/G pump cable	6-3/G pump cable
Power Supply			
# modules/PV array size	12/960 watts	16/1232 watts	24/1200 watts
PV make/model	Based on Availability	Solarex MSX 77	ASE-50-AL
PV warranty	variable	20 years	10 years
PV field history	variable	9 years	2 years
Array mount	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	90V batteries		optional gen. interface
Supplier			
Supplier name	Photocomm	Direct Power & Water	Applied Power
PV pump experience	15 years	5 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	48 hours
Estimated ship weight	450 lb		555 lb
Price			
Controller Price	$351		$1,525
Pump Price	$1,590	$1,755	$1,063
System Price	**$8,832**	**$10,091**	**$11,609**

Node G125 (125 ft, 6000 GPD)

Chart 2: Pumping System Comparisons

Node G150 (150 ft, 6000 GPD)

System ID	PSN-DP48-P	PSN-PC57-P	PSN-AP19-P
Est. GPD/Max. GPM	6557/13.2	6247/14.2	6845/19.8
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 11-210	SCS 18-160	SP3A-10
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	10-2/G pump cable	10-2/G pump cable	6-3/G pump cable
Power Supply			
# modules/PV array size	16/1232 watts	16/1280 watts	32/1600 watts
PV make/model	Solarex MSX 77	Based on Availability	ASE-50-AL
PV warranty	20 years	variable	10 years
PV field history	9 years	variable	2 years
Array mount	Wattsun tracker	Zomeworks tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option		120V batteries	optional gen. interface
Supplier			
Supplier name	Direct Power & Water	Photocomm	Applied Power
PV pump experience	5 years	15 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	2 days	24 hours	48 hours
Estimated ship weight		650 lb	1722 lb
Price			
Controller Price		$351	$1,525
Pump Price	$1,865	$1,590	$1,063
System Price	**$11,069**	**$13,329**	**$14,579**

Node G150 (150 ft, 6000 GPD)

Chart 2: Pumping System Comparisons

Node H25 (25 ft., 6000 GPD)

System ID	PSN-PC58-P	PSN-DP12-P	PSN-AP20-P
Est. GPD/Max. GPM	8419/14.8	8640/17.3	7500/19
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 14-70	SCS 14-70	SP8A-5
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	12-2/G pump cable	12-2/G pump cable	10-3/G pump cable
Power Supply			
# modules/PV array size	4/320 watts	6/360 watts	8/400 watts
PV make/model	Based on Availability	Solarex MSX 60	ASE-50-AL
PV warranty	variable	20 years	10 years
PV field history	variable	9 years	2 years
Array mount	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCA 8-60	Solarjack PCB 8-60	Grundfos SA-1500
Back-up power option	30V batteries		optional gen. interface
Supplier			
Supplier name	Photocomm	Direct Power & Water	Applied Power
PV pump experience	15 years	5 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	48 hours
Estimated ship weight	150 lb		232 lb
Price			
Controller Price	$241		$1,525
Pump Price	$1,484	$1,645	$1,244
System Price	**$4,234**	**$4,623**	**$5,850**

Node H25 (25 ft., 6000 GPD)

Chart 2: Pumping System Comparisons

Node H50 (50 ft., 8000 GPD)

System ID	PSN-DP21-P	PSN-PC59-P	PSN-AP32-P
Est. GPD/Max. GPM	8811/17.3	9351/18.1	7310/23.8
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 14-70	SCS 14-70	SP5A-7
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	12-2/G pump cable	12-2/G pump cable	8-3/G pump cable
Power Supply			
# modules/PV array size	8/616 watts	12/600 watts	8/616 watts
PV make/model	Solarex MSX 77	Based on Availability	Solarex MSX-77
PV warranty	20 years	variable	20 years
PV field history	9 years	variable	9 years
Array mount	Wattsun tracker	Zomeworks tracker	fixed/pole
Controller make/model	Solarjack PCA 8-60	Solarjack PCA 8-60	Grundfos SA-1500
Back-up power option		45V batteries	optional gen. interface
Supplier			
Supplier name	Direct Power & Water	Photocomm	Applied Power
PV pump experience	5 years	15 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	2 days	24 hours	1-2 weeks
Estimated ship weight		300 lb	266 lb
Price			
Controller Price		$241	$1,525
Pump Price	$1,645	$1,484	$1,099
System Price	**$6,316**	**$6,344**	**$7,747**

Node H50 (50 ft., 8000 GPD)

Chart 2: Pumping System Comparisons

Node H75 (75 ft., 8000 GPD)

System ID	PSN-PC60-P	PSN-DP30-P	PSN-AP29-P
Est. GPD/Max. GPM	7500/15.1	8320/19	7760/26.4
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 18-160	SCS 18-160	SP5A-7
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	12-2/G pump cable	12-2/G pump cable	6-3/G pump cable
Power Supply			
# modules/PV array size	12/720 watts	12/768 watts	16/1024 watts
PV make/model	Based on Availability	Solarex MSX 64	Solarex MSX-64
PV warranty	variable	20 years	20 years
PV field history	variable	9 years	9 years
Array mount	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	90V batteries		optional gen. interface
Supplier			
Supplier name	Photocomm	Direct Power & Water	Applied Power
PV pump experience	15 years	5 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	1-2 weeks
Estimated ship weight	320 lb		430 lb
Price			
Controller Price	$351		$1,525
Pump Price	$1,590	$1,645	$1,099
System Price	**$7,182**	**$8,131**	**$10,263**

Node H75 (75 ft., 8000 GPD)

Chart 2: Pumping System Comparisons

Node H100 (100 ft., 8000 GPD)

System ID	PSN-PC61-P	PSN-DP36-P	PSN-AP18-P
Est. GPD/Max. GPM	8104/16.27	9200/20	7703/24
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 18-160	SCS 18-160	SP5A-7
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	10-2/G pump cable	10-2/G pump cable	6-3/G pump cable
Power Supply			
# modules/PV array size	12/960 watts	11/1078 watts	24/1200 watts
PV make/model	Based on Availability	Solarex MSX 77	ASE-50-AL
PV warranty	variable	20 years	10 years
PV field history	variable	9 years	2 years
Array mount	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	90V batteries		optional gen. interface
Supplier			
Supplier name	Photocomm	Direct Power & Water	Applied Power
PV pump experience	15 years	5 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	48 hours
Estimated ship weight	450 lb		555 lb
Price			
Controller Price	$351		$1,525
Pump Price	$1,590	$1,755	$1,099
System Price	**$8,832**	**$9,816**	**$11,646**

Node H100 (100 ft., 8000 GPD)

Chart 2: Pumping System Comparisons

Node H125 (125 ft, 8000 GPD)

System ID	PSN-DP43A-P	PSN-PC62-P	PSN-AP21-P
Est. GPD/Max. GPM	8194/19.2	8264/17.7	8505/28.6
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 18-160	SCS 18-160	SP5A-7
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	10-2/G pump cable	10-2/G pump cable	6-3/G pump cable
Power Supply			
# modules/PV array size	16/1232 watts	16/1280 watts	40/2000 watts
PV make/model	Solarex MSX 77	Based on Availability	ASE-50-AL
PV warranty	20 years	variable	10 years
PV field history	9 years	variable	2 years
Array mount	Wattsun tracker	Zomeworks tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option		120V batteries	optional gen. interface
Supplier			
Supplier name	Direct Power & Water	Photocomm	Applied Power
PV pump experience	5 years	15 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	2 days	24 hours	48 hours
Estimated ship weight		700 lb	887 lb
Price			
Controller Price		$351	$1,525
Pump Price	$1,810	$1,590	$1,099
System Price	**$11,366**	**$13,329**	**$17,586**

Chart 2: Pumping System Comparisons

Node H150 (150 ft, 8000 GPD)

System ID	PSN-DP49-P	PSN-PC63-P	PSN-AP22-P
Est. GPD/Max. GPM	6960/14.9	9064/20.6	8625/21.3
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 11-210	SCS 20-200	SP3A-10
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe		2" poly	2" PVC
Recommended wire	10-2/G pump cable	10-2/G pump cable	6-3/G pump cable
Power Supply			
# modules/PV array size	16/1328 watts	20/1600 watts	40/2000 watts
PV make/model	Solarex MSX 83	Based on Availability	ASE-50-AL
PV warranty	20 years	variable	10 years
PV field history	9 years	variable	2 years
Array mount	Wattsun tracker	Zomeworks tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCB 8-180	Grundfos SA-1500
Back-up power option		150V batteries	optional gen. interface
Supplier			
Supplier name	Direct Power & Water	Photocomm	Applied Power
PV pump experience	5 years	15 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	2 days	24 hours	48 hours
Estimated ship weight		900 lb	887 lb
Price			
Controller Price		$351	$1,525
Pump Price	$1,975	$2,030	$1,063
System Price	**$11,844**	**$15,377**	**$17,549**

Node H150 (150 ft, 8000 GPD)

Chart 2: Pumping System Comparisons

Node I25 (25 ft., 10000 GPD)

System ID	PSN-DP13-P	PSN-PC64-P	PSN-AP41-P
Est. GPD/Max. GPM	10700/19.3	10838/18.2	10568/48.4
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 14-70	SCS 14-70	SP8A-5
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	12-2/G pump cable	12-2/G pump cable	8-3/G pump cable
Power Supply			
# modules/PV array size	6/462 watts	6/480 watts	16/800 watts
PV make/model	Solarex MSX 77	Based on Availability	ASE-50-AL
PV warranty	20 years	variable	10 years
PV field history	9 years	variable	2 years
Array mount	Wattsun tracker	Zomeworks tracker	fixed/pole
Controller make/model	Solarjack PCA 8-60	Solarjack PCB 8-60	Grundfos SA-1500
Back-up power option		45V batteries	optional gen. interface
Supplier			
Supplier name	Direct Power & Water	Photocomm	Applied Power
PV pump experience	5 years	15 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	2 days	24 hours	48 hours
Estimated ship weight		200 lb	360 lb
Price			
Controller Price		$241	$1,525
Pump Price	$1,678	$1,484	$1,244
System Price	$5,243	$5,365	$8,191

Node I25 (25 ft., 10000 GPD)

Chart 2: Pumping System Comparisons

Node I50 (50 ft., 10000 GPD)

System ID	PSN-PC65-P	PSN-DP22-P	PSN-AP12-P
Est. GPD/Max. GPM	10299/18.3	11286/19.7	10143/26.4
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 18-160	SCS 18-160	SP5A-7
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	12-2/G pump cable	12-2/G pump cable	8-3/G pump cable
Power Supply			
# modules/PV array size	6/720 watts	10/770 watts	16/800 watts
PV make/model	Based on Availability	Solarex MSX 77	ASE-50-AL
PV warranty	variable	20 years	10 years
PV field history	variable	9 years	2 years
Array mount	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	90V batteries		optional gen. interface
Supplier			
Supplier name	Photocomm	Direct Power & Water	Applied Power
PV pump experience	15 years	5 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	48 hours
Estimated ship weight	300 lb		396 lb
Price			
Controller Price	$351		$1,525
Pump Price	$1,590	$1,678	$1,099
System Price	**$7,182**	**$7,893**	**$8,676**

Node I50 (50 ft., 10000 GPD)

Chart 2: Pumping System Comparisons

Node I75 (75 ft, 10000 GPD)

System ID	PSN-PC66-P	PSN-DP31-P	PSN-AP18-P
Est. GPD/Max. GPM	10483/19.4	10900/20.7	10815/30
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 18-160	SCS 18-160	SP5A-7
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	12-2/G pump cable	12-2/G pump cable	6-3/G pump cable
Power Supply			
# modules/PV array size	12/960 watts	12/996 watts	24/1200 watts
PV make/model	Based on Availability	Solarex MSX 83	ASE-50-AL
PV warranty	variable	20 years	10 years
PV field history	variable	9 years	2 years
Array mount	Zomeworks tracker	Wattsun tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option	90V batteries		optional gen. interface
Supplier			
Supplier name	Photocomm	Direct Power & Water	Applied Power
PV pump experience	15 years	5 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	24 hours	2 days	48 hours
Estimated ship weight	450 lb		555 lb
Price			
Controller Price	$351		$1,525
Pump Price	$1,590	$1,755	$1,099
System Price	**$8,832**	**$9,508**	**$11,646**

Node I75 (75 ft, 10000 GPD)

Chart 2: Pumping System Comparisons

Node I100 (100 ft, 10000 GPD)

System ID	PSN-DP37-P	PSN-PC67-P	PSN-AP24-P
Est. GPD/Max. GPM	10700/21,8	10177/19.2	10143/30.8
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 18-160	SCS 18-160	SP5A-7
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	10-2/G pump cable	10-2/G pump cable	6-3/G pump cable
Power Supply			
# modules/PV array size	16/1328 watts	16/1280 watts	32/1600 watts
PV make/model	Solarex MSX 83	Based on Availability	ASE-50-AL
PV warranty	20 years	variable	10 years
PV field history	9 years	variable	2 years
Array mount	Wattsun tracker	Zomeworks tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option		120V batteries	optional gen. interface
Supplier			
Supplier name	Direct Power & Water	Photocomm	Applied Power
PV pump experience	5 years	15 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	2 days	24 hours	48 hours
Estimated ship weight		700 lb	1722 lb
Price			
Controller Price		$351	$1,525
Pump Price	$1,810	$1,590	$1,099
System Price	$11,657	$13,329	$14,616

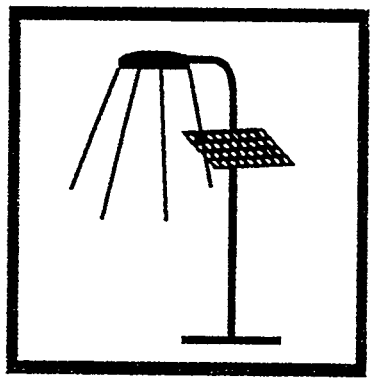
Node I100 (100 ft, 10000 GPD)

Chart 2: Pumping System Comparisons

Node I125 (125 ft, 10000 GPD)

System ID	PSN-DP37-P	PSN-PC68-P	PSN-AP21-P
Est. GPD/Max. GPM	8900/19.2	9793/19.2	11326/30.8
Pump			
Pump type	Centrifugal	Centrifugal	Centrifugal
Pump manufacturer	SolarJack	SolarJack	Grundfos
Pump model	SCS 18-160	SCS 18-160	SP5A-7
Minimum well casing	4 inch	4 inch	4 inch
Pump field history	2 years	2 years	16 years
Rebuild interval/cost			up to 20 yr/new pump
Recommended pipe			2" PVC
Recommended wire	10-2/G pump cable	10-2/G pump cable	6-3/G pump cable
Power Supply			
# modules/PV array size	16/1328 watts	24/1440 watts	40/2000 watts
PV make/model	Solarex MSX 83	Based on Availability	ASE-50-AL
PV warranty	20 years	variable	10 years
PV field history	9 years	variable	2 years
Array mount	Wattsun tracker	Zomeworks tracker	fixed/pole
Controller make/model	Solarjack PCB 8-120	Solarjack PCB 8-120	Grundfos SA-1500
Back-up power option		120V batteries	optional gen. interface
Supplier			
Supplier name	Direct Power & Water	Photocomm	Applied Power
PV pump experience	5 years	15 years	12 years
System warranty	2 years	2 years	2 years
Est. lead time to ship	2 days	24 hours	48 hours
Estimated ship weight		750 lb	887 lb
Price			
Controller Price		$351	$1,525
Pump Price	$1,810	$1,590	$1,099
System Price	$11,657	$13,910	$17,586

Node I125 (125 ft, 10000 GPD)



1997 Lighting Product List

PSN

hotovoltaic Services Network, Inc.

Lighting Product List

Many PV-powered lighting systems were evaluated for inclusion in this new Lighting Product List. Once again, the systems selected for the list represent the best combinations of high quality equipment, system price and supplier experience, capabilities and support.

To ensure that the systems on the Lighting Product List are of high quality and meet utility needs for performance, reliability and convenience, the PSN used the minimum requirements listed below as a preliminary screening tool in evaluating proposed lighting systems. Systems that did not meet these requirements were not considered for the Product List.

Minimum Requirements

All of the PV-powered lighting systems selected for the PSN list meet the following minimum system and supplier requirements:

- ✓ Systems are supplied complete and self contained with all hardware and wiring necessary for installation except for poles or sign lighting arms and wiring for sign lights.
- ✓ Systems are as pre-assembled and pre-wired as is feasible and cost-effective for shipping.
- ✓ Systems are designed for 20 year life with minimum maintenance.
- ✓ All PV system components exposed to the elements are capable of withstanding exposure to temperatures of -20 °C (-4 °F) to 45 °C (113 °F) and up to 90 mph winds.
- ✓ All system components and hardware must be able to perform in a condensing environment
- ✓ Systems meet all applicable National Electric Code requirements to ensure installer/operator safety including: a manual disconnect switch, proper grounding, proper size wire and disconnects, and hazard warning signs. However, all UL (or equivalent) listed components are not required since few PV-powered systems on the market today meet that requirement.
- ✓ PV modules meet IEEE P1262 and UL 1703 standards and include a minimum 10 year, 90% power rating warranty.
- ✓ System components have proven and documented records of field performance in similar applications for a minimum period of one year.
- ✓ Systems are supplied with complete installation, operation and maintenance manuals.
- ✓ Systems have adequate protection against lightning and load induced voltage surges.
- ✓ The entire PV system is warranted for its rated light output (at the design foot-candles and daily run time) for a minimum of two (2) years. (Utilities process all warranty claims through the PSN.)
- ✓ The system manufacturer has documented experience in supplying similar packaged lighting systems.
- ✓ The price quotes contained in the Lighting Product List are effective through December of 1997.

Area Lighting System Selection

When selecting an area lighting system for a specific application, first consult Area Lighting Chart A1: Performance Nodes. Use Chart 1 to select a performance node (labeled intersection) that is closest to your desired combination of light level (in foot candles) and coverage area in radial or square feet.

Next turn to Chart 2: Area Lighting System Comparisons and go to the page labeled with the selected node. This page will give you information about the area lighting systems of-

fered by the PSN that are appropriate for that particular combination of light and area. If your application is between nodes, also check the nodes immediately before and after your required light level and area.

The systems on Chart 2 are listed from left to right in order of system cost based on the medium and large size power supply options. When reviewing lighting systems, please remember that there may be significant differences between systems that could justify a higher cost such as larger batteries or PV arrays and different type lamps. For additional information such as photometrics for each luminaire, refer to the PSN System Specification sheets at the end of the section.

Sign Lighting System Selection

When selecting a sign lighting system for a specific application, first consult Sign Lighting Chart S1: Performance Nodes. Use Chart 1 to select a performance node (labeled intersection) that is closest to your desired combination of light level on a sign (in foot candles) and the size of the sign.

Next turn to Chart 2: Sign Lighting System Comparisons and go to the page labeled with the selected node. This page will give you information about the sign lighting systems offered by the PSN that are appropriate for your particular combination of light level and sign size. If your application is between nodes, also check the nodes immediately before and after your required light level and sign size.

The systems on Chart 2 are listed from left to right in order of system cost based on the medium size power supply option. When reviewing lighting systems, please remember that there may be significant differences between systems that could justify a higher cost such larger batteries or PV array. For additional information such as photometrics for each luminaire, refer to the PSN System Specification sheets at the end of the section.

Lighting System Comparison Charts

There are two sets of Lighting System Comparison Charts, the first set for area lighting and the second for sign lighting. The area and sign lighting charts contain one double page for each lighting node, are laid out in the same format and contain the same information.

Each System Comparison Chart is labeled by lighting node in the top and bottom right corners of the two page chart. The first line on the top page of each chart is the ***PSN series*** identification number. This number identifies only the system series which is characterized by a specific lamp and system supplier. Each series is offered with as many as four different size power supply options that correspond to different hours of lamp run time.

The information specific to each power supply option for a series is listed on the second page of each chart in the same column as the series. This information includes the system identification numbers labeled ***Small ID, Med ID, Large ID and X-Large ID.*** These PSN system identification numbers are what you would use to order a lighting system. The system prices that correspond to each power supply option are listed in the rows labeled ***Small System $, Med System $, Large System $, and XL System.***

Back on the top page of each chart under the Luminaire heading, ***Lamp Type*** refers to the lamp technology used in the luminaire (either compact fluorescent or low pressure sodium lamps). ***Lamp output rating*** is the lamp's rated light output in lumens and ***Lamp input rating*** is the lamp's rated power draw in watts. ***Lamp life*** lists the estimated hours of run time that each lamp will last. ***Luminaire type*** is a general description of the lamp housing style and ***Luminaire make/model*** names the manufacturer and model number. ***Optional luminaire types available*** lists the other luminaires available with this system at a slightly different price. ***Starting temp. range.*** gives the ambient temperature range at which each lamp is

rated to start reliably. ***IES cut-off*** tells whether each luminaire includes a light cut-off which meets Illumination Engineering Society standards.

Under the System heading, ***Field history*** lists the number of years each lighting system has been installed in the field.

Lighting controls gives a brief description of the different lighting operation controls available with each system such as dusk to dawn (D to D), and real time clocks (clock). ***Timer range*** is the range of hours for which each controller timer can be set. ***Controller make/model*** is the name of the lighting/charge controller manufacturer and the model number. ***Charge method*** is how the battery charge controller controls the level of charge in the batteries such as pulse width modulation (PWM).

Under the Power Supply heading, ***PV tilt range*** describes the angles from horizontal to which the PV array can be set. ***PV warranty*** lists the manufacturer's warranty on PV power output and ***PV field history*** gives the number of years that the PV module has been commercially available. ***Battery make/model*** lists the manufacturer and model number of the batteries and ***Battery type*** describes the type of battery technology used (such as flooded lead acid and sealed valve regulated). ***Estimated battery life*** is the system supplier's estimate of the battery's life when it is used according to recommendations.

Under the Supplier heading, ***Supplier name*** lists the PV system supplier that provides each lighting system to the PSN. ***PV lighting experience*** lists the system supplier's experience with PV lighting systems and ***System warranty*** lists the supplier's warranty for the entire packaged system. ***Lead time to ship*** describes the time each supplier requires to ship a system after receipt of an order.

On the second page, ***PV watts*** gives size of the PV array (in peak watts) for each power supply option and ***PV make/model*** names the manufacturer and model of the PV modules. ***Battery Capacity Avail.*** is the available battery capacity in days of storage.

The next line is labeled ***ND/CO/AZ***. These abbreviations stand for Bismarck, North Dakota; Boulder, Colorado and Tucson, Arizona. These are the locations for which performance estimates are given on the next lines. The line labeled ***Run time*** gives the estimated hours of lamp run time for each of the three locations. The line labeled ***Sun hours*** gives the daily hours of solar insolation in each location upon which the run times are based. The run times are also based on the PV array tilt angle which is given on the ***line labeled PV tilt angle.***

Area Lighting System Selection

Chart A1: Performance Nodes

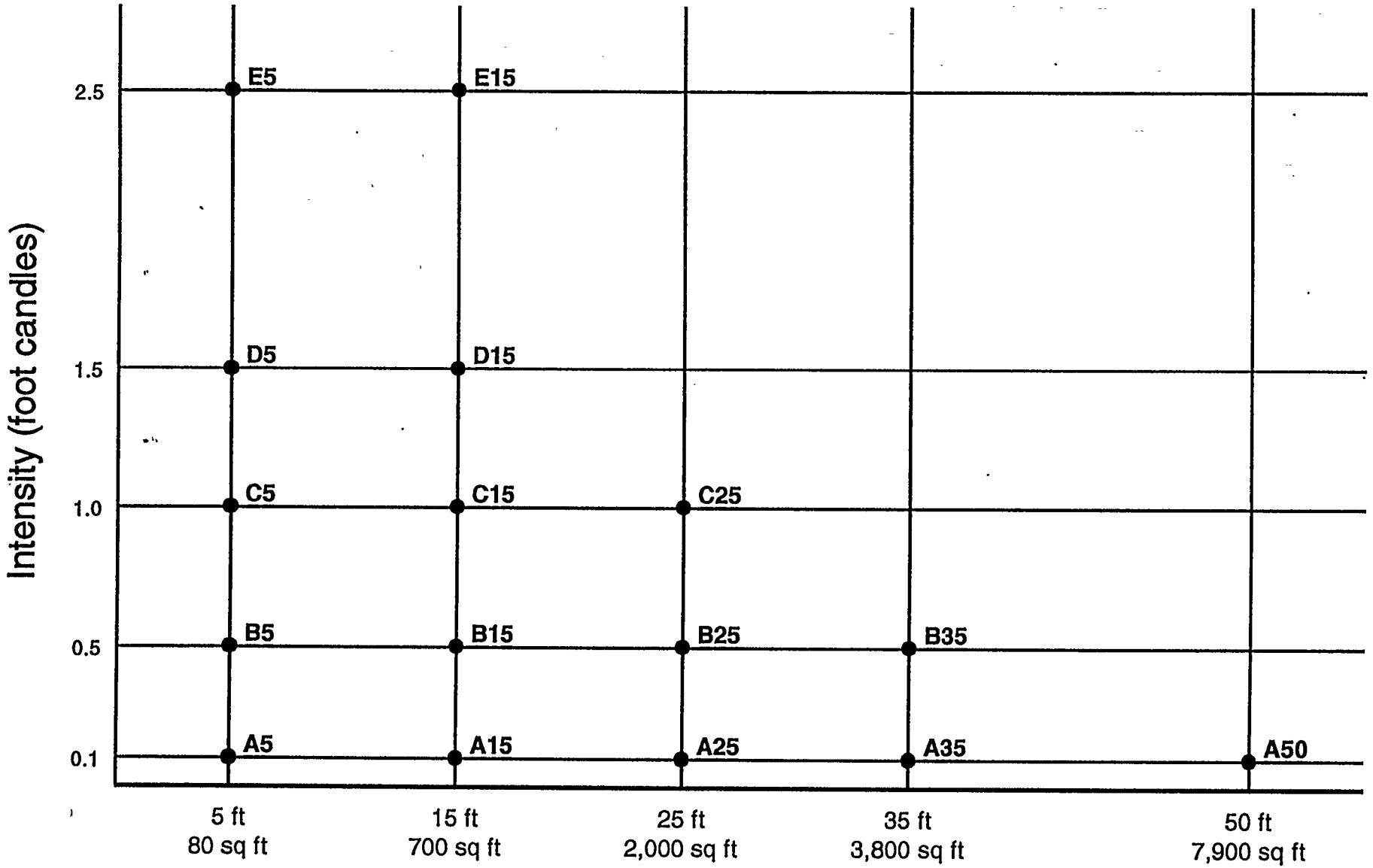


Chart 2: Area Lighting System Comparisons

Node A-A05 (0.1FC, 5 ft radius)

Series ID	SEP06-0-AL	SEP08-0-AL	SEP13-0-AL	SW02-0-AL	SOL08-0-AL	SOL07-0-AL
Luminaire						
Lamp Type	CF	CF	LPS	CF	CF	LPS
Lamp input / output	13W / 825 Lumens	26W / 1800 Lumens	35W / 4800 Lumens	36W / 2900 Lumens	24W / 1800 Lumens	35W / 4800 Lumens
Lamp life	10,000 hrs	10,000 hrs	18,000 hrs	10,000 hrs	12,000 hrs	18,000 hrs
# of lamps / # luminaire	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1
Luminaire type	area flood	utility gas light	cobra head	shoe box	shoe box	cobra head
Luminaire make/model	SEPCO-F2	GE/PM17	GE/M-400A2	Mor-Lite 1x36	Phoenix Metals	GE
Optional luminaire types avaliable			power flood		cobra, decorative, power flood	
Starting temp. range	0 to 140 F	0 to 140 F	-40 to 150 F	-40 to 130 F	-40 to 150 F	-40 to 150 F
IES cut off	yes	no	no	no	yes	no
System						
Field history	3 years	3 years	2 years	2 years	6 years	6 years
Lighting controls	D to D, clock, timers	D to D, clock, timers	D to D, clock, timers	2 timers	dusk/dawn,timer	dusk/dawn,timer
Timer range	0-15 hours	0-15 hours	0-15 hours	1-15 & 1-8 hrs	0-15 hours	0-15 hours
Controller make/model	SEPCO/LCU-1	SEPCO/LCU-1	SEPCO/LCU-1	SWSLC-12-SI-ST	Bobier/SCU-1	Bobier/SCU-1
Charge method	PWM	PWM	PWM	FET shunt 14.5v	stop @ 14.4v	stop @ 14.4v
Power Supply						
PV tilt range	15 or 45 deg	15 or 45 deg	15 or 45 deg	25-60 deg	15 or 45 deg	15 or 45 deg
PV warranty	10yr / 90%	10yr / 90%	10yr / 90%	10yr / 90%	20yr / 80%	20yr / 80%
PV field history	10+ years	10+ years	10+ years	10+ years	6 years	6 years
Battery make/model	East Penn/8G27	East Penn/8G27	East Penn/8G27	Concorde/GPC1295	Deka/8G24	Deka/8G24
Battery type	gelled, valve reg.	gelled, valve reg.	gelled, valve reg.	starved, valve reg.	gelled, valve reg.	gelled, valve reg.
Estimated Battery life	5-7 years	5-7 years	5-7 years	5 years	5 years	5 years
Supplier						
Supplier name	SEPCO	SEPCO	SEPCO	SunWize	Solar Outdoor Lighting	Solar Outdoor Lighting
PV lighting experience	3	3	3	3	6	6
System warranty	2 years	2 years	2 years	2 years	2 years	2 years
Lead time to ship	1 week	1 week	1 week	4 weeks	4 days	4 days

System Prices by Power Supply Size:

Small ID	SEP06-S-AL	SEP08-S-AL	SEP13-S-AL	SW02-S-AL	SOL08-S-AL	SOL07-S-AL
PV Watts	50	50	75	110	53	83
PV make/model	Siemens	Siemens	Siemens	Siemens 55	Solarex/MSX-53	Solarex/MSX-83
Battery Capacity Avail.	10.1 days	5.0 days	3.7 days	5.1 days	5.3 days	3.7 days
ND/CO/AZ						
Run time	8 / 10 / 12	5 / 7 / 8	4 / 6 / 7	12 / 17 / 22	5 / 7 / 9	4 / 6 / 7
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
Small System $	$1,485	$1,601	$1,625	$1,590	$1,959	$2,476

Medium ID	SEP06-M-AL	SEP08-M-AL	SEP13-M-AL	SW02-M-AL	SOL08-M-AL	SOL07-M-AL
PV Watts	75	75	100	110	77	141
PV make/model	Siemens	Siemens	Siemens	Siemens 55	Solarex/MSX-77	Solarex/MSX-64&77
Battery Capacity Avail.	6.1 days	3.0 days	3.1 days	6.1 days	6.4 days	4.4 days
ND/CO/AZ						
Run time	11 / 14 / 18	7 / 10 / 12	6 / 8 / 10	8 / 12 / 14	8 / 10 / 13	7 / 10 / 13
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
Med System $	$1,629	$1,745	$1,769	$1,975	$2,269	$3,200

Large ID	SEP06-L-AL	SEP08-L-AL	SEP13-L-AL	SW02-L-AL	SOL08-L-AL	SOL07-L-AL
PV Watts	100	100	150	165	113	192
PV make/model	Siemens	Siemens	Siemens	Siemens 55	Solarex/MSX-53&64	Solarex/MSX-64
Battery Capacity Avail.	5.9 days	3.0 days	3.2 days	4.4 days	4.6 days	3.1 days
ND/CO/AZ						
Run time	15 / 20 / 25	10 / 13 / 16	9 / 12 / 15	8 / 12 / 14	10 / 15 / 18	10 / 14 / 17
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
Large System $	$1,918	$2,035	$2,059	$2,525	$2,838	$3,717

X-Large ID	SEP06-X-AL	SEP08-X-AL	SEP13-X-AL	SW02-X-AL	SOL08-X-AL	SOL07-X-AL
PV Watts	150	150	200	220	141	249
PV make/model	Siemens	Siemens	Siemens	Siemens 55	Solarex/MSX-64&77	Solarex/MSX-83
Battery Capacity Avail.	6.7 days	3.4 days	3.4 days	5.1 days	3.6 days	2.4 days
ND/CO/AZ						
Run time	22 / 30 / 38	15 / 20 / 25	12 / 16 / 20	16 / 24 / 24	13 / 18 / 0	13 / 18 / 0
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
XL System $	$2,857	$2,973	$2,997	$2,910	$3,200	$4,337

Chart 2: Area Lighting System Comparisons

Node A-A15 (0.1FC, 15 ft radius)

Series ID	SEP05-0-AL	SEP08-0-AL	SEP13-0-AL	SW02-0-AL	SOL08-0-AL	SOL07-0-AL
Luminaire						
Lamp Type	CF	CF	LPS	CF	CF	LPS
Lamp input / output	39W / 2850 Lumens	26W / 1800 Lumens	35W / 4800 Lumens	36W / 2900 Lumens	24W / 1800 Lumens	35W / 4800 Lumens
Lamp life	10,000 hrs	10,000 hrs	18,000 hrs	10,000 hrs	12,000 hrs	18,000 hrs
# of lamps / # luminaire	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1
Luminaire type	area flood	utility gas light	cobra head	shoe box	shoe box	cobra head
Luminaire make/model	SEPCO-F1	GE/PM17	GE/M-400A2	Mor-Lite 1x36	Phoenix Metals	GE
Optional luminaire types avaliable		cobra, wall, power flood, shoe box	power flood		cobra head	
Starting temp. range	0 to 140 F	0 to 140 F	-40 to 150 F	-40 to 130 F	-40 to 150 F	-40 to 150 F
IES cut off	yes	no	no	no	yes	no
System						
Field history	3 years	3 years	2 years	2 years	6 years	6 years
Lighting controls	D to D, clock, timers	D to D, clock, timers	D to D, clock, timers	2 timers	dusk/dawn,timer	dusk/dawn,timer
Timer range	0-15 hours	0-15 hours	0-15 hours	1-15 & 1-8 hrs	0-15 hours	0-15 hours
Controller make/model	SEPCO/LCU-1	SEPCO/LCU-1	SEPCO/LCU-1	SWSLC-12-SI-ST	Bobier/SCU-1	Bobier/SCU-1
Charge method	PWM	PWM	PWM	FET shunt 14.5v	stop @ 14.4v	stop @ 14.4v
Power Supply						
PV tilt range	15 or 45 deg	15 or 45 deg	15 or 45 deg	25-60 deg	15 or 45 deg	15 or 45 deg
PV warranty	10yr / 90%	10yr / 90%	10yr / 90%	10yr / 90%	20yr / 80%	20yr / 80%
PV field history	10+ years	10+ years	10+ years	10+ years	6 years	6 years
Battery make/model	East Penn/8G27	East Penn/8G27	East Penn/8G27	Concorde/GPC1295	Deka/8G24	Deka/8G24
Battery type	gelled, valve reg.	gelled, valve reg.	gelled, valve reg.	starved, valve reg.	gelled, valve reg.	gelled, valve reg.
Estimated Battery life	5-7 years	5-7 years	5-7 years	5 years	5 years	5 years
Supplier						
Supplier name	SEPCO	SEPCO	SEPCO	SunWize	Solar Outdoor Lighting	Solar Outdoor Lighting
PV lighting experience	3	3	3	3	6	6
System warranty	2 years	2 years	2 years	2 years	2 years	2 years
Lead time to ship	1 week	1 week	1 week	4 weeks	4 days	4 days

System Prices by Power Supply Size:

Small ID	SEP05-S-AL	SEP08-S-AL	SEP13-S-AL	SW02-S-AL	SOL08-S-AL	SOL07-S-AL
PV Watts	50	50	75	110	53	83
PV make/model	Siemens	Siemens	Siemens	Siemens 55	Solarex/MSX-53	Solarex/MSX-83
Battery Capacity Avail.	3.4 days	5.0 days	3.7 days	5.1 days	5.3 days	3.7 days
ND/CO/AZ						
Run time	4 / 5 / 6	5 / 7 / 8	4 / 6 / 7	12 / 17 / 22	5 / 7 / 9	4 / 6 / 7
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
Small System $	$1,519	$1,601	$1,625	$1,590	$1,959	$2,476

Medium ID	SEP05-M-AL	SEP08-M-AL	SEP13-M-AL	SW02-M-AL	SOL08-M-AL	SOL07-M-AL
PV Watts	75	75	100	110	77	141
PV make/model	Siemens	Siemens	Siemens	Siemens 55	Solarex/MSX-77	Solarex/MSX-64&77
Battery Capacity Avail.	2.0 days	3.0 days	3.1 days	6.1 days	6.4 days	4.4 days
ND/CO/AZ						
Run time	10 / 8 / 10	7 / 10 / 12	6 / 8 / 10	8 / 12 / 14	8 / 10 / 13	7 / 10 / 13
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
Med System $	$1,663	$1,745	$1,769	$1,975	$2,269	$3,200

Large ID	SEP05-L-AL	SEP08-L-AL	SEP13-L-AL	SW02-L-AL	SOL08-L-AL	SOL07-L-AL
PV Watts	100	100	150	165	113	192
PV make/model	Siemens	Siemens	Siemens	Siemens 55	Solarex/MSX-53&64	Solarex/MSX-64
Battery Capacity Avail.	2.0 days	3.0 days	3.2 days	4.4 days	4.6 days	3.1 days
ND/CO/AZ						
Run time	8 / 10 / 13	10 / 13 / 16	9 / 12 / 15	8 / 12 / 14	10 / 15 / 18	10 / 14 / 17
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
Large System $	$1,953	$2,035	$2,059	$2,525	$2,838	$3,717

X-Large ID	SEP05-X-AL	SEP08-X-AL	SEP13-X-AL	SW02-X-AL	SOL08-X-AL	SOL07-X-AL
PV Watts	150	150	200	220	141	249
PV make/model	Siemens	Siemens	Siemens	Siemens 55	Solarex/MSX-64&77	Solarex/MSX-83
Battery Capacity Avail.	2.2 days	3.4 days	3.4 days	5.1 days	3.6 days	2.4 days
ND/CO/AZ						
Run time	12 / 16 / 20	15 / 20 / 25	12 / 16 / 20	16 / 24 / 24	13 / 18 / 0	13 / 18 / 0
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
XL System $	$2,891	$2,973	$2,997	$2,910	$3,200	$4,337

Node A-A15 (0.1FC, 15 ft radius)

Chart 2: Area Lighting System Comparisons **Node A-A25 (0.1FC, 25 ft radius)**

Series ID	SEP08-0-AL	SEP13-0-AL	SW02-0-AL	SOL08-0-AL	SEP15-0-AL	SOL07-0-AL
Luminaire						
Lamp Type	CF	LPS	CF	CF	CF	LPS
Lamp input / output	26W / 1800 Lumens	35W / 4800 Lumens	36W / 2900 Lumens	24W / 1800 Lumens	26W / 1800 Lumens	35W / 4800 Lumens
Lamp life	10,000 hrs	18,000 hrs	10,000 hrs	12,000 hrs		18,000 hrs
# of lamps / # luminaire	1 / 1	1 / 1	1 / 1	1 / 1	2 / 2	1 / 1
Luminaire type	utility gas light	cobra head	shoe box	shoe box	power flood	cobra head
Luminaire make/model	GE/PM17	GE/M-400A2	Mor-Lite 1x36	Phoenix Metals	GE/PF400KN	GE
Optional luminaire types avaliable	cobra, power flood, shoe box	power flood		cobra head		
Starting temp. range	0 to 140 F	-40 to 150 F	-40 to 130 F	-40 to 150 F	0 to 140 F	-40 to 150 F
IES cut off	no	no	no	yes	yes	no
System						
Field history	3 years	2 years	2 years	6 years	3 years	6 years
Lighting controls	D to D, clock, timers	D to D, clock, timers	2 timers	dusk/dawn,timer	D to D, clock, timers	dusk/dawn,timer
Timer range	0-15 hours	0-15 hours	1-15 & 1-8 hrs	0-15 hours	0-15 hours	0-15 hours
Controller make/model	SEPCO/LCU-1	SEPCO/LCU-1	SWSLC-12-SI-ST	Bobier/SCU-1	SEPCO/LCU-1	Bobier/SCU-1
Charge method	PWM	PWM	FET shunt 14.5v	stop @ 14.4v	PWM	stop @ 14.4v
Power Supply						
PV tilt range	15 or 45 deg	15 or 45 deg	25-60 deg	15 or 45 deg	15 or 45 deg	15 or 45 deg
PV warranty	10yr / 90%	10yr / 90%	10yr / 90%	20yr / 80%	10yr / 90%	20yr / 80%
PV field history	10+ years	10+ years	10+ years	6 years	10+ years	6 years
Battery make/model	East Penn/8G27	East Penn/8G27	Concorde/GPC1295	Deka/8G24	East Penn/8G27	Deka/8G24
Battery type	gelled, valve reg.	gelled, valve reg.	starved, valve reg.	gelled, valve reg.	gelled, valve reg.	gelled, valve reg.
Estimated Battery life	5-7 years	5-7 years	5 years	5 years	5-7 years	5 years
Supplier						
Supplier name	SEPCO	SEPCO	SunWize	Solar Outdoor Lighting	SEPCO	Solar Outdoor Lighting
PV lighting experience	3	3	3	6	3	6
System warranty	2 years	2 years	2 years	2 years	2 years	2 years
Lead time to ship	1 week	1 week	4 weeks	4 days	1 week	4 days

System Prices by Power Supply Size:

Small ID	SEP08-S-AL	SEP13-S-AL	SW02-S-AL	SOL08-S-AL	SEP15-S-AL	SOL07-S-AL
PV Watts	50	75	110	53	100	83
PV make/model	Siemens	Siemens	Siemens 55	Solarex/MSX-53	Siemens	Solarex/MSX-83
Battery Capacity Avail.	5.0 days	3.7 days	5.1 days	5.3 days	6.9 days	3.7 days
ND/CO/AZ						
Run time	5 / 7 / 8	4 / 6 / 7	12 / 17 / 22	5 / 7 / 9	4 / 6 / 8	4 / 6 / 7
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45
Small System $	$1,601	$1,625	$1,590	$1,959	$2,242	$2,476

Medium ID	SEP08-M-AL	SEP13-M-AL	SW02-M-AL	SOL08-M-AL	SEP15-M-AL	SOL07-M-AL
PV Watts	75	100	110	77	150	141
PV make/model	Siemens	Siemens	Siemens 55	Solarex/MSX-77	Siemens	Solarex/MSX-64&77
Battery Capacity Avail.	3.0 days	3.1 days	6.1 days	6.4 days	6.1 days	4.4 days
ND/CO/AZ						
Run time	7 / 10 / 12	6 / 8 / 10	8 / 12 / 14	8 / 10 / 13	7 / 9 / 11	7 / 10 / 13
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45
Med System $	$1,745	$1,769	$1,975	$2,269	$2,532	$3,200

Large ID	SEP08-L-AL	SEP13-L-AL	SW02-L-AL	SOL08-L-AL	SEP15-L-AL	SOL07-L-AL
PV Watts	100	150	165	113	200	192
PV make/model	Siemens	Siemens	Siemens 55	Solarex/MSX-53&64	Siemens	Solarex/MSX-64
Battery Capacity Avail.	3.0 days	3.2 days	4.4 days	4.6 days	5.9 days	3.1 days
ND/CO/AZ						
Run time	10 / 13 / 16	9 / 12 / 15	8 / 12 / 14	10 / 15 / 18	9 / 12 / 15	10 / 14 / 17
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45
Large System $	$2,035	$2,059	$2,525	$2,838	$3,470	$3,717

X-Large ID	SEP08-X-AL	SEP13-X-AL	SW02-X-AL	SOL08-X-AL	SEP15-X-AL	SOL07-X-AL
PV Watts	150	200	220	141	250	249
PV make/model	Siemens	Siemens	Siemens 55	Solarex/MSX-64&77	Siemens	Solarex/MSX-83
Battery Capacity Avail.	3.4 days	3.4 days	5.1 days	3.6 days	4.6 days	2.4 days
ND/CO/AZ						
Run time	15 / 20 / 25	12 / 16 / 20	16 / 24 / 24	13 / 18 / 0	12 / 15 / 18	13 / 18 / 0
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45
XL System $	$2,973	$2,997	$2,910	$3,200	$3,954	$4,337

Chart 2: Area Lighting System Comparisons **Node A-A35 (0.1FC, 35 ft radius)**

Series ID	SEP07-0-AL	SEP13-0-AL	SOL08-0-AL	SW01-0-AL	SOL07-0-AL
Luminaire					
Lamp Type	CF	LPS	CF	CF	LPS
Lamp input / output	27W / 1800 Lumens	35W / 4800 Lumens	24W / 1800 Lumens	36W / 2900 Lumens	35W / 4800 Lumens
Lamp life	10,000 hrs	18,000 hrs	12,000 hrs	10,000 hrs	18,000 hrs
# of lamps / # luminaire	1 / 1	1 / 1	1 / 1	2 / 1	1 / 1
Luminaire type	coach	cobra head	shoe box	shoe box	cobra head
Luminaire make/model	GE/T10C	GE/M-400A2	Phoenix Metals	Mor-Lite 2x36	GE
Optional luminaire types avaliable	cobra head, power flood, shoe box	power flood	cobra head		
Starting temp. range	0 to 140 F	-40 to 150 F	-40 to 150 F	-40 to 130 F	-40 to 150 F
IES cut off	no	no	yes	no	no
System					
Field history	3 years	2 years	6 years	2 years	6 years
Lighting controls	D to D, clock, timers	D to D, clock, timers	dusk/dawn,timer	2 timers	dusk/dawn,timer
Timer range	0-15 hours	0-15 hours	0-15 hours	1-15 & 1-8 hrs	0-15 hours
Controller make/model	SEPCO/LCU-1	SEPCO/LCU-1	Bobier/SCU-1	SWSLC-12-SI-ST	Bobier/SCU-1
Charge method	PWM	PWM	stop @ 14.4v	FET shunt 14.5v	stop @ 14.4v
Power Supply					
PV tilt range	15 or 45 deg	15 or 45 deg	15 or 45 deg	25-60 deg	15 or 45 deg
PV warranty	10yr / 90%	10yr / 90%	20yr / 80%	10yr / 90%	20yr / 80%
PV field history	10+ years	10+ years	6 years	10+ years	6 years
Battery make/model	East Penn/8G27	East Penn/8G27	Deka/8G24	Concorde/GPC1295	Deka/8G24
Battery type	gelled, valve reg.	gelled, valve reg.	gelled, valve reg.	starved, valve reg.	gelled, valve reg.
Estimated Battery life	5-7 years	5-7 years	5 years	5 years	5 years
Supplier					
Supplier name	SEPCO	SEPCO	Solar Outdoor Lighting	SunWize	Solar Outdoor Lighting
PV lighting experience	3	3	6	3	6
System warranty	2 years	2 years	2 years	2 years	2 years
Lead time to ship	1 week	1 week	4 days	4 weeks	4 days

System Prices by Power Supply Size:

Small ID	SEP07-S-AL	SEP13-S-AL	SOL08-S-AL	SW01-S-AL	SOL07-S-AL
PV Watts	50	75	53	110	83
PV make/model	Siemens	Siemens	Solarex/MSX-53	Siemens 55	Solarex/MSX-83
Battery Capacity Avail.	4.9 days	3.7 days	5.3 days	10.2 days	3.7 days
ND/CO/AZ					
Run time	6 / 7 / 9	4 / 6 / 7	5 / 7 / 9	10 / 14 / 18	4 / 6 / 7
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45
Small System $	$1,596	$1,625	$1,959	$2,305	$2,476

Medium ID	SEP07-M-AL	SEP13-M-AL	SOL08-M-AL	SW01-M-AL	SOL07-M-AL
PV Watts	75	100	77	220	141
PV make/model	Siemens	Siemens	Solarex/MSX-77	Siemens 55	Solarex/MSX-64&77
Battery Capacity Avail.	2.9 days	3.1 days	6.4 days	6.1 days	4.4 days
ND/CO/AZ					
Run time	8 / 10 / 13	6 / 8 / 10	8 / 10 / 13	8 / 12 / 14	7 / 10 / 13
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45
Med System $	$1,740	$1,769	$2,269	$3,075	$3,200

Large ID	SEP07-L-AL	SEP13-L-AL	SOL08-L-AL	SW01-L-AL	SOL07-L-AL
PV Watts	100	150	113	275	192
PV make/model	Siemens	Siemens	Solarex/MSX-53&64	Siemens 55	Solarex/MSX-64
Battery Capacity Avail.	2.8 days	3.2 days	4.6 days	6.6 days	3.1 days
ND/CO/AZ					
Run time	11 / 14 / 18	9 / 12 / 15	10 / 15 / 18	4 / 6 / 7	10 / 14 / 17
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45
Large System $	$2,029	$2,059	$2,838	$3,790	$3,717

X-Large ID	SEP07-X-AL	SEP13-X-AL	SOL08-X-AL		SOL07-X-AL
PV Watts	150	200	141		249
PV make/model	Siemens	Siemens	Solarex/MSX-64&77		Solarex/MSX-83
Battery Capacity Avail.	3.2 days	3.4 days	3.6 days		2.4 days
ND/CO/AZ					
Run time	16 / 22 / 27	12 / 16 / 20	13 / 18 / 0		13 / 18 / 0
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5		3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45		45 / 45 / 45
XL System $	$2,968	$2,997	$3,200		$4,337

Chart 2: Area Lighting System Comparisons **Node A-A50 (0.1FC, 50 ft radius)**

Series ID	SEP02-0-AL	SEP13-0-AL	SOL10-0-AL	SOL07-0-AL	SOL09-0-AL
Luminaire					
Lamp Type	CF	LPS	CF	LPS	CF
Lamp input / output	26W / 1800 Lumens	35W / 4800 Lumens	36W / 2900 Lumens	35W / 4800 Lumens	24W / 1800 Lumens
Lamp life	10,000 hrs	18,000 hrs	10,000 hrs	18,000 hrs	12,000 hrs
# of lamps / # luminaire	1 / 1	1 / 1	1 / 1	1 / 1	2 / 1
Luminaire type	cobra head	cobra head	shoe box	cobra head	shoe box
Luminaire make/model	GE/M400A2	GE/M-400A2	Phoenix Metals	GE	Phoenix Metals
Optional luminaire types avaliable	shoe box				
Starting temp. range	0 to 140 F	-40 to 150 F	-40 to 150 F	-40 to 150 F	-40 to 150 F
IES cut off	no	no	yes	no	yes
System					
Field history	3 years	2 years	6 years	6 years	6 years
Lighting controls	D to D, clock, timers	D to D, clock, timers	dusk/dawn,timer	dusk/dawn,timer	dusk/dawn,timer
Timer range	0-15 hours	0-15 hours	0-15 hours	0-15 hours	0-15 hours
Controller make/model	SEPCO/LCU-1	SEPCO/LCU-1	Bobier/SCU-1	Bobier/SCU-1	Bobier/SCU-1
Charge method	PWM	PWM	stop @ 14.4v	stop @ 14.4v	stop @ 14.4v
Power Supply					
PV tilt range	15 or 45 deg	15 or 45 deg	15 or 45 deg	15 or 45 deg	15 or 45 deg
PV warranty	10yr / 90%	10yr / 90%	20yr / 80%	20yr / 80%	20yr / 80%
PV field history	10+ years	10+ years	6 years	6 years	6 years
Battery make/model	East Penn/8G27	East Penn/8G27	Deka/8G24	Deka/8G24	Deka/8G24
Battery type	gelled, valve reg.	gelled, valve reg.	gelled, valve reg.	gelled, valve reg.	gelled, valve reg.
Estimated Battery life	5-7 years	5-7 years	5 years	5 years	5 years
Supplier					
Supplier name	SEPCO	SEPCO	Solar Outdoor Lighting	Solar Outdoor Lighting	Solar Outdoor Lighting
PV lighting experience	3	3	6	6	6
System warranty	2 years	2 years	2 years	2 years	2 years
Lead time to ship	1 week	1 week	4 days	4 days	4 days

System Prices by Power Supply Size:

Small ID	SEP02-S-AL	SEP13-S-AL	SOL10-S-AL	SOL07-S-AL	SOL09-S-AL
PV Watts	50	75	64	83	106
PV make/model	Siemens	Siemens	Solarex/MSX-64	Solarex/MSX-83	Solarex/MSX-53
Battery Capacity Avail.	5.0 days	3.7 days	3.6 days	3.7 days	10.7 days
ND/CO/AZ					
Run time	5 / 7 / 8	4 / 6 / 7	4 / 6 / 8	4 / 6 / 7	5 / 7 / 8
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45
Small System $	$1,625	$1,625	$2,114	$2,476	$2,890

Medium ID	SEP02-M-AL	SEP13-M-AL	SOL10-M-AL	SOL07-M-AL	SOL09-M-AL
PV Watts	75	100	106	141	160
PV make/model	Siemens	Siemens	Solarex/MSX-53	Solarex/MSX-64&77	Solarex/MSX-80
Battery Capacity Avail.	3.0 days	3.1 days	4.3 days	4.4 days	9.6 days
ND/CO/AZ					
Run time	7 / 10 / 12	6 / 8 / 10	8 / 10 / 13	7 / 10 / 13	7 / 10 / 12
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45
Med System $	$1,769	$1,769	$2,786	$3,200	$3,407

Large ID	SEP02-L-AL	SEP13-L-AL	SOL10-L-AL	SOL07-L-AL	SOL09-L-AL
PV Watts	100	150	141	192	219
PV make/model	Siemens	Siemens	Solarex/MSX-64&77	Solarex/MSX-64	Solarex/MSX-53&83
Battery Capacity Avail.	3.0 days	3.2 days	3.0 days	3.1 days	9.1 days
ND/CO/AZ					
Run time	10 / 13 / 16	9 / 12 / 15	10 / 10 / 17	10 / 14 / 17	10 / 14 / 17
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45
Large System $	$2,059	$2,059	$3,200	$3,717	$4,027

X-Large ID	SEP02-X-AL	SEP13-X-AL	SOL10-X-AL	SOL07-X-AL	
PV Watts	150	200	180	249	
PV make/model	Siemens	Siemens	Solarex/MSX-60	Solarex/MSX-83	
Battery Capacity Avail.	3.4 days	3.4 days	2.4 days	2.4 days	
ND/CO/AZ					
Run time	15 / 20 / 25	12 / 16 / 20	13 / 18 / 0	13 / 18 / 0	
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	
XL System $	$2,997	$2,997	$3,614	$4,337	

Chart 2: Area Lighting System Comparisons **Node A-B05 (0.5FC, 5 ft radius)**

Series ID	SEP01-0-AL	SEP13-0-AL	SW02-0-AL	SOL08-0-AL	SOL07-0-AL
Luminaire					
Lamp Type	CF	LPS	CF	CF	LPS
Lamp input / output	26W / 1800 Lumens	35W / 4800 Lumens	36W / 2900 Lumens	24W / 1800 Lumens	35W / 4800 Lumens
Lamp life	10,000 hrs	18,000 hrs	10,000 hrs	12,000 hrs	18,000 hrs
# of lamps / # luminaire	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1
Luminaire type	cobra head	cobra head	shoe box	shoe box	cobra head
Luminaire make/model	GE/M400A2 cutoff	GE/M-400A2	Mor-Lite 1x36	Phoenix Metals	GE
Optional luminaire types avaliable	utility gas, wall, power flood, shoe box	power flood		cobra head	
Starting temp. range	0 to 140 F	-40 to 150 F	-40 to 130 F	-40 to 150 F	-40 to 150 F
IES cut off	yes	no	no	yes	no
System					
Field history	3 years	2 years	2 years	6 years	6 years
Lighting controls	D to D, clock, timers	D to D, clock, timers	2 timers	dusk/dawn,timer	dusk/dawn,timer
Timer range	0-15 hours	0-15 hours	1-15 & 1-8 hrs	0-15 hours	0-15 hours
Controller make/model	SEPCO/LCU-1	SEPCO/LCU-1	SWSLC-12-SI-ST	Bobier/SCU-1	Bobier/SCU-1
Charge method	PWM	PWM	FET shunt 14.5v	stop @ 14.4v	stop @ 14.4v
Power Supply					
PV tilt range	15 or 45 deg	15 or 45 deg	25-60 deg	15 or 45 deg	15 or 45 deg
PV warranty	10yr / 90%	10yr / 90%	10yr / 90%	20yr / 80%	20yr / 80%
PV field history	10+ years	10+ years	10+ years	6 years	6 years
Battery make/model	East Penn/8G27	East Penn/8G27	Concorde/GPC1295	Deka/8G24	Deka/8G24
Battery type	gelled, valve reg.	gelled, valve reg.	starved, valve reg.	gelled, valve reg.	gelled, valve reg.
Estimated Battery life	5-7 years	5-7 years	5 years	5 years	5 years
Supplier					
Supplier name	SEPCO	SEPCO	SunWize	Solar Outdoor Lighting	Solar Outdoor Lighting
PV lighting experience	3	3	3	6	6
System warranty	2 years	2 years	2 years	2 years	2 years
Lead time to ship	1 week	1 week	4 weeks	4 days	4 days

System Prices by Power Supply Size:

Small ID	SEP01-S-AL	SEP13-S-AL	SW02-S-AL	SOL08-S-AL	SOL07-S-AL
PV Watts	50	75	110	53	83
PV make/model	Siemens	Siemens	Siemens 55	Solarex/MSX-53	Solarex/MSX-83
Battery Capacity Avail.	5.0 days	3.7 days	5.1 days	5.3 days	3.7 days
ND/CO/AZ					
Run time	5 / 7 / 8	4 / 6 / 7	12 / 17 / 22	5 / 7 / 9	4 / 6 / 7
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
Small System $	$1,625	$1,625	$1,590	$1,959	$2,476

Medium ID	SEP01-M-AL	SEP13-M-AL	SW02-M-AL	SOL08-M-AL	SOL07-M-AL
PV Watts	75	100	110	77	141
PV make/model	Siemens	Siemens	Siemens 55	Solarex/MSX-77	Solarex/MSX-64&77
Battery Capacity Avail.	3.0 days	3.1 days	6.1 days	6.4 days	4.4 days
ND/CO/AZ					
Run time	7 / 10 / 12	6 / 8 / 10	8 / 12 / 14	8 / 10 / 13	7 / 10 / 13
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
Med System $	$1,769	$1,769	$1,975	$2,269	$3,200

Large ID	SEP01-L-AL	SEP13-L-AL	SW02-L-AL	SOL08-L-AL	SOL07-L-AL
PV Watts	100	150	165	113	192
PV make/model	Siemens	Siemens	Siemens 55	Solarex/MSX-53&64	Solarex/MSX-64
Battery Capacity Avail.	3.0 days	3.2 days	4.4 days	4.6 days	3.1 days
ND/CO/AZ					
Run time	10 / 13 / 16	9 / 12 / 15	8 / 12 / 14	10 / 15 / 18	10 / 14 / 17
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
Large System $	$2,059	$2,059	$2,525	$2,838	$3,717

X-Large ID	SEP01-X-AL	SEP13-X-AL	SW02-X-AL	SOL08-X-AL	SOL07-X-AL
PV Watts	150	200	220	141	249
PV make/model	Siemens	Siemens	Siemens 55	Solarex/MSX-64&77	Solarex/MSX-83
Battery Capacity Avail.	3.4 days	3.4 days	5.1 days	3.6 days	2.4 days
ND/CO/AZ					
Run time	15 / 20 / 25	12 / 16 / 20	16 / 24 / 24	13 / 18 / 0	13 / 18 / 0
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
XL System $	$2,997	$2,997	$2,910	$3,200	$4,337

Chart 2: Area Lighting System Comparisons — **Node A-B15 (0.5FC, 15 ft radius)**

Series ID	SEP05-0-AL	SEP01-0-AL	SEP13-0-AL	SW02-0-AL	SOL10-0-AL	SOL05-0-AL
Luminaire						
Lamp Type	CF	CF	LPS	CF	CF	CF
Lamp input / output	39W / 2850 Lumens	26W / 1800 Lumens	35W / 4800 Lumens	36W / 2900 Lumens	36W / 2900 Lumens	32W / 2400 Lumens
Lamp life	10,000 hrs	10,000 hrs	18,000 hrs	10,000 hrs	10,000 hrs	10,000 hrs
# of lamps / # luminaire	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1
Luminaire type	area flood	cobra head	cobra head	shoe box	shoe box	cobra head
Luminaire make/model	SEPCO-F1	GE/M400A2 cutoff	GE/M-400A2	Mor-Lite 1x36	Phoenix Metals	GE
Optional luminaire types avaliable		power flood, shoe box	power flood			
Starting temp. range	0 to 140 F	0 to 140 F	-40 to 150 F	-40 to 130 F	-40 to 150 F	-40 to 150 F
IES cut off	yes	yes	no	no	yes	no
System						
Field history	3 years	3 years	2 years	2 years	6 years	6 years
Lighting controls	D to D, clock, timers	D to D, clock, timers	D to D, clock, timers	2 timers	dusk/dawn,timer	dusk/dawn,timer
Timer range	0-15 hours	0-15 hours	0-15 hours	1-15 & 1-8 hrs	0-15 hours	0-15 hours
Controller make/model	SEPCO/LCU-1	SEPCO/LCU-1	SEPCO/LCU-1	SWSLC-12-SI-ST	Bobier/SCU-1	Bobier/SCU-1
Charge method	PWM	PWM	PWM	FET shunt 14.5v	stop @ 14.4v	stop @ 14.4v
Power Supply						
PV tilt range	15 or 45 deg	15 or 45 deg	15 or 45 deg	25-60 deg	15 or 45 deg	15 or 45 deg
PV warranty	10yr / 90%	10yr / 90%	10yr / 90%	10yr / 90%	20yr / 80%	20yr / 80%
PV field history	10+ years	10+ years	10+ years	10+ years	6 years	6 years
Battery make/model	East Penn/8G27	East Penn/8G27	East Penn/8G27	Concorde/GPC1295	Deka/8G24	Deka/8G24
Battery type	gelled, valve reg.	gelled, valve reg.	gelled, valve reg.	starved, valve reg.	gelled, valve reg.	gelled, valve reg.
Estimated Battery life	5-7 years	5-7 years	5-7 years	5 years	5 years	5 years
Supplier						
Supplier name	SEPCO	SEPCO	SEPCO	SunWize	Solar Outdoor Lighting	Solar Outdoor Lighting
PV lighting experience	3	3	3	3	6	6
System warranty	2 years	2 years	2 years	2 years	2 years	2 years
Lead time to ship	1 week	1 week	1 week	4 weeks	4 days	4 days

System Prices by Power Supply Size:

Small ID	SEP05-S-AL	SEP01-S-AL	SEP13-S-AL	SW02-S-AL	SOL10-S-AL	SOL05-S-AL
PV Watts	50	50	75	110	64	77
PV make/model	Siemens	Siemens	Siemens	Siemens 55	Solarex/MSX-64	Solarex/MSX-77
Battery Capacity Avail.	3.4 days	5.0 days	3.7 days	5.1 days	3.6 days	4.0 days
ND/CO/AZ						
Run time	4 / 5 / 6	5 / 7 / 8	4 / 6 / 7	12 / 17 / 22	4 / 6 / 8	5 / 7 / 8
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
Small System $	$1,519	$1,625	$1,625	$1,590	$2,114	$2,269

Medium ID	SEP05-M-AL	SEP01-M-AL	SEP13-M-AL	SW02-M-AL	SOL10-M-AL	SOL05-M-AL
PV Watts	75	75	100	110	106	120
PV make/model	Siemens	Siemens	Siemens	Siemens 55	Solarex/MSX-53	Solarex/MSX-60
Battery Capacity Avail.	2.0 days	3.0 days	3.1 days	6.1 days	4.3 days	4.8 days
ND/CO/AZ						
Run time	10 / 8 / 10	7 / 10 / 12	6 / 8 / 10	8 / 12 / 14	8 / 10 / 13	7 / 10 / 13
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
Med System $	$1,663	$1,769	$1,769	$1,975	$2,786	$2,890

Large ID	SEP05-L-AL	SEP01-L-AL	SEP13-L-AL	SW02-L-AL	SOL10-L-AL	SOL05-L-AL
PV Watts	100	100	150	165	141	166
PV make/model	Siemens	Siemens	Siemens	Siemens 55	Solarex/MSX-64&77	Solarex/MSX-83
Battery Capacity Avail.	2.0 days	3.0 days	3.2 days	4.4 days	3.0 days	3.4 days
ND/CO/AZ						
Run time	8 / 10 / 13	10 / 13 / 16	9 / 12 / 15	8 / 12 / 14	10 / 10 / 17	10 / 14 / 17
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
Large System $	$1,953	$2,059	$2,059	$2,525	$3,200	$3,407

X-Large ID	SEP05-X-AL	SEP01-X-AL	SEP13-X-AL	SW02-X-AL	SOL10-X-AL	SOL05-X-AL
PV Watts	150	150	200	220	180	219
PV make/model	Siemens	Siemens	Siemens	Siemens 55	Solarex/MSX-60	Solarex/MSX-53&83
Battery Capacity Avail.	2.2 days	3.4 days	3.4 days	5.1 days	2.4 days	2.7 days
ND/CO/AZ						
Run time	12 / 16 / 20	15 / 20 / 25	12 / 16 / 20	16 / 24 / 24	13 / 18 / 0	13 / 18 / 0
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
XL System $	$2,891	$2,997	$2,997	$2,910	$3,614	$3,924

Chart 2: Area Lighting System Comparisons **Node A-B25 (0.5FC, 25 ft radius)**

Series ID	SEP13-0-AL	SW02-0-AL	SOL10-0-AL	SEP15-0-AL
Luminaire				
Lamp Type	LPS	CF	CF	CF
Lamp input / output	35W / 4800 Lumens	36W / 2900 Lumens	36W / 2900 Lumens	26W / 1800 Lumens
Lamp life	18,000 hrs	10,000 hrs	10,000 hrs	
# of lamps / # luminaire	1 / 1	1 / 1	1 / 1	2 / 2
Luminaire type	cobra head	shoe box	shoe box	power flood
Luminaire make/model	GE/M-400A2	Mor-Lite 1x36	Phoenix Metals	GE/PF400KN
Optional luminaire types avaliable				
Starting temp. range	-40 to 150 F	-40 to 130 F	-40 to 150 F	0 to 140 F
IES cut off	no	no	yes	yes
System				
Field history	2 years	2 years	6 years	3 years
Lighting controls	D to D, clock, timers	2 timers	dusk/dawn,timer	D to D, clock, timers
Timer range	0-15 hours	1-15 & 1-8 hrs	0-15 hours	0-15 hours
Controller make/model	SEPCO/LCU-1	SWSLC-12-SI-ST	Bobier/SCU-1	SEPCO/LCU-1
Charge method	PWM	FET shunt 14.5v	stop @ 14.4v	PWM
Power Supply				
PV tilt range	15 or 45 deg	25-60 deg	15 or 45 deg	15 or 45 deg
PV warranty	10yr / 90%	10yr / 90%	20yr / 80%	10yr / 90%
PV field history	10+ years	10+ years	6 years	10+ years
Battery make/model	East Penn/8G27	Concorde/GPC1295	Deka/8G24	East Penn/8G27
Battery type	gelled, valve reg.	starved, valve reg.	gelled, valve reg.	gelled, valve reg.
Estimated Battery life	5-7 years	5 years	5 years	5-7 years
Supplier				
Supplier name	SEPCO	SunWize	Solar Outdoor Lighting	SEPCO
PV lighting experience	3	3	6	3
System warranty	2 years	2 years	2 years	2 years
Lead time to ship	1 week	4 weeks	4 days	1 week

System Prices by Power Supply Size:

Small ID	SEP13-S-AL	SW02-S-AL	SOL10-S-AL	SEP15-S-AL
PV Watts	75	110	64	100
PV make/model	Siemens	Siemens 55	Solarex/MSX-64	Siemens
Battery Capacity Avail.	3.7 days	5.1 days	3.6 days	6.9 days
ND/CO/AZ				
Run time	4 / 6 / 7	12 / 17 / 22	4 / 6 / 8	4 / 6 / 8
Sun hours	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
Small System $	$1,625	$1,590	$2,114	$2,242

Medium ID	SEP13-M-AL	SW02-M-AL	SOL10-M-AL	SEP15-M-AL
PV Watts	100	110	106	150
PV make/model	Siemens	Siemens 55	Solarex/MSX-53	Siemens
Battery Capacity Avail.	3.1 days	6.1 days	4.3 days	6.1 days
ND/CO/AZ				
Run time	6 / 8 / 10	8 / 12 / 14	8 / 10 / 13	7 / 9 / 11
Sun hours	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
Med System $	$1,769	$1,975	$2,786	$2,532

Large ID	SEP13-L-AL	SW02-L-AL	SOL10-L-AL	SEP15-L-AL
PV Watts	150	165	141	200
PV make/model	Siemens	Siemens 55	Solarex/MSX-64&77	Siemens
Battery Capacity Avail.	3.2 days	4.4 days	3.0 days	5.9 days
ND/CO/AZ				
Run time	9 / 12 / 15	8 / 12 / 14	10 / 10 / 17	9 / 12 / 15
Sun hours	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
Large System $	$2,059	$2,525	$3,200	$3,470

X-Large ID	SEP13-X-AL	SW02-X-AL	SOL10-X-AL	SEP15-X-AL
PV Watts	200	220	180	250
PV make/model	Siemens	Siemens 55	Solarex/MSX-60	Siemens
Battery Capacity Avail.	3.4 days	5.1 days	2.4 days	4.6 days
ND/CO/AZ				
Run time	12 / 16 / 20	16 / 24 / 24	13 / 18 / 0	12 / 15 / 18
Sun hours	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
XL System $	$2,997	$2,910	$3,614	$3,954

Chart 2: Area Lighting System Comparisons — **Node A-B35 (0.5FC, 35 ft radius)**

Series ID	**SEP13-0-AL**
Luminaire	
Lamp Type	LPS
Lamp input / output	35W / 4800 Lumens
Lamp life	18,000 hrs
# of lamps / # luminaire	1 / 1
Luminaire type	cobra head
Luminaire make/model	GE/M-400A2
Optional luminaire types avaliable	
Starting temp. range	-40 to 150 F
IES cut off	no
System	
Field history	2 years
Lighting controls	D to D, clock, timers
Timer range	0-15 hours
Controller make/model	SEPCO/LCU-1
Charge method	PWM
Power Supply	
PV tilt range	15 or 45 deg
PV warranty	10yr / 90%
PV field history	10+ years
Battery make/model	East Penn/8G27
Battery type	gelled, valve reg.
Estimated Battery life	5-7 years
Supplier	
Supplier name	SEPCO
PV lighting experience	3
System warranty	2 years
Lead time to ship	1 week

System Prices by Power Supply Size:

Small ID	SEP13-S-AL
PV Watts	75
PV make/model	Siemens
Battery Capacity Avail.	3.7 days
ND/CO/AZ	
Run time	4 / 6 / 7
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
Small System $	$1,625

Medium ID	SEP13-M-AL
PV Watts	100
PV make/model	Siemens
Battery Capacity Avail.	3.1 days
ND/CO/AZ	
Run time	6 / 8 / 10
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
Med System $	$1,769

Large ID	SEP13-L-AL
PV Watts	150
PV make/model	Siemens
Battery Capacity Avail.	3.2 days
ND/CO/AZ	
Run time	9 / 12 / 15
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
Large System $	$2,059

X-Large ID	SEP13-X-AL
PV Watts	200
PV make/model	Siemens
Battery Capacity Avail.	3.4 days
ND/CO/AZ	
Run time	12 / 16 / 20
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
XL System $	$2,997

Chart 2: Area Lighting System Comparisons — **Node A-C05 (1FC, 5 ft radius)**

Series ID	SEP05-0-AL	SEP13-0-AL	SEP03-0-AL	SW02-0-AL	SOL10-0-AL	SOL07-0-AL
Luminaire						
Lamp Type	CF	LPS	CF	CF	CF	LPS
Lamp input / output	39W / 2850 Lumens	35W / 4800 Lumens	26W / 1800 Lumens	36W / 2900 Lumens	36W / 2900 Lumens	35W / 4800 Lumens
Lamp life	10,000 hrs	18,000 hrs	10,000 hrs	10,000 hrs	10,000 hrs	18,000 hrs
# of lamps / # luminaire	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1
Luminaire type	area flood	cobra head	power flood	shoe box	shoe box	cobra head
Luminaire make/model	SEPCO-F1	GE/M-400A2	GE/PF400KN	Mor-Lite 1x36	Phoenix Metals	GE
Optional luminaire types avaliable		power flood	wall, power flood			
Starting temp. range	0 to 140 F	-40 to 150 F	0 to 140 F	-40 to 130 F	-40 to 150 F	-40 to 150 F
IES cut off	yes	no	yes	no	yes	no
System						
Field history	3 years	2 years	3 years	2 years	6 years	6 years
Lighting controls	D to D, clock, timers	D to D, clock, timers	D to D, clock, timers	2 timers	dusk/dawn,timer	dusk/dawn,timer
Timer range	0-15 hours	0-15 hours	0-15 hours	1-15 & 1-8 hrs	0-15 hours	0-15 hours
Controller make/model	SEPCO/LCU-1	SEPCO/LCU-1	SEPCO/LCU-1	SWSLC-12-SI-ST	Bobier/SCU-1	Bobier/SCU-1
Charge method	PWM	PWM	PWM	FET shunt 14.5v	stop @ 14.4v	stop @ 14.4v
Power Supply						
PV tilt range	15 or 45 deg	15 or 45 deg	15 or 45 deg	25-60 deg	15 or 45 deg	15 or 45 deg
PV warranty	10yr / 90%	10yr / 90%	10yr / 90%	10yr / 90%	20yr / 80%	20yr / 80%
PV field history	10+ years	10+ years	10+ years	10+ years	6 years	6 years
Battery make/model	East Penn/8G27	East Penn/8G27	East Penn/8G27	Concorde/GPC1295	Deka/8G24	Deka/8G24
Battery type	gelled, valve reg.	gelled, valve reg.	gelled, valve reg.	starved, valve reg.	gelled, valve reg.	gelled, valve reg.
Estimated Battery life	5-7 years	5-7 years	5-7 years	5 years	5 years	5 years
Supplier						
Supplier name	SEPCO	SEPCO	SEPCO	SunWize	Solar Outdoor Lighting	Solar Outdoor Lighting
PV lighting experience	3	3	3	3	6	6
System warranty	2 years	2 years	2 years	2 years	2 years	2 years
Lead time to ship	1 week	1 week	1 week	4 weeks	4 days	4 days

System Prices by Power Supply Size:

Small ID	SEP05-S-AL	SEP13-S-AL	SEP03-S-AL	SW02-S-AL	SOL10-S-AL	SOL07-S-AL
PV Watts	50	75	50	110	64	83
PV make/model	Siemens	Siemens	Siemens	Siemens 55	Solarex/MSX-64	Solarex/MSX-83
Battery Capacity Avail.	3.4 days	3.7 days	5.0 days	5.1 days	3.6 days	3.7 days
ND/CO/AZ						
Run time	4 / 5 / 6	4 / 6 / 7	5 / 7 / 8	12 / 17 / 22	4 / 6 / 8	4 / 6 / 7
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
Small System $	$1,519	$1,625	$1,714	$1,590	$2,114	$2,476

Medium ID	SEP05-M-AL	SEP13-M-AL	SEP03-M-AL	SW02-M-AL	SOL10-M-AL	SOL07-M-AL
PV Watts	75	100	75	110	106	141
PV make/model	Siemens	Siemens	Siemens	Siemens 55	Solarex/MSX-53	Solarex/MSX-64&77
Battery Capacity Avail.	2.0 days	3.1 days	3.0 days	6.1 days	4.3 days	4.4 days
ND/CO/AZ						
Run time	10 / 8 / 10	6 / 8 / 10	7 / 10 / 12	8 / 12 / 14	8 / 10 / 13	7 / 10 / 13
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
Med System $	$1,663	$1,769	$1,858	$1,975	$2,786	$3,200

Large ID	SEP05-L-AL	SEP13-L-AL	SEP03-L-AL	SW02-L-AL	SOL10-L-AL	SOL07-L-AL
PV Watts	100	150	100	165	141	192
PV make/model	Siemens	Siemens	Siemens	Siemens 55	Solarex/MSX-64&77	Solarex/MSX-64
Battery Capacity Avail.	2.0 days	3.2 days	3.0 days	4.4 days	3.0 days	3.1 days
ND/CO/AZ						
Run time	8 / 10 / 13	9 / 12 / 15	10 / 13 / 16	8 / 12 / 14	10 / 10 / 17	10 / 14 / 17
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
Large System $	$1,953	$2,059	$2,147	$2,525	$3,200	$3,717

X-Large ID	SEP05-X-AL	SEP13-X-AL	SEP03-X-AL	SW02-X-AL	SOL10-X-AL	SOL07-X-AL
PV Watts	150	200	150	220	180	249
PV make/model	Siemens	Siemens	Siemens	Siemens 55	Solarex/MSX-60	Solarex/MSX-83
Battery Capacity Avail.	2.2 days	3.4 days	3.4 days	5.1 days	2.4 days	2.4 days
ND/CO/AZ						
Run time	12 / 16 / 20	12 / 16 / 20	15 / 20 / 25	16 / 24 / 24	13 / 18 / 0	13 / 18 / 0
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45	45 / 45 / 45
XL System $	$2,891	$2,997	$3,086	$2,910	$3,614	$4,337

Node A-C05 (1FC, 5 ft radius)

Chart 2: Area Lighting System Comparisons — **Node A-C15 (1FC, 15 ft radius)**

Series ID	SOL11-0-AL	SEP13-0-AL	SEP03-0-AL	SW02-0-AL	SEP15-0-AL
Luminaire					
Lamp Type	CF	LPS	CF	CF	CF
Lamp input / output	36W / 1800 Lumens	35W / 4800 Lumens	26W / 1800 Lumens	36W / 2900 Lumens	26W / 1800 Lumens
Lamp life	10,000 hrs	18,000 hrs	10,000 hrs	10,000 hrs	
# of lamps / # luminaire	1 / 1	1 / 1	1 / 1	1 / 1	2 / 2
Luminaire type	shoe box	cobra head	power flood	shoe box	power flood
Luminaire make/model	Phoenix Metals	GE/M-400A2	GE/PF400KN	Mor-Lite 1x36	GE/PF400KN
Optional luminaire types avaliable		power flood			
Starting temp. range	-40 to 150 F	-40 to 150 F	0 to 140 F	-40 to 130 F	0 to 140 F
IES cut off	yes	no	yes	no	yes
System					
Field history	6 years	2 years	3 years	2 years	3 years
Lighting controls	dusk/dawn,timer	D to D, clock, timers	D to D, clock, timers	2 timers	D to D, clock, timers
Timer range	0-15 hours	0-15 hours	0-15 hours	1-15 & 1-8 hrs	0-15 hours
Controller make/model	Bobier/SCU-1	SEPCO/LCU-1	SEPCO/LCU-1	SWSLC-12-SI-ST	SEPCO/LCU-1
Charge method	stop @ 14.4v	PWM	PWM	FET shunt 14.5v	PWM
Power Supply					
PV tilt range	15 or 45 deg	15 or 45 deg	15 or 45 deg	25-60 deg	15 or 45 deg
PV warranty	20yr / 80%	10yr / 90%	10yr / 90%	10yr / 90%	10yr / 90%
PV field history	6 years	10+ years	10+ years	10+ years	10+ years
Battery make/model	Deka/8G24	East Penn/8G27	East Penn/8G27	Concorde/GPC1295	East Penn/8G27
Battery type	gelled, valve reg.	gelled, valve reg.	gelled, valve reg.	starved, valve reg.	gelled, valve reg.
Estimated Battery life	5 years	5-7 years	5-7 years	5 years	5-7 years
Supplier					
Supplier name	Solar Outdoor Lighting	SEPCO	SEPCO	SunWize	SEPCO
PV lighting experience	6	3	3	3	3
System warranty	2 years	2 years	2 years	2 years	2 years
Lead time to ship	4 days	1 week	1 week	4 weeks	1 week

System Prices by Power Supply Size:

Small ID	SOL11-S-AL	SEP13-S-AL	SEP03-S-AL	SW02-S-AL	SEP15-S-AL
PV Watts	120	75	50	110	100
PV make/model	Solarex/MSX-60	Siemens	Siemens	Siemens 55	Siemens
Battery Capacity Avail.	7.1 days	3.7 days	5.0 days	5.1 days	6.9 days
ND/CO/AZ					
Run time	5 / 6 / 7	4 / 6 / 7	5 / 7 / 8	12 / 17 / 22	4 / 6 / 8
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45
Small System $	$2,993	$1,625	$1,714	$1,590	$2,242

Medium ID		SEP13-M-AL	SEP03-M-AL	SW02-M-AL	SEP15-M-AL
PV Watts		100	75	110	150
PV make/model		Siemens	Siemens	Siemens 55	Siemens
Battery Capacity Avail.		3.1 days	3.0 days	6.1 days	6.1 days
ND/CO/AZ					
Run time		6 / 8 / 10	7 / 10 / 12	8 / 12 / 14	7 / 9 / 11
Sun hours		3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5
PV tilt angle		45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45
Med System $		$1,769	$1,858	$1,975	$2,532

Large ID		SEP13-L-AL	SEP03-L-AL	SW02-L-AL	SEP15-L-AL
PV Watts		150	100	165	200
PV make/model		Siemens	Siemens	Siemens 55	Siemens
Battery Capacity Avail.		3.2 days	3.0 days	4.4 days	5.9 days
ND/CO/AZ					
Run time		9 / 12 / 15	10 / 13 / 16	8 / 12 / 14	9 / 12 / 15
Sun hours		3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5
PV tilt angle		45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45
Large System $		$2,059	$2,147	$2,525	$3,470

X-Large ID		SEP13-X-AL	SEP03-X-AL	SW02-X-AL	SEP15-X-AL
PV Watts		200	150	220	250
PV make/model		Siemens	Siemens	Siemens 55	Siemens
Battery Capacity Avail.		3.4 days	3.4 days	5.1 days	4.6 days
ND/CO/AZ					
Run time		12 / 16 / 20	15 / 20 / 25	16 / 24 / 24	12 / 15 / 18
Sun hours		3 / 4 / 5	3 / 4 / 5	3 / 4 / 6	3 / 4 / 5
PV tilt angle		45 / 45 / 45	45 / 45 / 45	60 / 55 / 45	45 / 45 / 45
XL System $		$2,997	$3,086	$2,910	$3,954

Chart 2: Area Lighting System Comparisons

Node A-C25 (1FC, 25 ft radius)

Series ID	**SEP13-0-AL**
Luminaire	
Lamp Type	LPS
Lamp input / output	35W / 4800 Lumens
Lamp life	18,000 hrs
# of lamps / # luminaire	1 / 1
Luminaire type	cobra head
Luminaire make/model	GE/M-400A2
Optional luminaire types avaliable	
Starting temp. range	-40 to 150 F
IES cut off	no
System	
Field history	2 years
Lighting controls	D to D, clock, timers
Timer range	0-15 hours
Controller make/model	SEPCO/LCU-1
Charge method	PWM
Power Supply	
PV tilt range	15 or 45 deg
PV warranty	10yr / 90%
PV field history	10+ years
Battery make/model	East Penn/8G27
Battery type	gelled, valve reg.
Estimated Battery life	5-7 years
Supplier	
Supplier name	SEPCO
PV lighting experience	3
System warranty	2 years
Lead time to ship	1 week

System Prices by Power Supply Size:

Small ID	SEP13-S-AL
PV Watts	75
PV make/model	Siemens
Battery Capacity Avail.	3.7 days
ND/CO/AZ	
Run time	4 / 6 / 7
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
Small System $	$1,625

Medium ID	SEP13-M-AL
PV Watts	100
PV make/model	Siemens
Battery Capacity Avail.	3.1 days
ND/CO/AZ	
Run time	6 / 8 / 10
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
Med System $	$1,769

Large ID	SEP13-L-AL
PV Watts	150
PV make/model	Siemens
Battery Capacity Avail.	3.2 days
ND/CO/AZ	
Run time	9 / 12 / 15
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
Large System $	$2,059

X-Large ID	SEP13-X-AL
PV Watts	200
PV make/model	Siemens
Battery Capacity Avail.	3.4 days
ND/CO/AZ	
Run time	12 / 16 / 20
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
XL System $	$2,997

Chart 2: Area Lighting System Comparisons — **Node A-D05 (1.5FC, 5 ft radius)**

Series ID	SOL11-0-AL	SEP05-0-AL	SEP13-0-AL	SEP10-0-AL
Luminaire				
Lamp Type	CF	CF	LPS	CF
Lamp input / output	36W / 1800 Lumens	39W / 2850 Lumens	35W / 4800 Lumens	27W / 1800 Lumens
Lamp life	10,000 hrs	10,000 hrs	18,000 hrs	10,000 hrs
# of lamps / # luminaire	1 / 1	1 / 1	1 / 1	1 / 1
Luminaire type	shoe box	area flood	cobra head	wall mount
Luminaire make/model	Phoenix Metals	SEPCO-F1	GE/M-400A2	GE/W194T
Optional luminaire types avaliable				
Starting temp. range	-40 to 150 F	0 to 140 F	-40 to 150 F	0 to 140 F
IES cut off	yes	yes	no	no
System				
Field history	6 years	3 years	2 years	3 years
Lighting controls	dusk/dawn,timer	D to D, clock, timers	D to D, clock, timers	D to D, clock, timers
Timer range	0-15 hours	0-15 hours	0-15 hours	0-15 hours
Controller make/model	Bobier/SCU-1	SEPCO/LCU-1	SEPCO/LCU-1	SEPCO/LCU-1
Charge method	stop @ 14.4v	PWM	PWM	PWM
Power Supply				
PV tilt range	15 or 45 deg	15 or 45 deg	15 or 45 deg	15 or 45 deg
PV warranty	20yr / 80%	10yr / 90%	10yr / 90%	10yr / 90%
PV field history	6 years	10+ years	10+ years	10+ years
Battery make/model	Deka/8G24	East Penn/8G27	East Penn/8G27	East Penn/8G27
Battery type	gelled, valve reg.	gelled, valve reg.	gelled, valve reg.	gelled, valve reg.
Estimated Battery life	5 years	5-7 years	5-7 years	5-7 years
Supplier				
Supplier name	Solar Outdoor Lighting	SEPCO	SEPCO	SEPCO
PV lighting experience	6	3	3	3
System warranty	2 years	2 years	2 years	2 years
Lead time to ship	4 days	1 week	1 week	1 week

System Prices by Power Supply Size:

Small ID	SOL11-S-AL	SEP05-S-AL	SEP13-S-AL	SEP10-S-AL
PV Watts	120	50	75	50
PV make/model	Solarex/MSX-60	Siemens	Siemens	Siemens
Battery Capacity Avail.	7.1 days	3.4 days	3.7 days	4.9 days
ND/CO/AZ				
Run time	5 / 6 / 7	4 / 5 / 6	4 / 6 / 7	6 / 7 / 9
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45	45 / 45 / 45
Small System $	$2,993	$1,519	$1,625	$1,626

Medium ID		SEP05-M-AL	SEP13-M-AL	SEP10-M-AL
PV Watts		75	100	75
PV make/model		Siemens	Siemens	Siemens
Battery Capacity Avail.		2.0 days	3.1 days	2.9 days
ND/CO/AZ				
Run time		10 / 8 / 10	6 / 8 / 10	8 / 10 / 13
Sun hours		3 / 4 / 5	3 / 4 / 5	3 / 4 / 5
PV tilt angle		45 / 45 / 45	45 / 45 / 45	45 / 45 / 45
Med System $		$1,663	$1,769	$1,770

Large ID		SEP05-L-AL	SEP13-L-AL	SEP10-L-AL
PV Watts		100	150	100
PV make/model		Siemens	Siemens	Siemens
Battery Capacity Avail.		2.0 days	3.2 days	2.8 days
ND/CO/AZ				
Run time		8 / 10 / 13	9 / 12 / 15	11 / 14 / 18
Sun hours		3 / 4 / 5	3 / 4 / 5	3 / 4 / 5
PV tilt angle		45 / 45 / 45	45 / 45 / 45	45 / 45 / 45
Large System $		$1,953	$2,059	$2,060

X-Large ID		SEP05-X-AL	SEP13-X-AL	SEP10-X-AL
PV Watts		150	200	150
PV make/model		Siemens	Siemens	Siemens
Battery Capacity Avail.		2.2 days	3.4 days	3.2 days
ND/CO/AZ				
Run time		12 / 16 / 20	12 / 16 / 20	16 / 22 / 27
Sun hours		3 / 4 / 5	3 / 4 / 5	3 / 4 / 5
PV tilt angle		45 / 45 / 45	45 / 45 / 45	45 / 45 / 45
XL System $		$2,891	$2,997	$2,998

Chart 2: Area Lighting System Comparisons

Node A-D15 (1.5FC, 15 ft radius)

Series ID	SEP13-0-AL	SEP15-0-AL	SW01-0-AL
Luminaire			
Lamp Type	LPS	CF	CF
Lamp input / output	35W / 4800 Lumens	26W / 1800 Lumens	36W / 2900 Lumens
Lamp life	18,000 hrs		10,000 hrs
# of lamps / # luminaire	1 / 1	2 / 2	2 / 1
Luminaire type	cobra head	power flood	shoe box
Luminaire make/model	GE/M-400A2	GE/PF400KN	Mor-Lite 2x36
Optional luminaire types avaliable			
Starting temp. range	-40 to 150 F	0 to 140 F	-40 to 130 F
IES cut off	no	yes	no
System			
Field history	2 years	3 years	2 years
Lighting controls	D to D, clock, timers	D to D, clock, timers	2 timers
Timer range	0-15 hours	0-15 hours	1-15 & 1-8 hrs
Controller make/model	SEPCO/LCU-1	SEPCO/LCU-1	SWSLC-12-SI-ST
Charge method	PWM	PWM	FET shunt 14.5v
Power Supply			
PV tilt range	15 or 45 deg	15 or 45 deg	25-60 deg
PV warranty	10yr / 90%	10yr / 90%	10yr / 90%
PV field history	10+ years	10+ years	10+ years
Battery make/model	East Penn/8G27	East Penn/8G27	Concorde/GPC1295
Battery type	gelled, valve reg.	gelled, valve reg.	starved, valve reg.
Estimated Battery life	5-7 years	5-7 years	5 years
Supplier			
Supplier name	SEPCO	SEPCO	SunWize
PV lighting experience	3	3	3
System warranty	2 years	2 years	2 years
Lead time to ship	1 week	1 week	4 weeks

System Prices by Power Supply Size:

Small ID	SEP13-S-AL	SEP15-S-AL	SW01-S-AL
PV Watts	75	100	110
PV make/model	Siemens	Siemens	Siemens 55
Battery Capacity Avail.	3.7 days	6.9 days	10.2 days
ND/CO/AZ			
Run time	4 / 6 / 7	4 / 6 / 8	10 / 14 / 18
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6
PV tilt angle	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45
Small System $	$1,625	$2,242	$2,305

Medium ID	SEP13-M-AL	SEP15-M-AL	SW01-M-AL
PV Watts	100	150	220
PV make/model	Siemens	Siemens	Siemens 55
Battery Capacity Avail.	3.1 days	6.1 days	6.1 days
ND/CO/AZ			
Run time	6 / 8 / 10	7 / 9 / 11	8 / 12 / 14
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6
PV tilt angle	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45
Med System $	$1,769	$2,532	$3,075

Large ID	SEP13-L-AL	SEP15-L-AL	SW01-L-AL
PV Watts	150	200	275
PV make/model	Siemens	Siemens	Siemens 55
Battery Capacity Avail.	3.2 days	5.9 days	6.6 days
ND/CO/AZ			
Run time	9 / 12 / 15	9 / 12 / 15	4 / 6 / 7
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6
PV tilt angle	45 / 45 / 45	45 / 45 / 45	60 / 55 / 45
Large System $	$2,059	$3,470	$3,790

X-Large ID	SEP13-X-AL	SEP15-X-AL	
PV Watts	200	250	
PV make/model	Siemens	Siemens	
Battery Capacity Avail.	3.4 days	4.6 days	
ND/CO/AZ			
Run time	12 / 16 / 20	12 / 15 / 18	
Sun hours	3 / 4 / 5	3 / 4 / 5	
PV tilt angle	45 / 45 / 45	45 / 45 / 45	
XL System $	$2,997	$3,954	

Chart 2: Area Lighting System Comparisons

Node A-E05 (2.5FC, 5 ft radius)

Series ID	SEP15-0-AL	SW01-0-AL
Luminaire		
Lamp Type	CF	CF
Lamp input / output	26W / 1800 Lumens	36W / 2900 Lumens
Lamp life		10,000 hrs
# of lamps / # luminaire	2 / 2	2 / 1
Luminaire type	power flood	shoe box
Luminaire make/model	GE/PF400KN	Mor-Lite 2x36
Optional luminaire types avaliable		
Starting temp. range	0 to 140 F	-40 to 130 F
IES cut off	yes	no
System		
Field history	3 years	2 years
Lighting controls	D to D, clock, timers	2 timers
Timer range	0-15 hours	1-15 & 1-8 hrs
Controller make/model	SEPCO/LCU-1	SWSLC-12-SI-ST
Charge method	PWM	FET shunt 14.5v
Power Supply		
PV tilt range	15 or 45 deg	25-60 deg
PV warranty	10yr / 90%	10yr / 90%
PV field history	10+ years	10+ years
Battery make/model	East Penn/8G27	Concorde/GPC1295
Battery type	gelled, valve reg.	starved, valve reg.
Estimated Battery life	5-7 years	5 years
Supplier		
Supplier name	SEPCO	SunWize
PV lighting experience	3	3
System warranty	2 years	2 years
Lead time to ship	1 week	4 weeks

System Prices by Power Supply Size:

Small ID	SEP15-S-AL	SW01-S-AL
PV Watts	100	110
PV make/model	Siemens	Siemens 55
Battery Capacity Avail.	6.9 days	10.2 days
ND/CO/AZ		
Run time	4 / 6 / 8	10 / 14 / 18
Sun hours	3 / 4 / 5	3 / 4 / 6
PV tilt angle	45 / 45 / 45	60 / 55 / 45
Small System $	$2,242	$2,305

Medium ID	SEP15-M-AL	SW01-M-AL
PV Watts	150	220
PV make/model	Siemens	Siemens 55
Battery Capacity Avail.	6.1 days	6.1 days
ND/CO/AZ		
Run time	7 / 9 / 11	8 / 12 / 14
Sun hours	3 / 4 / 5	3 / 4 / 6
PV tilt angle	45 / 45 / 45	60 / 55 / 45
Med System $	$2,532	$3,075

Large ID	SEP15-L-AL	SW01-L-AL
PV Watts	200	275
PV make/model	Siemens	Siemens 55
Battery Capacity Avail.	5.9 days	6.6 days
ND/CO/AZ		
Run time	9 / 12 / 15	4 / 6 / 7
Sun hours	3 / 4 / 5	3 / 4 / 6
PV tilt angle	45 / 45 / 45	60 / 55 / 45
Large System $	$3,470	$3,790

X-Large ID	SEP15-X-AL	
PV Watts	250	
PV make/model	Siemens	
Battery Capacity Avail.	4.6 days	
ND/CO/AZ		
Run time	12 / 15 / 18	
Sun hours	3 / 4 / 5	
PV tilt angle	45 / 45 / 45	
XL System $	$3,954	

Chart 2: Area Lighting System Comparisons — **Node A-E15 (2.5FC, 15 ft radius)**

Series ID	**SEP15-0-AL**
Luminaire	
Lamp Type	CF
Lamp input / output	26W / 1800 Lumens
Lamp life	
# of lamps / # luminaire	2 / 2
Luminaire type	power flood
Luminaire make/model	GE/PF400KN
Optional luminaire types avaliable	
Starting temp. range	0 to 140 F
IES cut off	yes
System	
Field history	3 years
Lighting controls	D to D, clock, timers
Timer range	0-15 hours
Controller make/model	SEPCO/LCU-1
Charge method	PWM
Power Supply	
PV tilt range	15 or 45 deg
PV warranty	10yr / 90%
PV field history	10+ years
Battery make/model	East Penn/8G27
Battery type	gelled, valve reg.
Estimated Battery life	5-7 years
Supplier	
Supplier name	SEPCO
PV lighting experience	3
System warranty	2 years
Lead time to ship	1 week

System Prices by Power Supply Size:

Small ID	SEP15-S-AL
PV Watts	100
PV make/model	Siemens
Battery Capacity Avail.	6.9 days
ND/CO/AZ	
Run time	4 / 6 / 8
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
Small System $	$2,242

Medium ID	SEP15-M-AL
PV Watts	150
PV make/model	Siemens
Battery Capacity Avail.	6.1 days
ND/CO/AZ	
Run time	7 / 9 / 11
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
Med System $	$2,532

Large ID	SEP15-L-AL
PV Watts	200
PV make/model	Siemens
Battery Capacity Avail.	5.9 days
ND/CO/AZ	
Run time	9 / 12 / 15
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
Large System $	$3,470

X-Large ID	SEP15-X-AL
PV Watts	250
PV make/model	Siemens
Battery Capacity Avail.	4.6 days
ND/CO/AZ	
Run time	12 / 15 / 18
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
XL System $	$3,954

Sign Lighting System Selection

Chart S1: Performance Nodes

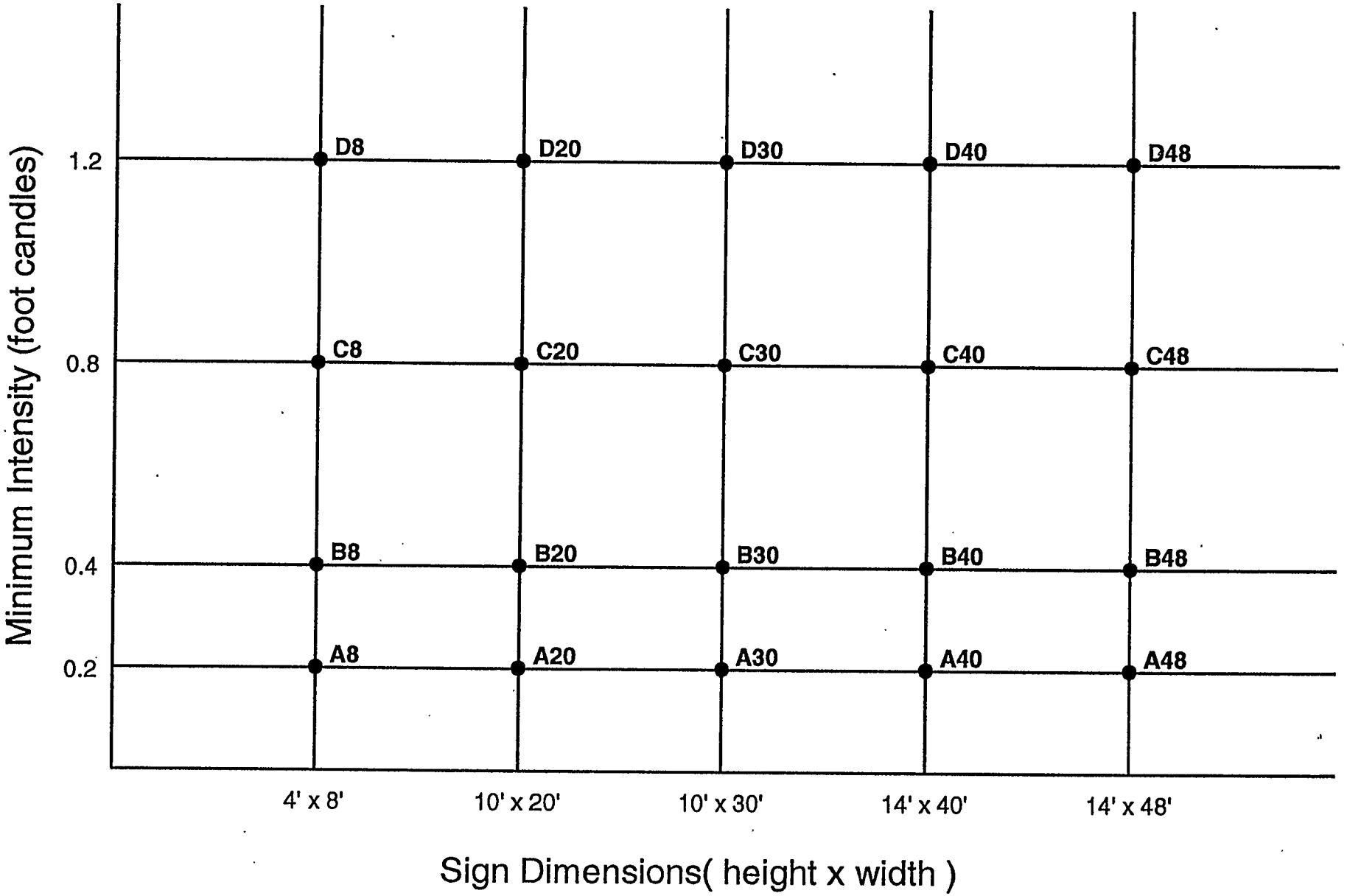


Chart 2: Sign Lighting System Comparisons

Node S-A08 (0.2FC, 8 ft wide)

Series ID	SEP01-0-SL	SOL01-0-SL
Luminaire		
Lamp Type	CF	CF
Lamp input / output	13W / 825 Lumens	13W / 900 Lumens
Lamp life	10,000 hrs	10,000 hrs
# of lamps / # luminaire	1 / 1	1 / 1
Luminaire type	flood	flood
Luminaire make/model	SEPCO F2	SunChrg/SLU-FLXX
Optional luminaire types avaliable		
Starting temp. range	0 to 140 F	0 to 140 F
IES cut off	yes	yes
System		
Field history	3 years	6 years
Lighting controls	D to D, clock, timers	dusk/dawn,timer
Timer range	0-15 hours	0-15 hours
Controller make/model	SEPCO/LCU-1	Bobier/SCU-1
Charge method	PWM	stop @ 14.4v
Power Supply		
PV tilt range	15 or 45 deg	45 deg
PV warranty	10yr / 90%	20yr / 80%
PV field history	10+ years	20 years
Battery make/model	East Penn/8G27	Deka/8G24
Battery type	gelled, valve reg.	gelled, valve reg.
Estimated Battery life	5-7 years	5 years
Supplier		
Supplier name	SEPCO	Solar Outdoor Lighting
PV lighting experience	3	6
System warranty	2 years	2 years
Lead time to ship	1 week	4 days

System Prices by Power Supply Size:

Small ID	SEP01-S-SL	SOL01-S-SL
PV Watts	35	53
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	9.8 days
ND/CO/AZ		
Run time	5 / 7 / 8	0 / 6 / 6
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Small System $	$1,341	$1,649

Medium ID	SEP01-M-SL	SOL01-M-SL
PV Watts	50	60
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	5.9 days
ND/CO/AZ		
Run time	7 / 10 / 12	0 / 10 / 10
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Med System $	$1,485	$1,752

Large ID	SEP01-L-SL	SOL01-L-SL
PV Watts	75	83
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	8.4 days
ND/CO/AZ		
Run time	10 / 13 / 16	0 / 14 / 14
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Large System $	$1,629	$2,218

X-Large ID	SEP01-X-SL	SOL01-X-SL
PV Watts	100	106
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	6.6 days
ND/CO/AZ		
Run time	15 / 20 / 25	0 / 18 / 18
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
XL System $	$1,918	$2,476

Chart 2: Sign Lighting System Comparisons

Node S-A20 (0.2FC, 20 ft wide)

Series ID	SEP03-0-SL	SOL01-0-SL
Luminaire		
Lamp Type	CF	CF
Lamp input / output	13W / 825 Lumens	13W / 900 Lumens
Lamp life	10,000 hrs	10,000 hrs
# of lamps / # luminaire	2 / 2	1 / 1
Luminaire type	flood	flood
Luminaire make/model	SEPCO F2	SunChrg/SLU-FLXX
Optional luminaire types avaliable		
Starting temp. range	0 to 140 F	0 to 140 F
IES cut off	yes	yes
System		
Field history	3 years	6 years
Lighting controls	D to D, clock, timers	dusk/dawn,timer
Timer range	0-15 hours	0-15 hours
Controller make/model	SEPCO/LCU-1	Bobier/SCU-1
Charge method	PWM	stop @ 14.4v
Power Supply		
PV tilt range	15 or 45 deg	45 deg
PV warranty	10yr / 90%	20yr / 80%
PV field history	10+ years	20 years
Battery make/model	East Penn/8G27	Deka/8G24
Battery type	gelled, valve reg.	gelled, valve reg.
Estimated Battery life	5-7 years	5 years
Supplier		
Supplier name	SEPCO	Solar Outdoor Lighting
PV lighting experience	3	6
System warranty	2 years	2 years
Lead time to ship	1 week	4 days

System Prices by Power Supply Size:

Small ID	SEP03-S-SL	SOL01-S-SL
PV Watts	50	53
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	9.8 days
ND/CO/AZ		
Run time	5 / 7 / 8	0 / 6 / 6
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Small System $	$1,666	$1,649

Medium ID	SEP03-M-SL	SOL01-M-SL
PV Watts	75	60
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	5.9 days
ND/CO/AZ		
Run time	7 / 10 / 12	0 / 10 / 10
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Med System $	$1,810	$1,752

Large ID	SEP03-L-SL	SOL01-L-SL
PV Watts	100	83
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	8.4 days
ND/CO/AZ		
Run time	10 / 13 / 16	0 / 14 / 14
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Large System $	$2,099	$2,218

X-Large ID	SEP03-X-SL	SOL01-X-SL
PV Watts	150	106
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	6.6 days
ND/CO/AZ		
Run time	15 / 20 / 25	0 / 18 / 18
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
XL System $	$3,038	$2,476

Chart 2: Sign Lighting System Comparisons

Node S-A30 (0.2FC, 30 ft wide)

Series ID	SEP05-0-SL
Luminaire	
Lamp Type	CF
Lamp input / output	13W / 825 Lumens
Lamp life	10,000 hrs
# of lamps / # luminaire	3 / 3
Luminaire type	flood
Luminaire make/model	SEPCO F2
Optional luminaire types avaliable	
Starting temp. range	0 to 140 F
IES cut off	yes
System	
Field history	3 years
Lighting controls	D to D, clock, timers
Timer range	0-15 hours
Controller make/model	SEPCO/LCU-1
Charge method	PWM
Power Supply	
PV tilt range	15 or 45 deg
PV warranty	10yr / 90%
PV field history	10+ years
Battery make/model	East Penn/8G27
Battery type	gelled, valve reg.
Estimated Battery life	5-7 years
Supplier	
Supplier name	SEPCO
PV lighting experience	3
System warranty	2 years
Lead time to ship	1 week

System Prices by Power Supply Size:

Small ID	SEP05-S-SL
PV Watts	175
PV make/model	Siemens
Battery Capacity Avail.	days
ND/CO/AZ	
Run time	4 / 5 / 6
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
Small System $	$1,837

Medium ID	SEP05-M-SL
PV Watts	100
PV make/model	Siemens
Battery Capacity Avail.	days
ND/CO/AZ	
Run time	10 / 8 / 10
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
Med System $	$2,127

Large ID	SEP05-L-SL
PV Watts	150
PV make/model	Siemens
Battery Capacity Avail.	days
ND/CO/AZ	
Run time	8 / 10 / 13
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
Large System $	$3,065

X-Large ID	SEP05-X-SL
PV Watts	200
PV make/model	Siemens
Battery Capacity Avail.	days
ND/CO/AZ	
Run time	12 / 16 / 20
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
XL System $	$3,549

Chart 2: Sign Lighting System Comparisons

Node S-A40 (0.2FC, 40 ft wide)

Series ID	SEP07-0-SL	SOL05-0-SL
Luminaire		
Lamp Type	CF	CF
Lamp input / output	39W / 2850 Lumens	36W / 2900 Lumens
Lamp life	10,000 hrs	10,000 hrs
# of lamps / # luminaire	4 / 4	4 / 2
Luminaire type	flood	flood
Luminaire make/model	SEPCO F1	SunChrg/SLU-FLXX
Optional luminaire types avaliable		
Starting temp. range	0 to 140 F	0 to 140 F
IES cut off	yes	yes
System		
Field history	3 years	6 years
Lighting controls	D to D, clock, timers	dusk/dawn,timer
Timer range	0-15 hours	0-15 hours
Controller make/model	SEPCO/LCU-1	Bobier/SCU-1
Charge method	PWM	stop @ 14.4v
Power Supply		
PV tilt range	15 or 45 deg	45 deg
PV warranty	10yr / 90%	20yr / 80%
PV field history	10+ years	20 years
Battery make/model	East Penn/8G27	Deka/8G24
Battery type	gelled, valve reg.	gelled, valve reg.
Estimated Battery life	5-7 years	5 years
Supplier		
Supplier name	SEPCO	Solar Outdoor Lighting
PV lighting experience	3	6
System warranty	2 years	2 years
Lead time to ship	1 week	4 days

System Prices by Power Supply Size:

Small ID	SEP07-S-SL	SOL05-S-SL
PV Watts	150	120
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	7.1 days
ND/CO/AZ		
Run time	6 / 7 / 9	0 / 6 / 6
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Small System $	$3,519	$2,786

Medium ID	SEP07-M-SL	SOL05-M-SL
PV Watts	200	212
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	6.4 days
ND/CO/AZ		
Run time	8 / 10 / 13	0 / 10 / 10
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Med System $	$4,097	$4,952

Large ID	SEP07-L-SL	SOL05-L-SL
PV Watts	300	282
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	6.1 days
ND/CO/AZ		
Run time	11 / 14 / 18	0 / 14 / 14
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Large System $	$5,974	$5,781

X-Large ID	SEP07-X-SL	SOL05-X-SL
PV Watts	400	360
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	4.7 days
ND/CO/AZ		
Run time	16 / 22 / 27	0 / 18 / 18
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
XL System $	$6,942	$6,607

Chart 2: Sign Lighting System Comparisons — **Node S-A48 (0.2FC, 48 ft wide)**

Series ID	SOL05-0-SL	SEP08-0-SL
Luminaire		
Lamp Type	CF	CF
Lamp input / output	36W / 2900 Lumens	39W / 2850 Lumens
Lamp life	10,000 hrs	10,000 hrs
# of lamps / # luminaire	4 / 2	6 / 6
Luminaire type	flood	flood
Luminaire make/model	SunChrg/SLU-FLXX	SEPCO F1
Optional luminaire types avaliable		
Starting temp. range	0 to 140 F	0 to 140 F
IES cut off	yes	yes
System		
Field history	6 years	3 years
Lighting controls	dusk/dawn,timer	D to D, clock, timers
Timer range	0-15 hours	0-15 hours
Controller make/model	Bobier/SCU-1	SEPCO/LCU-1
Charge method	stop @ 14.4v	PWM
Power Supply		
PV tilt range	45 deg	15 or 45 deg
PV warranty	20yr / 80%	10yr / 90%
PV field history	20 years	10+ years
Battery make/model	Deka/8G24	East Penn/8G27
Battery type	gelled, valve reg.	gelled, valve reg.
Estimated Battery life	5 years	5-7 years
Supplier		
Supplier name	Solar Outdoor Lighting	SEPCO
PV lighting experience	6	3
System warranty	2 years	2 years
Lead time to ship	4 days	1 week

System Prices by Power Supply Size:

Small ID	SOL05-S-SL	SEP08-S-SL
PV Watts	120	200
PV make/model	Solarex	Siemens
Battery Capacity Avail.	7.1 days	days
ND/CO/AZ		
Run time	0 / 6 / 6	5 / 7 / 8
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Small System $	$2,786	$4,631

Medium ID	SOL05-M-SL	SEP08-M-SL
PV Watts	212	300
PV make/model	Solarex	Siemens
Battery Capacity Avail.	6.4 days	days
ND/CO/AZ		
Run time	0 / 10 / 10	7 / 10 / 12
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Med System $	$4,952	$6,508

Large ID	SOL05-L-SL	SEP08-L-SL
PV Watts	282	400
PV make/model	Solarex	Siemens
Battery Capacity Avail.	6.1 days	days
ND/CO/AZ		
Run time	0 / 14 / 14	10 / 13 / 16
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Large System $	$5,781	$7,476

X-Large ID	SOL05-X-SL	SEP08-X-SL
PV Watts	360	500
PV make/model	Solarex	Siemens
Battery Capacity Avail.	4.7 days	days
ND/CO/AZ		
Run time	0 / 18 / 18	15 / 20 / 25
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
XL System $	$6,607	$8,980

Chart 2: Sign Lighting System Comparisons

Node S-B08 (0.4FC, 8 ft wide)

Series ID	SEP01-0-SL	SOL01-0-SL
Luminaire		
Lamp Type	CF	CF
Lamp input / output	13W / 825 Lumens	13W / 900 Lumens
Lamp life	10,000 hrs	10,000 hrs
# of lamps / # luminaire	1 / 1	1 / 1
Luminaire type	flood	flood
Luminaire make/model	SEPCO F2	SunChrg/SLU-FLXX
Optional luminaire types avaliable		
Starting temp. range	0 to 140 F	0 to 140 F
IES cut off	yes	yes
System		
Field history	3 years	6 years
Lighting controls	D to D, clock, timers	dusk/dawn,timer
Timer range	0-15 hours	0-15 hours
Controller make/model	SEPCO/LCU-1	Bobier/SCU-1
Charge method	PWM	stop @ 14.4v
Power Supply		
PV tilt range	15 or 45 deg	45 deg
PV warranty	10yr / 90%	20yr / 80%
PV field history	10+ years	20 years
Battery make/model	East Penn/8G27	Deka/8G24
Battery type	gelled, valve reg.	gelled, valve reg.
Estimated Battery life	5-7 years	5 years
Supplier		
Supplier name	SEPCO	Solar Outdoor Lighting
PV lighting experience	3	6
System warranty	2 years	2 years
Lead time to ship	1 week	4 days

System Prices by Power Supply Size:

Small ID	SEP01-S-SL	SOL01-S-SL
PV Watts	35	53
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	9.8 days
ND/CO/AZ		
Run time	5 / 7 / 8	0 / 6 / 6
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Small System $	$1,341	$1,649

Medium ID	SEP01-M-SL	SOL01-M-SL
PV Watts	50	60
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	5.9 days
ND/CO/AZ		
Run time	7 / 10 / 12	0 / 10 / 10
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Med System $	$1,485	$1,752

Large ID	SEP01-L-SL	SOL01-L-SL
PV Watts	75	83
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	8.4 days
ND/CO/AZ		
Run time	10 / 13 / 16	0 / 14 / 14
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Large System $	$1,629	$2,218

X-Large ID	SEP01-X-SL	SOL01-X-SL
PV Watts	100	106
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	6.6 days
ND/CO/AZ		
Run time	15 / 20 / 25	0 / 18 / 18
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
XL System $	$1,918	$2,476

Chart 2: Sign Lighting System Comparisons

Node S-B20 (0.4FC, 20 ft wide)

Series ID	SEP03-0-SL	SOL02-0-SL
Luminaire		
Lamp Type	CF	CF
Lamp input / output	13W / 825 Lumens	24W / 1800 Lumens
Lamp life	10,000 hrs	10,000 hrs
# of lamps / # luminaire	2 / 2	1 / 1
Luminaire type	flood	flood
Luminaire make/model	SEPCO F2	SunChrg/SLU-FLXX
Optional luminaire types avaliable		
Starting temp. range	0 to 140 F	0 to 140 F
IES cut off	yes	yes
System		
Field history	3 years	6 years
Lighting controls	D to D, clock, timers	dusk/dawn,timer
Timer range	0-15 hours	0-15 hours
Controller make/model	SEPCO/LCU-1	Bobier/SCU-1
Charge method	PWM	stop @ 14.4v
Power Supply		
PV tilt range	15 or 45 deg	45 deg
PV warranty	10yr / 90%	20yr / 80%
PV field history	10+ years	20 years
Battery make/model	East Penn/8G27	Deka/8G24
Battery type	gelled, valve reg.	gelled, valve reg.
Estimated Battery life	5-7 years	5 years
Supplier		
Supplier name	SEPCO	Solar Outdoor Lighting
PV lighting experience	3	6
System warranty	2 years	2 years
Lead time to ship	1 week	4 days

System Prices by Power Supply Size:

Small ID	SEP03-S-SL	SOL02-S-SL
PV Watts	50	53
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	5.3 days
ND/CO/AZ		
Run time	5 / 7 / 8	0 / 6 / 6
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Small System $	$1,666	$1,759

Medium ID	SEP03-M-SL	SOL02-M-SL
PV Watts	75	77
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	3.2 days
ND/CO/AZ		
Run time	7 / 10 / 12	0 / 10 / 10
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Med System $	$1,810	$2,166

Large ID	SEP03-L-SL	SOL02-L-SL
PV Watts	100	106
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	4.6 days
ND/CO/AZ		
Run time	10 / 13 / 16	0 / 14 / 14
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Large System $	$2,099	$2,476

X-Large ID	SEP03-X-SL	SOL02-X-SL
PV Watts	150	141
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	3.6 days
ND/CO/AZ		
Run time	15 / 20 / 25	0 / 18 / 18
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
XL System $	$3,038	$2,890

Chart 2: Sign Lighting System Comparisons

Node S-B30 (0.4FC, 30 ft wide)

Series ID	SEP05-0-SL
Luminaire	
Lamp Type	CF
Lamp input / output	13W / 825 Lumens
Lamp life	10,000 hrs
# of lamps / # luminaire	3 / 3
Luminaire type	flood
Luminaire make/model	SEPCO F2
Optional luminaire types avaliable	
Starting temp. range	0 to 140 F
IES cut off	yes
System	
Field history	3 years
Lighting controls	D to D, clock, timers
Timer range	0-15 hours
Controller make/model	SEPCO/LCU-1
Charge method	PWM
Power Supply	
PV tilt range	15 or 45 deg
PV warranty	10yr / 90%
PV field history	10+ years
Battery make/model	East Penn/8G27
Battery type	gelled, valve reg.
Estimated Battery life	5-7 years
Supplier	
Supplier name	SEPCO
PV lighting experience	3
System warranty	2 years
Lead time to ship	1 week

System Prices by Power Supply Size:

Small ID	SEP05-S-SL
PV Watts	175
PV make/model	Siemens
Battery Capacity Avail.	days
ND/CO/AZ	
Run time	4 / 5 / 6
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
Small System $	$1,837

Medium ID	SEP05-M-SL
PV Watts	100
PV make/model	Siemens
Battery Capacity Avail.	days
ND/CO/AZ	
Run time	10 / 8 / 10
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
Med System $	$2,127

Large ID	SEP05-L-SL
PV Watts	150
PV make/model	Siemens
Battery Capacity Avail.	days
ND/CO/AZ	
Run time	8 / 10 / 13
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
Large System $	$3,065

X-Large ID	SEP05-X-SL
PV Watts	200
PV make/model	Siemens
Battery Capacity Avail.	days
ND/CO/AZ	
Run time	12 / 16 / 20
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
XL System $	$3,549

Chart 2: Sign Lighting System Comparisons — **Node S-B40 (0.4FC, 40 ft wide)**

Series ID	SEP07-0-SL	SOL05-0-SL
Luminaire		
Lamp Type	CF	CF
Lamp input / output	39W / 2850 Lumens	36W / 2900 Lumens
Lamp life	10,000 hrs	10,000 hrs
# of lamps / # luminaire	4 / 4	4 / 2
Luminaire type	flood	flood
Luminaire make/model	SEPCO F1	SunChrg/SLU-FLXX
Optional luminaire types avaliable		
Starting temp. range	0 to 140 F	0 to 140 F
IES cut off	yes	yes
System		
Field history	3 years	6 years
Lighting controls	D to D, clock, timers	dusk/dawn,timer
Timer range	0-15 hours	0-15 hours
Controller make/model	SEPCO/LCU-1	Bobier/SCU-1
Charge method	PWM	stop @ 14.4v
Power Supply		
PV tilt range	15 or 45 deg	45 deg
PV warranty	10yr / 90%	20yr / 80%
PV field history	10+ years	20 years
Battery make/model	East Penn/8G27	Deka/8G24
Battery type	gelled, valve reg.	gelled, valve reg.
Estimated Battery life	5-7 years	5 years
Supplier		
Supplier name	SEPCO	Solar Outdoor Lighting
PV lighting experience	3	6
System warranty	2 years	2 years
Lead time to ship	1 week	4 days

System Prices by Power Supply Size:

Small ID	SEP07-S-SL	SOL05-S-SL
PV Watts	150	120
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	7.1 days
ND/CO/AZ		
Run time	6 / 7 / 9	0 / 6 / 6
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Small System $	$3,519	$2,786

Medium ID	SEP07-M-SL	SOL05-M-SL
PV Watts	200	212
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	6.4 days
ND/CO/AZ		
Run time	8 / 10 / 13	0 / 10 / 10
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Med System $	$4,097	$4,952

Large ID	SEP07-L-SL	SOL05-L-SL
PV Watts	300	282
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	6.1 days
ND/CO/AZ		
Run time	11 / 14 / 18	0 / 14 / 14
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Large System $	$5,974	$5,781

X-Large ID	SEP07-X-SL	SOL05-X-SL
PV Watts	400	360
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	4.7 days
ND/CO/AZ		
Run time	16 / 22 / 27	0 / 18 / 18
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
XL System $	$6,942	$6,607

Chart 2: Sign Lighting System Comparisons

Node S-B48 (0.4FC, 48 ft wide)

Series ID	SOL05-0-SL	SEP08-0-SL
Luminaire		
Lamp Type	CF	CF
Lamp input / output	36W / 2900 Lumens	39W / 2850 Lumens
Lamp life	10,000 hrs	10,000 hrs
# of lamps / # luminaire	4 / 2	6 / 6
Luminaire type	flood	flood
Luminaire make/model	SunChrg/SLU-FLXX	SEPCO F1
Optional luminaire types avaliable		
Starting temp. range	0 to 140 F	0 to 140 F
IES cut off	yes	yes
System		
Field history	6 years	3 years
Lighting controls	dusk/dawn,timer	D to D, clock, timers
Timer range	0-15 hours	0-15 hours
Controller make/model	Bobier/SCU-1	SEPCO/LCU-1
Charge method	stop @ 14.4v	PWM
Power Supply		
PV tilt range	45 deg	15 or 45 deg
PV warranty	20yr / 80%	10yr / 90%
PV field history	20 years	10+ years
Battery make/model	Deka/8G24	East Penn/8G27
Battery type	gelled, valve reg.	gelled, valve reg.
Estimated Battery life	5 years	5-7 years
Supplier		
Supplier name	Solar Outdoor Lighting	SEPCO
PV lighting experience	6	3
System warranty	2 years	2 years
Lead time to ship	4 days	1 week

System Prices by Power Supply Size:

Small ID	SOL05-S-SL	SEP08-S-SL
PV Watts	120	200
PV make/model	Solarex	Siemens
Battery Capacity Avail.	7.1 days	days
ND/CO/AZ		
Run time	0 / 6 / 6	5 / 7 / 8
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Small System $	$2,786	$4,631

Medium ID	SOL05-M-SL	SEP08-M-SL
PV Watts	212	300
PV make/model	Solarex	Siemens
Battery Capacity Avail.	6.4 days	days
ND/CO/AZ		
Run time	0 / 10 / 10	7 / 10 / 12
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Med System $	$4,952	$6,508

Large ID	SOL05-L-SL	SEP08-L-SL
PV Watts	282	400
PV make/model	Solarex	Siemens
Battery Capacity Avail.	6.1 days	days
ND/CO/AZ		
Run time	0 / 14 / 14	10 / 13 / 16
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Large System $	$5,781	$7,476

X-Large ID	SOL05-X-SL	SEP08-X-SL
PV Watts	360	500
PV make/model	Solarex	Siemens
Battery Capacity Avail.	4.7 days	days
ND/CO/AZ		
Run time	0 / 18 / 18	15 / 20 / 25
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
XL System $	$6,607	$8,980

Chart 2: Sign Lighting System Comparisons

Node S-C08 (0.8FC, 8 ft wide)

Series ID	SEP02-0-SL	SOL01-0-SL
Luminaire		
Lamp Type	CF	CF
Lamp input / output	39W / 2850 Lumens	13W / 900 Lumens
Lamp life	10,000 hrs	10,000 hrs
# of lamps / # luminaire	1 / 1	1 / 1
Luminaire type	flood	flood
Luminaire make/model	SEPCO F1	SunChrg/SLU-FLXX
Optional luminaire types avaliable		
Starting temp. range	0 to 140 F	0 to 140 F
IES cut off	yes	yes
System		
Field history	3 years	6 years
Lighting controls	D to D, clock, timers	dusk/dawn,timer
Timer range	0-15 hours	0-15 hours
Controller make/model	SEPCO/LCU-1	Bobier/SCU-1
Charge method	PWM	stop @ 14.4v
Power Supply		
PV tilt range	15 or 45 deg	45 deg
PV warranty	10yr / 90%	20yr / 80%
PV field history	10+ years	20 years
Battery make/model	East Penn/8G27	Deka/8G24
Battery type	gelled, valve reg.	gelled, valve reg.
Estimated Battery life	5-7 years	5 years
Supplier		
Supplier name	SEPCO	Solar Outdoor Lighting
PV lighting experience	3	6
System warranty	2 years	2 years
Lead time to ship	1 week	4 days

System Prices by Power Supply Size:

Small ID	SEP02-S-SL	SOL01-S-SL
PV Watts	50	53
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	9.8 days
ND/CO/AZ		
Run time	5 / 7 / 8	0 / 6 / 6
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Small System $	$1,519	$1,649

Medium ID	SEP02-M-SL	SOL01-M-SL
PV Watts	75	60
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	5.9 days
ND/CO/AZ		
Run time	7 / 10 / 12	0 / 10 / 10
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Med System $	$1,663	$1,752

Large ID	SEP02-L-SL	SOL01-L-SL
PV Watts	100	83
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	8.4 days
ND/CO/AZ		
Run time	10 / 13 / 16	0 / 14 / 14
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Large System $	$1,953	$2,218

X-Large ID	SEP02-X-SL	SOL01-X-SL
PV Watts	150	106
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	6.6 days
ND/CO/AZ		
Run time	15 / 20 / 25	0 / 18 / 18
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
XL System $	$2,891	$2,476

Chart 2: Sign Lighting System Comparisons

Node S-C20 (0.8FC, 20 ft wide)

Series ID	SOL02-0-SL	SEP04-0-SL	PC01-0-SL
Luminaire			
Lamp Type	CF	CF	CF
Lamp input / output	24W / 1800 Lumens	39W / 2850 Lumens	40W / 0 Lumens
Lamp life	10,000 hrs	10,000 hrs	
# of lamps / # luminaire	1 / 1	2 / 2	0 / 0
Luminaire type	flood	flood	flood
Luminaire make/model	SunChrg/SLU-FLXX	SEPCO F1	Western Billboard
Optional luminaire types avaliable			
Starting temp. range	0 to 140 F	0 to 140 F	-20 F
IES cut off	yes	yes	no
System			
Field history	6 years	3 years	1 year
Lighting controls	dusk/dawn,timer	D to D, clock, timers	dusk, timer
Timer range	0-15 hours	0-15 hours	2-8 hours
Controller make/model	Bobier/SCU-1	SEPCO/LCU-1	Trace/C12
Charge method	stop @ 14.4v	PWM	PWM,taper,temp comp
Power Supply			
PV tilt range	45 deg	15 or 45 deg	20-70 deg
PV warranty	20yr / 80%	10yr / 90%	12yr / 90%
PV field history	20 years	10+ years	15 years
Battery make/model	Deka/8G24	East Penn/8G27	Trojan/T105
Battery type	gelled, valve reg.	gelled, valve reg.	flooded
Estimated Battery life	5 years	5-7 years	4 years
Supplier			
Supplier name	Solar Outdoor Lighting	SEPCO	Photocomm
PV lighting experience	6	3	0
System warranty	2 years	2 years	
Lead time to ship	4 days	1 week	

System Prices by Power Supply Size:

Small ID	SOL02-S-SL	SEP04-S-SL	PC01-S-SL
PV Watts	53	75	240
PV make/model	Solarex	Siemens	Kyocera 120
Battery Capacity Avail.	5.3 days	days	20.7 days
ND/CO/AZ			
Run time	0 / 6 / 6	5 / 7 / 8	5 / 6 / 7
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6
PV tilt angle	45 / 45 / 45	45 / 45 / 45	61 / 55 / 47
Small System $	$1,759	$1,759	$3,636

Medium ID	SOL02-M-SL	SEP04-M-SL	PC01-M-SL
PV Watts	77	100	360
PV make/model	Solarex	Siemens	Kyocera 120
Battery Capacity Avail.	3.2 days	days	12.4 days
ND/CO/AZ			
Run time	0 / 10 / 10	7 / 10 / 12	8 / 10 / 13
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6
PV tilt angle	45 / 45 / 45	45 / 45 / 45	61 / 55 / 47
Med System $	$2,166	$2,049	$4,466

Large ID	SOL02-L-SL	SEP04-L-SL	PC01-L-SL
PV Watts	106	150	480
PV make/model	Solarex	Siemens	Kyocera 80
Battery Capacity Avail.	4.6 days	days	17.8 days
ND/CO/AZ			
Run time	0 / 14 / 14	10 / 13 / 16	9 / 14 / 17
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6
PV tilt angle	45 / 45 / 45	45 / 45 / 45	61 / 55 / 47
Large System $	$2,476	$2,987	$5,853

X-Large ID	SOL02-X-SL	SEP04-X-SL	
PV Watts	141	200	
PV make/model	Solarex	Siemens	
Battery Capacity Avail.	3.6 days	days	
ND/CO/AZ			
Run time	0 / 18 / 18	15 / 20 / 25	
Sun hours	3 / 4 / 5	3 / 4 / 5	
PV tilt angle	45 / 45 / 45	45 / 45 / 45	
XL System $	$2,890	$3,471	

Chart 2: Sign Lighting System Comparisons

Node S-C30 (0.8FC, 30 ft wide)

Series ID	SEP06-0-SL	SOL04-0-SL	PC02-0-SL
Luminaire			
Lamp Type	CF	CF	CF
Lamp input / output	39W / 2850 Lumens	24W / 1800 Lumens	40W / 0 Lumens
Lamp life	10,000 hrs	10,000 hrs	
# of lamps / # luminaire	3 / 3	4 / 2	0 / 0
Luminaire type	flood	flood	flood
Luminaire make/model	SEPCO F1	SunChrg/SLU-FLXX	Western Billboard
Optional luminaire types avaliable			
Starting temp. range	0 to 140 F	0 to 140 F	-20 F
IES cut off	yes	yes	no
System			
Field history	3 years	6 years	1 year
Lighting controls	D to D, clock, timers	dusk/dawn,timer	dusk, timer
Timer range	0-15 hours	0-15 hours	2-8 hours
Controller make/model	SEPCO/LCU-1	Bobier/SCU-1	Trace/C12
Charge method	PWM	stop @ 14.4v	PWM,taper,temp comp
Power Supply			
PV tilt range	15 or 45 deg	45 deg	20-70 deg
PV warranty	10yr / 90%	20yr / 80%	12yr / 90%
PV field history	10+ years	20 years	15 years
Battery make/model	East Penn/8G27	Deka/8G24	Trojan/T105
Battery type	gelled, valve reg.	gelled, valve reg.	flooded
Estimated Battery life	5-7 years	5 years	4 years
Supplier			
Supplier name	SEPCO	Solar Outdoor Lighting	Photocomm
PV lighting experience	3	6	0
System warranty	2 years	2 years	
Lead time to ship	1 week	4 days	

System Prices by Power Supply Size:

Small ID	SEP06-S-SL	SOL04-S-SL	PC02-S-SL
PV Watts	100	106	360
PV make/model	Siemens	Solarex	Kyocera 60
Battery Capacity Avail.	days	10.7 days	31.1 days
ND/CO/AZ			
Run time	8 / 10 / 12	0 / 6 / 6	5 / 6 / 7
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6
PV tilt angle	45 / 45 / 45	45 / 45 / 45	61 / 55 / 47
Small System $	$2,315	$2,683	$5,092

Medium ID	SEP06-M-SL	SOL04-M-SL	PC02-M-SL
PV Watts	150	154	600
PV make/model	Siemens	Solarex	Kyocera 60
Battery Capacity Avail.	days	9.6 days	37.3 days
ND/CO/AZ			
Run time	11 / 14 / 18	0 / 10 / 10	8 / 10 / 13
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6
PV tilt angle	45 / 45 / 45	45 / 45 / 45	61 / 55 / 47
Med System $	$3,254	$4,332	$7,790

Large ID	SEP06-L-SL	SOL04-L-SL	PC02-L-SL
PV Watts	200	212	720
PV make/model	Siemens	Solarex	Kyocera 120
Battery Capacity Avail.	days	9.1 days	26.6 days
ND/CO/AZ			
Run time	15 / 20 / 25	0 / 14 / 14	12 / 14 / 18
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6
PV tilt angle	45 / 45 / 45	45 / 45 / 45	61 / 55 / 47
Large System $	$3,738	$4,952	$8,428

X-Large ID	SEP06-X-SL	SOL04-X-SL	
PV Watts	250	282	
PV make/model	Siemens	Solarex	
Battery Capacity Avail.	days	7.1 days	
ND/CO/AZ			
Run time	22 / 30 / 38	0 / 18 / 18	
Sun hours	3 / 4 / 5	3 / 4 / 5	
PV tilt angle	45 / 45 / 45	45 / 45 / 45	
XL System $	$4,490	$5,781	

Chart 2: Sign Lighting System Comparisons

Node S-C40 (0.8FC, 40 ft wide)

Series ID	SEP07-0-SL	SOL05-0-SL	PC03-0-SL
Luminaire			
Lamp Type	CF	CF	CF
Lamp input / output	39W / 2850 Lumens	36W / 2900 Lumens	40W / 0 Lumens
Lamp life	10,000 hrs	10,000 hrs	
# of lamps / # luminaire	4 / 4	4 / 2	0 / 0
Luminaire type	flood	flood	flood
Luminaire make/model	SEPCO F1	SunChrg/SLU-FLXX	Western Billboard
Optional luminaire types avaliable			
Starting temp. range	0 to 140 F	0 to 140 F	-20 F
IES cut off	yes	yes	no
System			
Field history	3 years	6 years	1 year
Lighting controls	D to D, clock, timers	dusk/dawn,timer	dusk, timer
Timer range	0-15 hours	0-15 hours	2-8 hours
Controller make/model	SEPCO/LCU-1	Bobier/SCU-1	Trace/C12
Charge method	PWM	stop @ 14.4v	PWM,taper,temp comp
Power Supply			
PV tilt range	15 or 45 deg	45 deg	20-70 deg
PV warranty	10yr / 90%	20yr / 80%	12yr / 90%
PV field history	10+ years	20 years	15 years
Battery make/model	East Penn/8G27	Deka/8G24	Trojan/T105
Battery type	gelled, valve reg.	gelled, valve reg.	flooded
Estimated Battery life	5-7 years	5 years	4 years
Supplier			
Supplier name	SEPCO	Solar Outdoor Lighting	Photocomm
PV lighting experience	3	6	0
System warranty	2 years	2 years	
Lead time to ship	1 week	4 days	

System Prices by Power Supply Size:

Small ID	SEP07-S-SL	SOL05-S-SL	PC03-S-SL
PV Watts	150	120	480
PV make/model	Siemens	Solarex	Kyocera 60
Battery Capacity Avail.	days	7.1 days	41.4 days
ND/CO/AZ			
Run time	6 / 7 / 9	0 / 6 / 6	5 / 6 / 7
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6
PV tilt angle	45 / 45 / 45	45 / 45 / 45	61 / 55 / 47
Small System $	$3,519	$2,786	$6,730

Medium ID	SEP07-M-SL	SOL05-M-SL	PC03-M-SL
PV Watts	200	212	720
PV make/model	Siemens	Solarex	Kyocera 120
Battery Capacity Avail.	days	6.4 days	24.9 days
ND/CO/AZ			
Run time	8 / 10 / 13	0 / 10 / 10	7 / 10 / 12
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6
PV tilt angle	45 / 45 / 45	45 / 45 / 45	61 / 55 / 47
Med System $	$4,097	$4,952	$8,033

Large ID	SEP07-L-SL	SOL05-L-SL	PC03-L-SL
PV Watts	300	282	960
PV make/model	Siemens	Solarex	Kyocera 120
Battery Capacity Avail.	days	6.1 days	26.6 days
ND/CO/AZ			
Run time	11 / 14 / 18	0 / 14 / 14	12 / 14 / 18
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6
PV tilt angle	45 / 45 / 45	45 / 45 / 45	61 / 55 / 47
Large System $	$5,974	$5,781	$10,206

X-Large ID	SEP07-X-SL	SOL05-X-SL	
PV Watts	400	360	
PV make/model	Siemens	Solarex	
Battery Capacity Avail.	days	4.7 days	
ND/CO/AZ			
Run time	16 / 22 / 27	0 / 18 / 18	
Sun hours	3 / 4 / 5	3 / 4 / 5	
PV tilt angle	45 / 45 / 45	45 / 45 / 45	
XL System $	$6,942	$6,607	

Chart 2: Sign Lighting System Comparisons

Node S-C48 (0.8FC, 48 ft wide)

Series ID	SOL06-0-SL	SEP08-0-SL	PC04-0-SL
Luminaire			
Lamp Type	CF	CF	CF
Lamp input / output	24W / 1800 Lumens	39W / 2850 Lumens	40W / 0 Lumens
Lamp life	10,000 hrs	10,000 hrs	
# of lamps / # luminaire	9 / 3	6 / 6	0 / 0
Luminaire type	flood	flood	flood
Luminaire make/model	SunChrg/SLU-FLXX	SEPCO F1	Western Billboard
Optional luminaire types avaliable			
Starting temp. range	0 to 140 F	0 to 140 F	-20 F
IES cut off	yes	yes	no
System			
Field history	6 years	3 years	1 year
Lighting controls	dusk/dawn,timer	D to D, clock, timers	dusk, timer
Timer range	0-15 hours	0-15 hours	2-8 hours
Controller make/model	Bobier/SCU-1	SEPCO/LCU-1	Trace/C12
Charge method	stop @ 14.4v	PWM	PWM,taper,temp comp
Power Supply			
PV tilt range	45 deg	15 or 45 deg	20-70 deg
PV warranty	20yr / 80%	10yr / 90%	12yr / 90%
PV field history	20 years	10+ years	15 years
Battery make/model	Deka/8G24	East Penn/8G27	Trojan/T105
Battery type	gelled, valve reg.	gelled, valve reg.	flooded
Estimated Battery life	5 years	5-7 years	4 years
Supplier			
Supplier name	Solar Outdoor Lighting	SEPCO	Photocomm
PV lighting experience	6	3	0
System warranty	2 years	2 years	
Lead time to ship	4 days	1 week	

System Prices by Power Supply Size:

Small ID	SOL06-S-SL	SEP08-S-SL	PC04-S-SL
PV Watts	159	200	720
PV make/model	Solarex	Siemens	Kyocera 120
Battery Capacity Avail.	16.0 days	days	62.2 days
ND/CO/AZ			
Run time	0 / 6 / 6	5 / 7 / 8	5 / 0 / 7
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6
PV tilt angle	45 / 45 / 45	45 / 45 / 45	61 / 55 / 47
Small System $	$4,947	$4,631	$9,285

Medium ID	SOL06-M-SL	SEP08-M-SL	PC04-M-SL
PV Watts	231	300	1020
PV make/model	Solarex	Siemens	Kyocera 51
Battery Capacity Avail.	16.0 days	days	62.2 days
ND/CO/AZ			
Run time	0 / 10 / 10	7 / 10 / 12	8 / 0 / 13
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6
PV tilt angle	45 / 45 / 45	45 / 45 / 45	61 / 55 / 47
Med System $	$6,498	$6,508	$13,196

Large ID	SOL06-L-SL	SEP08-L-SL	PC04-L-SL
PV Watts	318	400	1440
PV make/model	Solarex	Siemens	Kyocera 120
Battery Capacity Avail.	13.7 days	days	44.4 days
ND/CO/AZ			
Run time	0 / 14 / 14	10 / 13 / 16	12 / 0 / 18
Sun hours	3 / 4 / 5	3 / 4 / 5	3 / 4 / 6
PV tilt angle	45 / 45 / 45	45 / 45 / 45	61 / 55 / 47
Large System $	$7,428	$7,476	$15,211

X-Large ID	SOL06-X-SL	SEP08-X-SL	
PV Watts	423	500	
PV make/model	Solarex	Siemens	
Battery Capacity Avail.	10.7 days	days	
ND/CO/AZ			
Run time	0 / 18 / 18	15 / 20 / 25	
Sun hours	3 / 4 / 5	3 / 4 / 5	
PV tilt angle	45 / 45 / 45	45 / 45 / 45	
XL System $	$8,670	$8,980	

Chart 2: Sign Lighting System Comparisons

Node S-D08 (1.2FC, 80 ft wide)

Series ID	SEP02-0-SL	SOL01-0-SL
Luminaire		
Lamp Type	CF	CF
Lamp input / output	39W / 2850 Lumens	13W / 900 Lumens
Lamp life	10,000 hrs	10,000 hrs
# of lamps / # luminaire	1 / 1	1 / 1
Luminaire type	flood	flood
Luminaire make/model	SEPCO F1	SunChrg/SLU-FLXX
Optional luminaire types avaliable		
Starting temp. range	0 to 140 F	0 to 140 F
IES cut off	yes	yes
System		
Field history	3 years	6 years
Lighting controls	D to D, clock, timers	dusk/dawn,timer
Timer range	0-15 hours	0-15 hours
Controller make/model	SEPCO/LCU-1	Bobier/SCU-1
Charge method	PWM	stop @ 14.4v
Power Supply		
PV tilt range	15 or 45 deg	45 deg
PV warranty	10yr / 90%	20yr / 80%
PV field history	10+ years	20 years
Battery make/model	East Penn/8G27	Deka/8G24
Battery type	gelled, valve reg.	gelled, valve reg.
Estimated Battery life	5-7 years	5 years
Supplier		
Supplier name	SEPCO	Solar Outdoor Lighting
PV lighting experience	3	6
System warranty	2 years	2 years
Lead time to ship	1 week	4 days

System Prices by Power Supply Size:

Small ID	SEP02-S-SL	SOL01-S-SL
PV Watts	50	53
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	9.8 days
ND/CO/AZ		
Run time	5 / 7 / 8	0 / 6 / 6
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Small System $	$1,519	$1,649

Medium ID	SEP02-M-SL	SOL01-M-SL
PV Watts	75	60
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	5.9 days
ND/CO/AZ		
Run time	7 / 10 / 12	0 / 10 / 10
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Med System $	$1,663	$1,752

Large ID	SEP02-L-SL	SOL01-L-SL
PV Watts	100	83
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	8.4 days
ND/CO/AZ		
Run time	10 / 13 / 16	0 / 14 / 14
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Large System $	$1,953	$2,218

X-Large ID	SEP02-X-SL	SOL01-X-SL
PV Watts	150	106
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	6.6 days
ND/CO/AZ		
Run time	15 / 20 / 25	0 / 18 / 18
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
XL System $	$2,891	$2,476

Chart 2: Sign Lighting System Comparisons

Node S-D20 (1.2FC, 20 ft wide)

Series ID	SEP04-0-SL
Luminaire	
Lamp Type	CF
Lamp input / output	39W / 2850 Lumens
Lamp life	10,000 hrs
# of lamps / # luminaire	2 / 2
Luminaire type	flood
Luminaire make/model	SEPCO F1
Optional luminaire types avaliable	
Starting temp. range	0 to 140 F
IES cut off	yes
System	
Field history	3 years
Lighting controls	D to D, clock, timers
Timer range	0-15 hours
Controller make/model	SEPCO/LCU-1
Charge method	PWM
Power Supply	
PV tilt range	15 or 45 deg
PV warranty	10yr / 90%
PV field history	10+ years
Battery make/model	East Penn/8G27
Battery type	gelled, valve reg.
Estimated Battery life	5-7 years
Supplier	
Supplier name	SEPCO
PV lighting experience	3
System warranty	2 years
Lead time to ship	1 week

System Prices by Power Supply Size:

Small ID	SEP04-S-SL
PV Watts	75
PV make/model	Siemens
Battery Capacity Avail.	days
ND/CO/AZ	
Run time	5 / 7 / 8
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
Small System $	$1,759

Medium ID	SEP04-M-SL
PV Watts	100
PV make/model	Siemens
Battery Capacity Avail.	days
ND/CO/AZ	
Run time	7 / 10 / 12
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
Med System $	$2,049

Large ID	SEP04-L-SL
PV Watts	150
PV make/model	Siemens
Battery Capacity Avail.	days
ND/CO/AZ	
Run time	10 / 13 / 16
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
Large System $	$2,987

X-Large ID	SEP04-X-SL
PV Watts	200
PV make/model	Siemens
Battery Capacity Avail.	days
ND/CO/AZ	
Run time	15 / 20 / 25
Sun hours	3 / 4 / 5
PV tilt angle	45 / 45 / 45
XL System $	$3,471

Chart 2: Sign Lighting System Comparisons

Node S-D30 (1.2FC, 30 ft wide)

Series ID	SEP06-0-SL	SOL04-0-SL
Luminaire		
Lamp Type	CF	CF
Lamp input / output	39W / 2850 Lumens	24W / 1800 Lumens
Lamp life	10,000 hrs	10,000 hrs
# of lamps / # luminaire	3 / 3	4 / 2
Luminaire type	flood	flood
Luminaire make/model	SEPCO F1	SunChrg/SLU-FLXX
Optional luminaire types avaliable		
Starting temp. range	0 to 140 F	0 to 140 F
IES cut off	yes	yes
System		
Field history	3 years	6 years
Lighting controls	D to D, clock, timers	dusk/dawn,timer
Timer range	0-15 hours	0-15 hours
Controller make/model	SEPCO/LCU-1	Bobier/SCU-1
Charge method	PWM	stop @ 14.4v
Power Supply		
PV tilt range	15 or 45 deg	45 deg
PV warranty	10yr / 90%	20yr / 80%
PV field history	10+ years	20 years
Battery make/model	East Penn/8G27	Deka/8G24
Battery type	gelled, valve reg.	gelled, valve reg.
Estimated Battery life	5-7 years	5 years
Supplier		
Supplier name	SEPCO	Solar Outdoor Lighting
PV lighting experience	3	6
System warranty	2 years	2 years
Lead time to ship	1 week	4 days

System Prices by Power Supply Size:

Small ID	SEP06-S-SL	SOL04-S-SL
PV Watts	100	106
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	10.7 days
ND/CO/AZ		
Run time	8 / 10 / 12	0 / 6 / 6
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Small System $	$2,315	$2,683

Medium ID	SEP06-M-SL	SOL04-M-SL
PV Watts	150	154
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	9.6 days
ND/CO/AZ		
Run time	11 / 14 / 18	0 / 10 / 10
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Med System $	$3,254	$4,332

Large ID	SEP06-L-SL	SOL04-L-SL
PV Watts	200	212
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	9.1 days
ND/CO/AZ		
Run time	15 / 20 / 25	0 / 14 / 14
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Large System $	$3,738	$4,952

X-Large ID	SEP06-X-SL	SOL04-X-SL
PV Watts	250	282
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	7.1 days
ND/CO/AZ		
Run time	22 / 30 / 38	0 / 18 / 18
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
XL System $	$4,490	$5,781

Chart 2: Sign Lighting System Comparisons

Node S-D40 (1.2FC, 40 ft wide)

Series ID	SEP07-0-SL	SOL07-0-SL
Luminaire		
Lamp Type	CF	CF
Lamp input / output	39W / 2850 Lumens	36W / 2900 Lumens
Lamp life	10,000 hrs	10,000 hrs
# of lamps / # luminaire	4 / 4	9 / 3
Luminaire type	flood	flood
Luminaire make/model	SEPCO F1	SunChrg/SLU-FLXX
Optional luminaire types avaliable		
Starting temp. range	0 to 140 F	0 to 140 F
IES cut off	yes	yes
System		
Field history	3 years	6 years
Lighting controls	D to D, clock, timers	dusk/dawn,timer
Timer range	0-15 hours	0-15 hours
Controller make/model	SEPCO/LCU-1	Bobier/SCU-1
Charge method	PWM	stop @ 14.4v
Power Supply		
PV tilt range	15 or 45 deg	45 deg
PV warranty	10yr / 90%	20yr / 80%
PV field history	10+ years	20 years
Battery make/model	East Penn/8G27	Deka/8G24
Battery type	gelled, valve reg.	gelled, valve reg.
Estimated Battery life	5-7 years	5 years
Supplier		
Supplier name	SEPCO	Solar Outdoor Lighting
PV lighting experience	3	6
System warranty	2 years	2 years
Lead time to ship	1 week	4 days

System Prices by Power Supply Size:

Small ID	SEP07-S-SL	SOL07-S-SL
PV Watts	150	180
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	10.7 days
ND/CO/AZ		
Run time	6 / 7 / 9	0 / 6 / 6
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Small System $	$3,519	$5,257

Medium ID	SEP07-M-SL	SOL07-M-SL
PV Watts	200	180
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	10.7 days
ND/CO/AZ		
Run time	8 / 10 / 13	0 / 10 / 10
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Med System $	$4,097	$7,428

Large ID	SEP07-L-SL	SOL07-L-SL
PV Watts	300	423
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	9.1 days
ND/CO/AZ		
Run time	11 / 14 / 18	0 / 14 / 14
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Large System $	$5,974	$8,670

X-Large ID	SEP07-X-SL	SOL07-X-SL
PV Watts	400	540
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	7.1 days
ND/CO/AZ		
Run time	16 / 22 / 27	0 / 18 / 18
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
XL System $	$6,942	$9,911

Chart 2: Sign Lighting System Comparisons

Node S-D48 (1.2FC, 48 ft wide)

Series ID	SEP08-0-SL	SOL07-0-SL
Luminaire		
Lamp Type	CF	CF
Lamp input / output	39W / 2850 Lumens	36W / 2900 Lumens
Lamp life	10,000 hrs	10,000 hrs
# of lamps / # luminaire	6 / 6	9 / 3
Luminaire type	flood	flood
Luminaire make/model	SEPCO F1	SunChrg/SLU-FLXX
Optional luminaire types avaliable		
Starting temp. range	0 to 140 F	0 to 140 F
IES cut off	yes	yes
System		
Field history	3 years	6 years
Lighting controls	D to D, clock, timers	dusk/dawn,timer
Timer range	0-15 hours	0-15 hours
Controller make/model	SEPCO/LCU-1	Bobier/SCU-1
Charge method	PWM	stop @ 14.4v
Power Supply		
PV tilt range	15 or 45 deg	45 deg
PV warranty	10yr / 90%	20yr / 80%
PV field history	10+ years	20 years
Battery make/model	East Penn/8G27	Deka/8G24
Battery type	gelled, valve reg.	gelled, valve reg.
Estimated Battery life	5-7 years	5 years
Supplier		
Supplier name	SEPCO	Solar Outdoor Lighting
PV lighting experience	3	6
System warranty	2 years	2 years
Lead time to ship	1 week	4 days

System Prices by Power Supply Size:

Small ID	SEP08-S-SL	SOL07-S-SL
PV Watts	200	180
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	10.7 days
ND/CO/AZ		
Run time	5 / 7 / 8	0 / 6 / 6
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Small System $	$4,631	$5,257

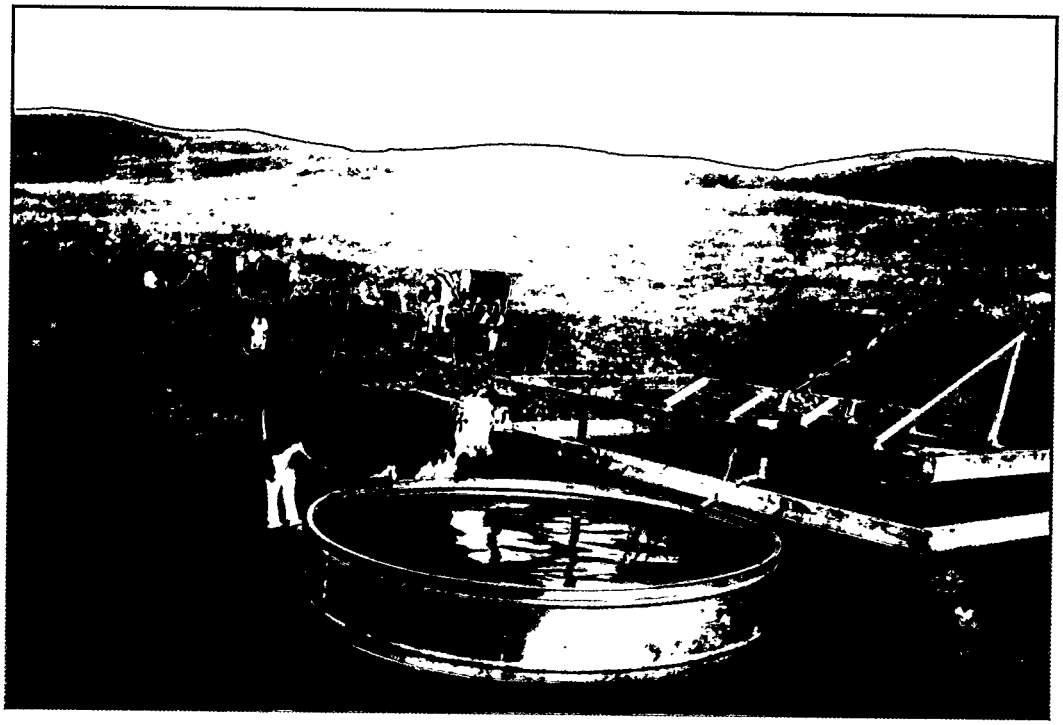
Medium ID	SEP08-M-SL	SOL07-M-SL
PV Watts	300	180
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	10.7 days
ND/CO/AZ		
Run time	7 / 10 / 12	0 / 10 / 10
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Med System $	$6,508	$7,428

Large ID	SEP08-L-SL	SOL07-L-SL
PV Watts	400	423
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	9.1 days
ND/CO/AZ		
Run time	10 / 13 / 16	0 / 14 / 14
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
Large System $	$7,476	$8,670

X-Large ID	SEP08-X-SL	SOL07-X-SL
PV Watts	500	540
PV make/model	Siemens	Solarex
Battery Capacity Avail.	days	7.1 days
ND/CO/AZ		
Run time	15 / 20 / 25	0 / 18 / 18
Sun hours	3 / 4 / 5	3 / 4 / 5
PV tilt angle	45 / 45 / 45	45 / 45 / 45
XL System $	$8,980	$9,911

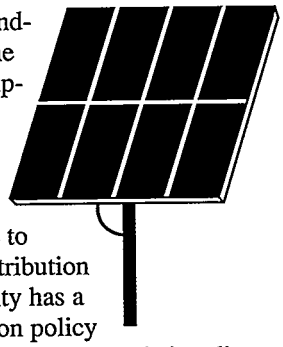
Solar Electricity
for Livestock Water Pumping

Solar electric or photovoltaic (PV) systems can be used to power water pumps in remote locations far from utility lines. They are used to pump water for livestock, wildlife, small scale irrigation and off-grid homes. In remote locations where power line extensions are not affordable, PV-powered pumping systems are often the least cost water solution. This booklet provides an introduction to PV-powered water pumping to help you evaluate the PV alternative.



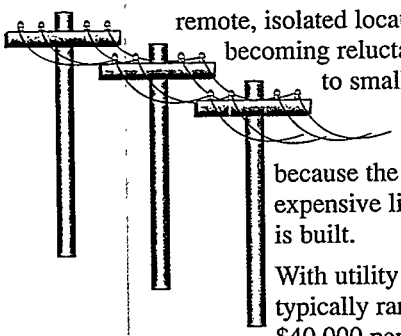
PSN
A publication of the Photovoltaic Services Network

PV vs. Line Extensions



The cost of extending a power line to a water pumping site depends on your local electric utility's line extension policy and the distance from the site to existing electrical distribution lines. If the local utility has a generous line extension policy and the pumping site is close to existing distribution lines, the cost of a line extension will be affordable.

However, many electric utilities expect customers to pay the full cost for line construction and livestock watering sites are often in remote, isolated locations. Utilities are also becoming reluctant to build power lines to small loads in remote locations even if the customer is willing to pay because the utility must pay for expensive line maintenance once it is built.

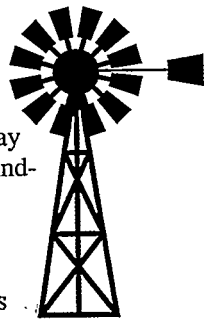


With utility line construction costs typically ranging from $10,000 to $40,000 per mile plus additional costs for maintenance, it may be to the utility's and customer's benefit to find an alternative source of power. Depending on your electricity requirements, a PV system could be the least cost option even when the nearest utility line is no more than 1/4 mile away.

Your local electric utility company can give you an estimate of the cost to extend a new line to a pumping site. Many utility companies are also offering PV service options as well, and can assist you with PV as an alternative solution to your power needs.

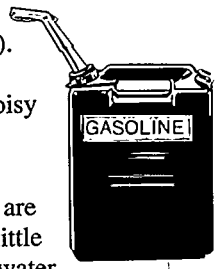
The PV Alternative

When electric utility service is not a viable choice, it's time to explore the alternatives. In some cases, other power sources for pumping water besides PV may be practical. These include windmills and engine generators.



Windmills have been used on ranches to water livestock for generations. Why are ranchers switching to PV systems? For two reasons: the wind often does not blow as much in the summer when livestock need water the most and windmills require plenty of maintenance. The seals on their well plunger assemblies must be replaced regularly. In addition, service personnel (usually the rancher) must climb the windmill tower periodically to change the gearbox oil.

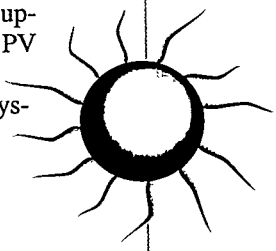
The other alternative, engine generators, require high maintenance as well (regular oil changes and tune-ups). Generators also require fuel to be hauled to the pumping site, are noisy and give-off unpleasant exhaust fumes.



In contrast, PV pumping systems are quiet, need no fuel, require very little maintenance and pump the most water during the sunniest, hot days of summer. PV pumping systems are becoming the most popular alternative because of their low maintenance requirements and high reliability.

Other advantages of a PV system include:

"Free" energy - once a PV system is purchased and installed, there is no additional cost for fuel. Sunlight is a renewable and plentiful resource throughout most of the United States. The solar resource has been measured and documented for many years and can be predicted with surprising accuracy.



Reliable power - PV power supplies have no moving parts and the PV modules carry ten to twenty year warranties. For these reasons, PV systems have become the power source of choice for many critical applications such as emergency lights and sirens.

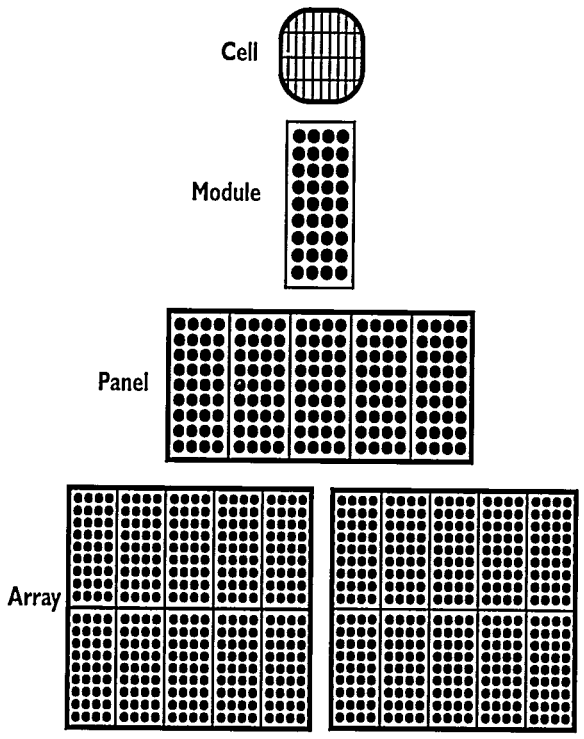
Flexibility - many PV pumping systems allow for convenient expansion. If the pump is sized large enough to accept additional power, PV modules can be added at a later date to increase water output.

Quick installation and portability - most PV water pumping systems can be installed in less than a day and because they are easy to install, they can be moved from one water source to another to follow livestock rotations. In fact, some ranchers have installed their PV systems on trailers to move them quickly to where water is needed. (The PV system on the cover of this booklet is mounted on a trailer.)

Photovoltaic Technology

PV is a descriptive name for a technology in which radiant light energy from the sun (not heat) is converted to direct current electrical energy. PV cells are made of semi-conducting materials, typically silicon, doped with special additives. When sunlight hits the surface of a silicon PV cell, approximately 1/2 volt is generated. The amount of current generated is directly proportional to the cell's size and to the intensity of sunlight.

As shown in the figure below, groups of 36 interconnected PV cells are packaged together into standard modules that provide a nominal 12 volts (or 18 volts at peak power). PV modules were originally configured in this manner to charge 12-volt batteries. Desired power, voltage and current can be obtained by connecting individual PV modules in series and parallel combinations in much the same way as batteries. When modules are mounted together in a single frame they are called a panel and when several panels are interconnected they are called an array. (Sometimes a single panel is also called an array.)



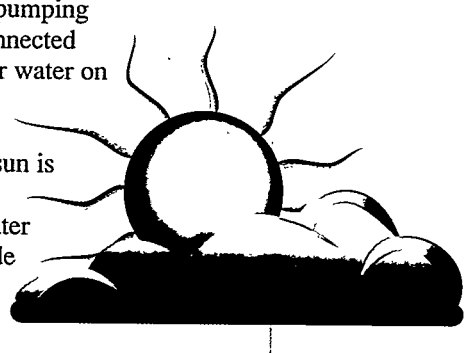
Source: NREL

PV Terminology

The first practical PV cell was developed about the same time as the first practical transistor - during the mid-1950s by Bell Laboratories. PV's first cost-effective application was to power the Vanguard satellite in 1958. Since then, PV usage has increased as the price decreased. PV modules are now less expensive than ever and they are readily available from at least eight major manufacturers.

Pumping Water with the Sun

PV-powered pumping systems are in many ways different from standard line-connected pumping systems. Unlike line-connected water pumps that deliver water on demand, most PV pumping systems only deliver water when the sun is shining. This means there must be a large water storage facility to provide water during the night and other times when the sun is not shining.



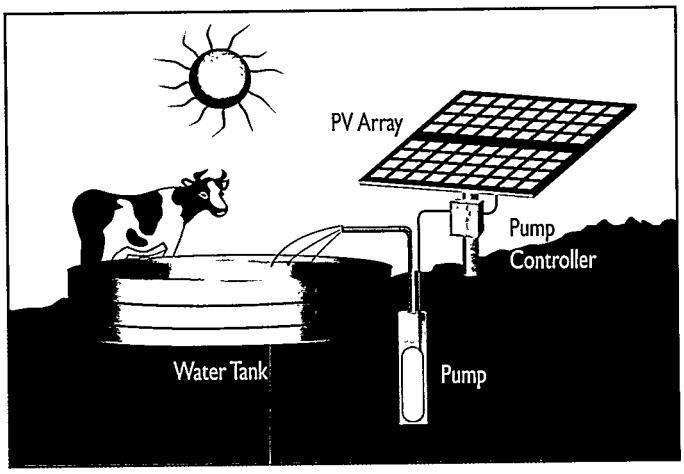
In most cases, the water storage or tank should be large enough to provide water through a minimum of three days of cloudy or overcast weather. For instance, if a rancher needs 1000 gallons per day to water his 50 cow/calf pairs, he should have a water tank that holds a minimum of 3000 gallons (i.e. a tank two feet tall by 16 feet in diameter). The storage should be even larger for critical applications such as when there is no back-up water source and for locations with long periods of inclement weather.

PV-powered pumping systems also vary greatly in their water output from season to season due to the changing availability of the sun. This is why daily water requirements must be known for each season to properly size a PV pumping system. Fortunately, these systems deliver the most water during the long hot days of summer when livestock drink the most.

Because PV power supplies are not unlimited sources of power and energy like utility power lines, the most cost-effective PV system is one that is properly sized for the application. If a PV pumping system is undersized, the user may save money on the system but in the long run will be dissatisfied with its low water production. On the other hand if a user over-estimates his water requirements to ensure adequate water delivery, the oversized system may turn out to be unaffordable. Before purchasing a PV

pumping system each user needs to take the time to accurately estimate his water requirements.

Water source information must be known accurately as well, especially if the water source is a well. If current well data is not available, a well test can be performed by local well and pump service companies. Although a well test may be an added expense, it can prevent the purchase of an improperly sized system that either costs more than necessary or must be corrected to provide enough water.



Pumping System Components

Most PV-powered pumping systems consist of a PV array, a water pump, a pump controller and a storage tank. Optional components include solar trackers, batteries with a charge controller and water level sensors or float switches.

PV Arrays

The PV array is comprised of PV modules that range in size from 50 to 80 peak watts and cost from $350 to $500 apiece. The PV modules are the most reliable component in any PV pumping system. They have been engineered to withstand extreme temperatures, severe winds and impacts from one inch hail balls at terminal velocity. PV modules have an expected life expectancy of 20 to 30 years and the manufacturers warrant them against power degradation for 10 to 20 years. PV modules require no care other than occasional cleaning of the surface if they are used in dusty locations.

Pumps

The main difference between conventional line-connected pumps and PV pumps is the fact that PV pumps are designed to run off of DC power supplies. Efforts are currently under way to develop a pump controller that can operate conventional submersible AC pumps with DC power supplies, but at this time there are no field proven products on the market. However, there are many reliable DC centrifugal and positive displacement pumps designed to operate with PV power supplies.

Centrifugal pumps move water by means of blades or impellers that rotate at high speeds. Because the movement of the water depends on the force created by the impeller, both the water flow rate and vertical lift capability are related to the speed of the impeller and pump motor. Due to this relationship, a centrifugal pump may fail to deliver any water if there is a significant decrease in the power supply (i.e. a cloudy day) or an increase in the pumping head.

To their advantage, centrifugal pumps have no seals or mating surfaces to wear out, are fairly tolerant of dirty water and typically require no regular maintenance. In general, centrifugal pumps are good for pumping medium to large volumes of water at low to medium heads. One example of a centrifugal pump is the standard, line connected submersible AC well pump.

Positive displacement pumps move water by mechanically advancing a sealed quantity of water. Some of the more common positive displacement pumps used with PV power supplies include diaphragm, piston, and jack pumps. A positive displacement pump's flow rate, is directly related to the motor speed and power input. But in contrast to centrifugal pumps, its vertical lift capacity is relatively unaffected by the motor speed. This means that PV-powered positive displacement pumps are more likely to pump water under low light conditions although at a slower rate.

Since all volumetric pumps have seals, mating surfaces or diaphragms that wear, they require regular maintenance to replace or repair worn parts. In general, positive displacement pumps are good for pumping small to moderate amounts of water at all heads. An example of a positive displacement pump is the down-hole cylinder and plunger used with windmills.

Centrifugal and positive displacement pumps come in both surface and submersible models for use with PV systems. However, for livestock watering applications, submersible pumps are by far the most popular. This is

due to the fact that they can be used in both wells and surface water supplies and are much easier to protect from freezing. The two most common types of PV pumps are submersible diaphragm and submersible centrifugal pumps.

Submersible diaphragm pumps are used in smaller PV pumping systems. They typically deliver as much as 1500 gallons per day and have a vertical lift limit of about 200 feet. However there are promising new diaphragm pumps on the market that may deliver up to 3000 gallons per day and up to 600 feet of lift. Prices for PV diaphragm pump systems start around $1,200.

Submersible centrifugal pumps are used in medium to large PV pumping systems. They can deliver as much as 40,000 gallons per day and have vertical lifts of up to 600 feet. Systems with these capabilities, however require very large PV power supplies and are not cost-effective for most applications. Typical centrifugal systems are much smaller with prices that start around $2,000.

Pump Controller

Pump controllers maximize the water delivery of pumps by matching the voltage and current output of the PV array to the requirements of the pump motor. This allows pumps to operate in reduced light conditions such as in the morning, in the evening and during some cloudy days.

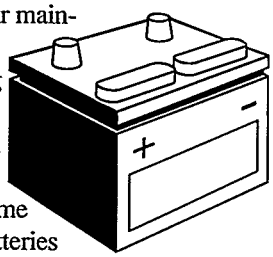
Some controllers also contain features to protect pumps from power surges, over-current, overheating and dry run conditions. They also accept input from water level sensors and float switches to prevent pumps from running dry or to stop the flow of water to a tank once it is full.

Solar Trackers

Trackers optimize the energy production of PV modules by facing them towards the sun as it travels across the sky. This increases the effective length of the pumping day and decreases the number of PV modules necessary to deliver the same amount of water. However, trackers with their moving parts add to the complexity of a pumping system and can be expensive. As a general rule, trackers do not gain enough energy during the winter months (especially in northern climates) to pay for their added expense. However, if your water requirements are highest in the summer, a PV pumping system with a solar tracker may be your least expensive option.

Batteries and Charge Controllers

Batteries are generally not used in water pumping systems because storage of water is more cost-effective than storage of electricity in batteries. Batteries add to the cost and complexity of a pumping system, must be protected from freezing conditions, require regular maintenance, and have a limited life. However, there are some pumping applications where batteries are required. These include wells with low recharge rates that must be pumped slowly over a period of time beyond normal sunlight hours. Batteries can maximize the output of slow wells by allowing them to be pumped over a 24-hour period. Another application is pumping systems that must deliver water on demand. These systems are sometimes used to provide water for off-grid residences and in situations where water cannot be stored due to water quality concerns.



An important factor in the life and reliability of a battery is the charge controller. The charge controller has two separate functions: 1) to prevent overcharging of the battery and 2) to keep the battery from being too deeply discharged. Battery life can be severely shortened by either of these conditions.

Storage Tanks

For stock watering applications, round open tanks of galvanized steel with steel, cement or clay bottoms are typically used. Although this type of tank is least expensive to purchase and install, a lot of water is lost to evaporation, especially in hot, dry, locations that are common in the west. If an enclosed tank with a watering trough is used instead, a smaller (and less expensive) PV pumping system may be able to keep up with your water demand at a lower total system cost. The water storage tank should be large enough to fulfill water requirements through a minimum of three days of cloudy or overcast weather.

Pumping System Examples

The following two pages contain examples of four PV pumping systems, two with submersible diaphragm pumps and two with submersible centrifugal pumps. Each example lists the daily water delivery, the total pumping head and the size, and cost range of the each system. Also, for each system, water delivery estimates for several locations across the country are provided.

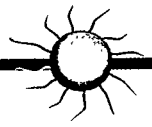
System Example #1: Small Diaphragm Pump System

System Description :

Total pumping head:	50 feet
Avg. daily water delivery *	500 gallons per day (GPD)
PV array size:	60-100 watts
Livestock watered:	25 cow/calf pairs
Typical price range:	$1,200-$1,500
Cost of new windmill to pump equivalent water (w/6hrs. of wind)	$2,300-$2,600

Variations In Average Daily Water Delivery (GPD)

	Austin, TX	Bismarck, ND	Boise, ID	Goodland, KS	Tucson, AZ
Summer	510	510	560	540	600
Spring/Fall	450	430	450	480	550
Winter	360	270	240	370	450



System Example #2: Large Diaphragm Pump System

System Description :

Total pumping head:	75 feet
Avg. daily water delivery *	2000 gallons per day (GPD)
PV array size:	300-350 watts
Livestock watered:	100 cow/calf pairs
Typical price range:	$3,400-$4,000
Cost of new windmill to pump equivalent water (w/6 hrs. of wind)	$3,400-$3,600

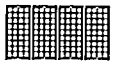
Variations In Average Daily Water Delivery (GPD)

	Austin, TX	Bismarck, ND	Boise, ID	Goodland, KS	Tucson, AZ
Summer	2000	2000	2300	2100	2400
Spring/Fall	1800	1700	1800	1900	2200
Winter	1400	1100	1000	1500	1800

* With solar insolation of 6 kWh/m²

System Example #3: Small Centrifugal Pump System

System Description :



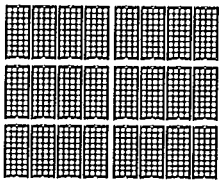
Total pumping head:	75 feet
Avg. daily water delivery *	2000 gallons per day (GPD)
PV array size:	300-350 watts
Livestock watered:	100 cow/calf pairs
Typical price range:	$3,600-$4,600
Cost of new windmill to pump equivalent water (w/6 hrs. of wind)	$3,400-$3,600

Variations In Average Daily Water Delivery (GPD)

	Austin, TX	Bismarck, ND	Boise, ID	Goodland, KS	Tucson, AZ
Summer	2000	2000	2300	2100	2400
Spring/Fall	1800	1700	1800	1800	2200
Winter	1400	1100	1000	1500	1800

System Example #4: Large Centrifugal Pump System

System Description :



Total pumping head:	200 feet
Avg. daily water delivery *	4000 gallons per day (GPD)
PV array size:	1,200-1,600 watts
Livestock watered:	200 cow/calf pairs
Typical price range:	$10,000-$15,000
Cost of new windmill to pump equivalent water (w/6 hrs. of wind)	volume not possible w/windmill

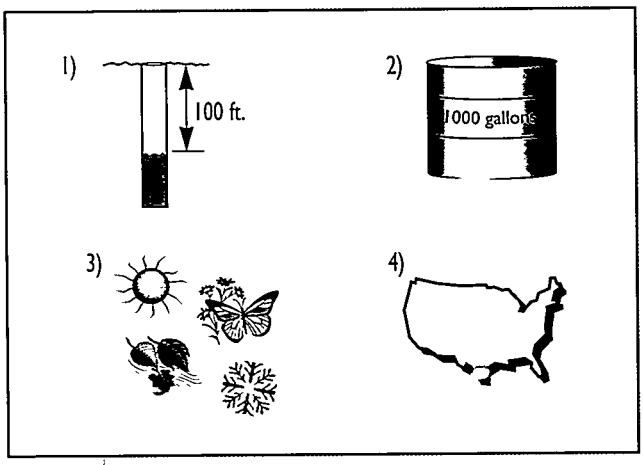
Variations In Average Daily Water Delivery (GPD)

	Austin, TX	Bismarck, ND	Boise, ID	Goodland, KS	Tucson, AZ
Summer	4100	4100	4500	4300	4800
Spring/Fall	3600	3400	3600	3900	4400
Winter	2800	2200	1900	3000	3600

With solar insolation of 6 kWh/m^2

Selecting a PV Pumping System

One of the first things that must be known when considering a PV pumping system is whether the energy required to pump the necessary amount of water can be cost-effectively supplied by a PV system. To obtain an answer, a minimum of four factors must be known: 1) the total pumping head, 2) the water requirement, 3) the seasons of use and 4) the site location.



The pumping head and the water requirement together determine the amount of energy required to raise the water. The season of use and location determine the amount sunshine available to supply that required energy. If the energy requirement is too high or if too little sunshine is available during a season of high use, the cost of a PV system large enough to provide the energy will be unreasonable, even in comparison to a long line extension. When the cost of a line extension and PV system are both too expensive, options such as generator-powered pumps become more attractive alternatives.

The PV system examples on pages 6 and 7 give an indication of the relative costs of different size PV systems. To obtain a more accurate cost estimate for a PV system, fill out the PV Pumping Information Form on page 11 and contact a your local utility or PV system vendor for a price quote. Those assisting you with your system selection carry a wide variety of PV pumping systems and can advise you as to which system makes the most sense for your particular application.

Careful consideration should be given to your choice of system supplier and their experience in designing and supplying PV systems. PV systems can (and should) be designed and installed to provide decades of safe, reliable service. Systems not designed and installed in a safe manner could result in fire or personal injury. The National Electrical Code (NEC) was developed to ensure safe electrical systems. The PV system supplier you choose should design PV pumping systems to comply with the NEC.

Obtaining a PV Pumping System

There are three basic means for obtaining, installing and maintaining a PV pumping system: 1) the local electric utility; 2) local PV vendors; and 3) PV catalogs.

The local electric utility:

In many cases, the same electric utility company that provided you with an estimate for the cost of constructing a utility line can also provide you with a quote for a PV system alternative. It is the mission of electric utilities to provide you with electricity, and the PV alternative is consistent with that mission. Depending on the nature of their PV service program, utilities may the following several choices.

PV Energy Services: this method is similar to the way they provide traditional grid-powered electricity. The utility owns, installs, and maintains the PV system and bills you on a monthly basis the same as for regular electric service. The bill is usually based on the initial cost of the installed system and includes their anticipated cost of maintenance and replacement parts. This service option is usually the least cost option offered by the utility and eliminates most of the technical and financial risk to the customer.

Financing: the utility may provide access to the equipment they can buy in volume and offer it to you with a financing package. They may also provide you with an optional extended warranty (service and maintenance contract). With this option you end up owning the hardware and may be responsible for future component replacements.

There are many advantages to obtaining a PV system from the local utility. The systems offered by utilities have been designed and built to meet high utility standards including the requirements of the NEC. They are complete pre-packaged systems to simplify delivery and installation. The ability of the utility to finance the system may also be of tremendous value to those who are unable or unwilling to tie up the capital for a direct purchase. The utility is in the business of providing

electricity and has been, in some cases, for nearly a century. They are used to providing customers with quick and efficient service.

To obtain a system from a utility follow the procedure suggested below:

- Contact your local utility for a line extension quote and ask if they also offer PV services;
- If they do offer PV services, simply follow their procedure to receive quotes for the PV options they offer;
- If your local utility does not offer PV services, there are many other electric utilities that do. The Photovoltaic Services Network (PSN) is an organization of many utilities across the country that all offer PV services. Since PV is electricity without wires, many of these utilities are offering PV services to customers regardless of utility service territory boundaries. For assistance call 303-980-1969 and ask for the PSN.

Local PV Vendors:

In some areas of the country a network of PV vendors can be found. These vendors have built their businesses on providing PV systems to regional customers. In addition, some well and pump service companies also sell and service PV pumping systems.

PV vendors can assist you with the design of your system and have access to many brands of hardware. Some vendors also staff licensed electricians that can be hired to install and maintain your system.

Most systems offered by PV vendors are cash sales and are custom designed to meet your exact needs. The vendor can work with you to decide on the best system and installation configuration for your particular situation.

To locate a PV vendor near you, contact:

Solar Energy Industries Association
122 C St., NW 4th Floor
Washington DC 20001-2109
(202) 383-2600

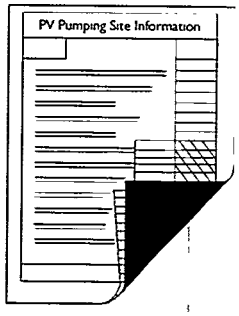
Independent Power Providers
PO Box 231
North Park, CA 93643
(209) 841-7001 or (916) 475-3402

Do-it-yourself Catalog Cash Sales:

Many PV companies have produced catalogs that list all the components necessary to build and install a complete system. Some catalogs also offer kits that are sized in graduated increments. This option usually requires you to have the ability to design and size the appropriate components as well as install and maintain your system. However, most catalog companies can provide some technical assistance over the phone.

Water Pumping Site Information

A certain amount of information is necessary to properly size a PV pumping system for a particular well or watering site and to determine which type of PV pump is best suited to the site and end use. Any PV pumping system supplier, whether it is the local utility or a PV vendor, will need to know this same information to be able to provide a price quote for a PV system. The form on page 11 lists the information that is needed. An explanation of the form is provided below.



Water Use Information:

Water End Use:- This information can be used by system suppliers to estimate or verify your daily water requirements. If the end use is for livestock watering, record the type (dairy cows, yearling cattle, sheep etc.) and number of livestock that will be watered. If the end use is for domestic household use, record the number of people in the household.

Average Daily Water Requirement: - Determine as accurately as possible your average daily water requirements (in gallons) for each season and record them here.

Water Storage - Circle the type of water storage that you will be using and record the storage capacity in gallons. If you plan to use an existing tank and you are unsure of the capacity, record its dimensions and a system supplier can help you calculate the capacity.

Water Source Information:

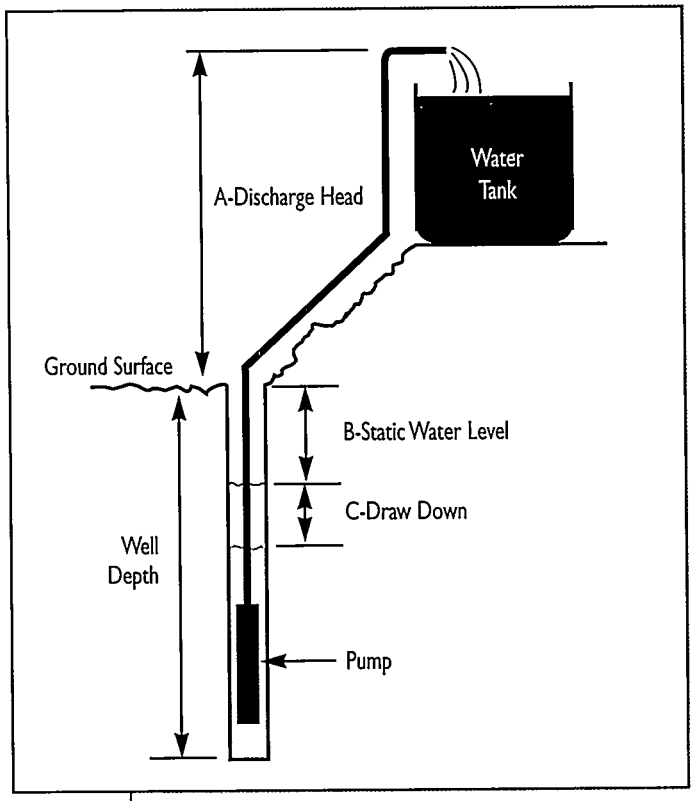
Water Source - The type of pump used with a PV pumping system is determined by the water source. Streams and ponds can take either surface or submersible pumps whereas wells require submersibles. If the source is a well, record the diameter of the well casing, the depth of the well and whether a recent well test has been performed. The diameter of the casing determines what type and size of submersible pump can be installed in the well. The depth of the well gives an indication of how far below the static water level a

pump can be submersed. The date of the latest well test gives a good indication of the accuracy of the well data.

Is this water source presently being used? - The answer gives pumping system installers an indication of whether additional work may have to be done before a PV-powered system is installed. For example, if the water is being pumped by a windmill and a submersible solar pump best suits the application, all of the windmill's down hole equipment may need to be removed prior to installation of the new pump. This question also alerts the installer to possible problems with water quality. A well that has not been used for a while may initially produce water with silt, sand or rust.

Static Water Level - This is the distance from the ground surface to the water level in the well, stream or pond when the water source is not being pumped (see diagram). This water level may change seasonally or from year to year. Record the deepest known static level.

Draw Down Level - As well as contributing to the total dynamic head, the draw down level indicates to the pump installer how deep the pump or water intake must be installed to remain submerged while pumping. The draw down level is the distance that the water level drops when the water source is being pumped (see diagram). Record the largest known draw down when the source is being pumped at a rate that supplies the daily water requirements within a five or six hour period. Also record the pumping rate. For example, if you need 3000 gallons of water per day, divide 3000 by five hours to get 600 gallons per hour. Divide 600 by 60 minutes to get 10 gallons per minute (GPM). In this case, the draw down is the distance the water level drops while the source is being pumped at 10 GPM.



Discharge Head - This is the vertical distance that the water is pumped uphill from the water source to a storage tank or a distribution point (see diagram). Record the vertical distance to the highest storage tank or distribution point.

Pressure Head - If a pressure tank is used to store the water (usually in domestic water systems) and if the same pump delivering the water is used to pressurize the tank, the pressure in the tank must be translated to an equivalent head of water. To do this, multiply the pressure in the tank (psi) by 2.31 to get the equivalent head in feet.

Friction Head - The friction head is the pressure loss due to the drag of moving fluid against the pipe walls. It is a function of the length of the pipe run, the diameter of the pipe, the smoothness of the pipe, and the velocity of the fluid. In most cases, when the water is used close to the water source, the friction head is negligible and can be ignored. However, if the water is pumped for any distance away from the source (over 300 ft.) the friction head must be added to the total pumping head. A PV system supplier can help you calculate the friction head.

Total Pumping Head: - The total dynamic pumping head is the sum of the above five heads. This is one of the critical numbers used to size pumping systems.

Water Quality: - If the water contains sand, silt or rust; pumps may need additional screens or filters for proper operation or a different type of pump that is not sensitive to impurities may be selected.

Solar Access: Does the area surrounding the site contain any trees or hills that may block the sunlight reaching the water site at any time of the day during any season of use? If so, the PV array may have to be located some distance away from the pump. The heavy gauge outdoor rated wire that must be used in a long cable run to a distant array adds to the expense of the pumping system.

PV Pumping Site Information

Name _____

Address _____

State & Zip Code _____

Telephone Number _____

Water Use Information

Water end use: (Circle one)

1. Livestock watering - Number of head _____
   Type of livestock: _____
2. Domestic household use - Number of people _____
3. Other - Please specify: _____

Average daily water requirement:

Summer: _____ Gallons/Day
Fall: _____ Gallons/Day
Winter: _____ Gallons/Day
Spring: _____ Gallons/Day

Water storage: (Circle one)

1. Above ground tank - Size: _____ Gallons
2. Pressure tank - Size: _____ Pressure: _____ psi
3. Other _____ Size: _____

Water Source Information

Water source: (Circle one)

1. Drilled Well - Well casing diameter: _____ inches
   Depth of well: _____ feet
   Max pumping rate for well: _____ GPM
   Date of most recent well test _____
2. Stream or pond _____
3. Other - Please specify: _____

Is this water source presently being used? Yes ☐ No ☐
If yes, how is it being pumped? _____

_____

Static water level: (Distance from ground surface to water before pumping) _____ Feet

Draw down level: (Distance water level drops when pumping at normal rates) _____ Feet

@ _____ GPM

Discharge head: (Vertical lift to uphill tank or distribution) _____ Feet

Pressure head: (Tank pressure in psi x 2.31) _____ Feet

Friction head: (see description previous page) _____ Feet

Total pumping head: (sum of above 5 lines) _____ Feet

Water quality: (Circle one) Very Good Good Fair Poor Very Poor

Water contains: (Circle all that apply) Silt Sand Rust Minerals

Does the site have unrestricted solar access? Yes ☐ No ☐

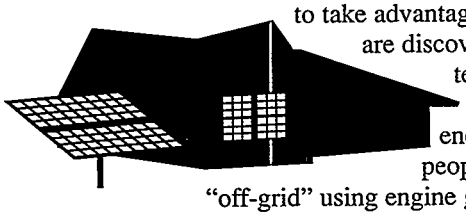
Additional PV Applications

Along with water pumping, there are many other applications that can be cost-effectively powered by PV systems.

Remote residences

PV systems can provide electricity in remote locations to homes, cabins, ranches, farms and any other facility that is not served by electric power lines.

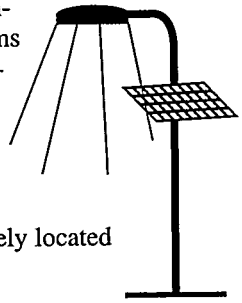
As people start to build their homes in remote locations to avoid pollution and crowds, and to take advantage of the scenery, they are discovering that PV systems are often their most cost-effective energy solution. Also, people who already live "off-grid" using engine generators for power are adding PV systems to decrease the noise, exhaust fumes, maintenance and constant need to haul fuel for their generators.



In addition, government agencies such as the National Park Service, Forest Service, and Bureau of Land Management are finding PV systems to be a fast, easy and inexpensive way to provide power to remote ranger stations, campgrounds and restroom facilities.

Remote Lighting

PV power systems are also being used more frequently for remote lighting applications. Due to the cost of trenching and running cable, many PV lighting systems are even cost competitive with nearby electric line connections. Some examples of PV lighting systems are:



- Remote security lighting
- Sign lighting, particularly remotely located bill boards
- Pathway lighting
- Lighting for remote out-buildings such as shops, barns or restrooms
- Street lighting

PV lighting systems offer many of the same maintenance and cost advantages as water pumping systems. Hardware for both of these applications (remote residential and lighting) may be available from your utility or local supplier as packaged systems.

In addition to these applications, PV systems can be cost-effective for many electric loads requiring low to moderate power and small amounts of energy. Your imagination is the only limit to using this versatile and innovative technology.

This booklet is provided to you by:

Solar Electricity

an Alternative to Utility Power Lines

Solar electric or photovoltaic (PV) systems can provide electricity in remote locations. They can be used in cabins, homes, ranches, farms, or any other facility that is not served by electric power lines. In locations where extending a power line to a site is prohibitively expensive, PV systems may be the least cost solution. This booklet provides an introduction to PV systems to help you evaluate the PV alternative.

PSN A publication of the Photovoltaic Services Network

PV vs. Line Extensions

The cost of extending a power line to a home or other facility depends on how the electric utility company charges for line extensions and the distance to existing electrical distribution lines. If the local utility has a generous line extension policy or a home or facility is located close to existing distribution lines, the cost of a line extension for electric service will be affordable.

However, if the local utility expects the customer to pay for all line construction costs and the home or facility is far from existing distribution lines, electric utility service may not be a viable choice. Your local electric utility company can give you an estimate of the cost to extend a line to your home or facility. Many utility companies are also offering PV service options and can assist you with PV as an alternative solution to your power needs.

The PV Alternative

With utility line construction costs typically ranging from $10,000 to $40,000 per mile it may be to the electric utility company's benefit and to the customer's benefit to find an alternative to a line extension. Depending on your electrical requirements, a PV system might be the least cost option even when the nearest utility pole is no more than 1/4 mile away.

In some cases, other sources of power may be practical. These include wind powered generators and low head hydro-electric generators. Of the three, PV systems are the most popular because of their low maintenance requirements and the more consistent availability of solar energy. Other advantages of a PV system include:

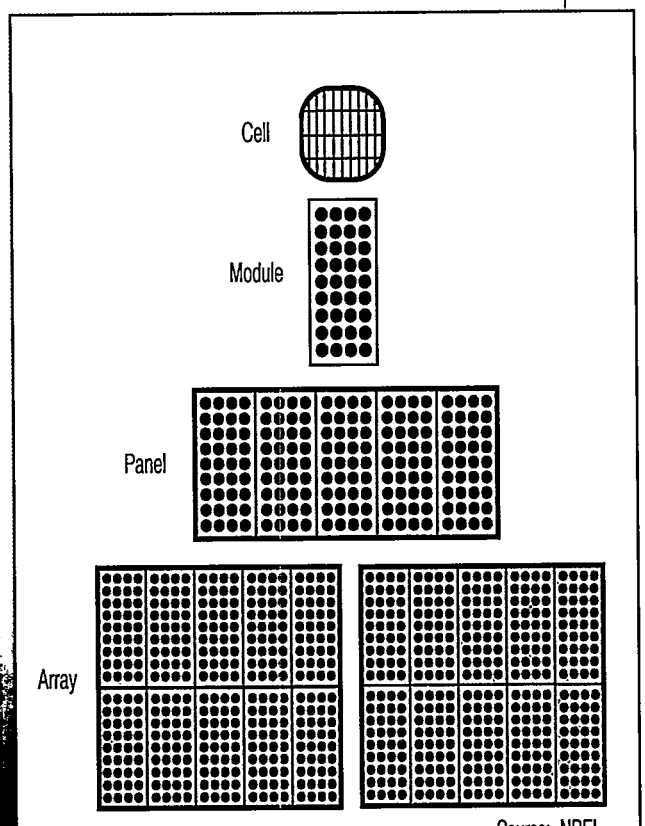
"Free energy" - once the PV system is installed there will be no additional cost for the energy. Sunlight as a renewable and plentiful resource throughout most of the United States. The solar resource has been measured and documented for many years and the annual average sunshine for a location can be predicted with surprising accuracy.

Reliable power - since as much as a week of a home's daily electricity requirement can be stored in the system's battery [illegible]

night. For this reason, PV systems have become the power source of choice for many critical applications such as emergency lights, communications and sirens.

Flexibility - most PV systems are designed to allow for convenient expansion. The PV modules which make up the PV array (see PV terminology diagram at bottom) are modular and more modules can be added if future electrical requirements increase. With time and population growth, the electric utility grid may gradually extend within economic reach of a PV-powered home. A residential PV system can be installed to easily accommodate future connection to the utility grid.

Quick Installation - many utilities now offer completely packaged PV systems that are pre-assembled at the factory and can be installed in less than one day. They require little site preparation and no modification to the residence. They can also be installed during house construction to power construction tools.



Source: NREL

PV Terminology

Photovoltaic Technology

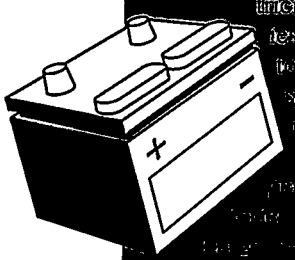
Photovoltaic is a descriptive name for a technology in which radiant light energy from the sun (photo) is converted to direct current electrical energy (voltaic). PV cells are made of semi-conducting materials, typically silicon, doped with special additives. When sunlight hits the surface of a PV cell, electricity is generated. A single silicon PV cell generates approximately 1/2 volt of DC electricity. The amount of electric current generated by a PV cell is directly proportional to its size and to sunlight intensity. If there is no light, no electricity is generated.

As shown in the figure, groups of 36 interconnected PV cells are packaged together into standard modules that provide a nominal 12 volts (or 18 volts at peak power). PV modules were originally configured in this manner to charge 12-volt batteries. Desired power, voltage and current can be obtained by connecting individual PV modules in series and parallel combinations, in much the same way as batteries are connected. When modules are mounted together in a single frame they are called a panel and when several panels are interconnected they are called an array. (Sometimes a single panel is also called an array.)

The first practical PV cell was developed about the same time as the first practical transistor - during the mid-1950s by Bell Laboratories. PV's first cost-effective application was to power the Vanguard satellite in 1958. Since then, PV usage has increased as the cost decreased. PV modules are now readily available from at least eight major manufacturers.

PV Systems

The primary and only essential component of a PV system is the PV array itself (see diagram on next page. However, because electricity is often needed when the sun is not shining, battery storage of electricity is usually required. The batteries used in PV systems are similar to automobile batteries, but are specially constructed to withstand many deep discharge cycles over a period of years. [illegible]



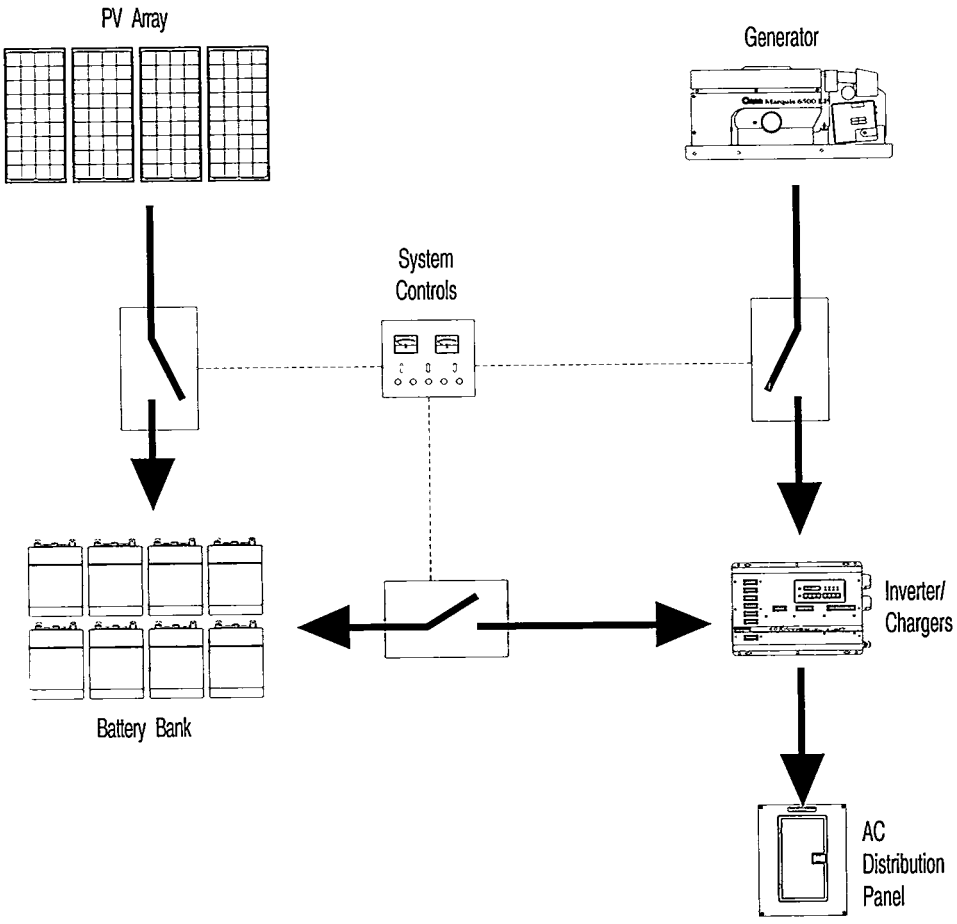
PV-powered water pumping is usually the only application that does not require battery storage. Instead, several days worth of water is pumped and stored in large tanks for use during night time and periods of cloudy weather.

Just as an automobile uses a voltage regulator to control the charging voltage to the battery, a similar type of controller is used in PV systems to prevent overcharging the battery bank. PV charge controllers limit the current from the PV array to the batteries once the batteries reach a pre-set voltage limit and are fully charged. Most systems also include a load disconnect control as well. This feature disconnects the electrical load from the batteries when the batteries reach a low state of charge.

PV arrays and batteries are generally configured to provide 12, 24, or 48 volts of DC power. However, 120-volt AC (alternating current) power is often required to operate conventional equipment such as appliances, motors and lights. The conversion from DC to AC current is achieved with a separate component called an inverter. An inverter makes it possible to operate common household appliances. Inverters can also power office equipment such as computers, copiers and facsimile machines.

An optional component for PV systems is a back-up engine generator. A back-up generator often results in a system with lower initial cost, lower cost of energy, more flexibility and more reliability. For a small incremental cost, a generator can provide additional energy for times when the sun doesn't shine or when more energy is needed. Generators are also commonly used to operate high power, intermittent loads such as washers and dryers, power tools, and sometimes even the well pump. High power tasks can be scheduled to occur simultaneously to maximize the operating efficiency of the generator.

Most systems available today include circuitry to allow the generator power to be automatically transferred to the load through the PV system with a portion of the power being used by the system itself for supplemental battery charging. The new [illegible]



PV System Components

System Safety

PV systems can (and should) be designed and installed to provide decades of safe, reliable service. Systems not installed in a safe manner could result in fire, personal injury, or even death. The National Electrical Code (NEC) was developed to ensure safe electrical systems and it addresses PV safety issues in a special section (Section 690). In addition to NEC compliance, local or regional codes may also require that a licensed electrician or technician install the PV system.

System Maintenance

There is virtually no maintenance required for PV modules. The expected life for typical PV modules is 20 to 30 years. However, batteries require water every three to six months (unless they are sealed maintenance free batteries) and the battery terminals should be cleaned once a year.

ten years. Those operating the system can extend the life of batteries by limiting the depth of daily discharge. This can be done through system controls or through proper task scheduling and energy awareness.

Oil in back-up generators must be replaced at least twice a year, or more often if the generator is used frequently. Other generator repair and maintenance such as tune-ups and major overhauls will depend upon the hours of use and the type of generator.

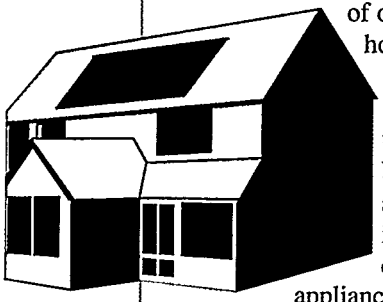
PV System Design

Designing a reliable, safe, and cost effective PV system requires extensive knowledge of electrical load size and characteristics, photovoltaic components, local solar insolation and climate, electrical wiring practices and local electrical codes. An improperly designed and installed PV system will both cost more to obtain as well as to maintain. Consideration should be given to [illegible]

Living In a PV Powered Home

Unlike a utility line, PV systems provide a limited amount of energy and a fixed power capability. Power refers to the wattage or combined wattage's of the appliances you wish to operate simultaneously and energy refers to the length of time they are run. In PV systems, the power capability is limited by the size of the inverter. The energy available from a PV system is limited by the size of the PV array, the storage capacity of the battery bank and the weather.

If designed properly, a PV system is capable of operating any and all household appliances. However, it may not be practical or cost - effective to have the PV system built to handle high power appliances. In many cases it is more efficient and less expensive to operate some appliances from an alternate power source such as a generator.



The occupants of a typical remote home powered by a PV system have a great deal of freedom in how they manage their system. Carefully choosing which appliances to operate on electricity and deciding how and when they are operated can reduce daily energy use.

PV systems can be (and often are) designed such that minimal lifestyle modifications are required to live comfortably. The primary decision made by most remote home owners is the acceptable balance between PV system cost and energy use adjustments. Energy use adjustments can range from none to many depending on the size of the PV system selected and the acceptable length of generator run time.

Energy Use Adjustments

Living in a PV powered home requires that attention be paid to the types of appliances used (referred to as electrical loads) and how and when they are operated. There are two basic loads:

- Inappropriate loads
- Appropriate loads

Inappropriate Loads

In general, PV systems are not used to power large heating and cooling loads. These appliances typically contain resistive heating elements or compressors that require high power and consume large quantities of energy. Propane is a more cost-effective energy source for these applications. Examples of these loads include:

- Baseboard heaters
- Cook stoves, ovens or ranges
- Clothes dryers
- Water heaters
- Dishwashers
- Space heaters
- Large refrigerators or freezers

Despite recent advancements in PV technology, PV energy is relatively expensive. Most of the above appliances are available powered by natural gas or propane. In most cases it is more cost-effective to replace existing electric appliances with gas models rather than increase the size of the PV system to accommodate them. Engine generators are also available that use propane as their fuel source. Using a propane generator reduces the need to haul and store more than one fuel.

Appropriate Loads

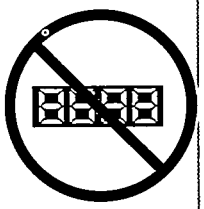
As was mentioned earlier, PV systems can be designed to power almost anything. The size of the system selected ultimately determines which loads are appropriate to operate. The following categories of appliances are considered appropriate for most medium to large sized residential PV systems (refer to the system examples on pages 8-11 for more detail on which loads are appropriate for a given size PV system).

- Most low wattage appliances including TVs, stereos, computers and small kitchen appliances
- Medium wattage appliances used for short durations such as microwave ovens and vacuum cleaners
- High wattage appliances used infrequently for very short durations such as hair dryers and power tools

Loads Requiring Special Consideration

There are some loads which require special consideration. PV systems are not generally used to power older conventional refrigerators or freezers. Although they have only moderate power requirements, these appliances consume a large amount of energy because they run for a large percent of the time and have automatic defrost cycles with electric heating elements. Instead, propane refrigerators, or special super efficient electric refrigerators can be used. Newer model refrigerators (1994 and later) that conform to higher efficiency standards may also be considered for use with larger residential PV systems.

Some appliances draw energy 24 hours/day. These include: clocks, appliances with lighted displays, remotely-controlled TVs, VCRs and stereos, and appliances that use charging transformers (plug-in black boxes) like flashlights and answering machines. Whereas these appliances are not high power devices in themselves, their energy requirements quickly accumulate. Many non-electric or battery powered alternatives perform the same functions.

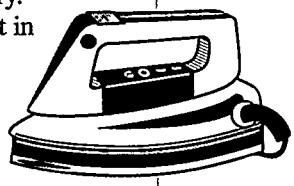


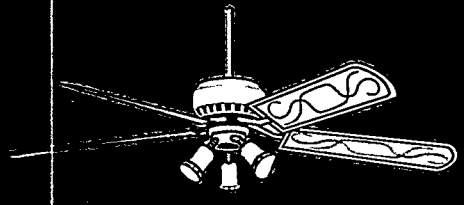
Washing machines also deserve careful consideration. Larger residential systems are capable of powering them, but their use might be best scheduled when the generator is running. Washing machines require water delivery and in many cases the well pump may be run on the generator. This is a matter of task scheduling - a minor but necessary energy use adjustment.

Conventional air conditioners also consume a large amount of electricity and are not recommended for use with PV systems. However, in many parts of the country with drier climates, fans and evaporative coolers provide an effective means of cooling and use moderate amounts of energy that are compatible with PV systems.

Task Scheduling

Task scheduling refers to planning several household chores coincident with the period-ic operation of the engine generator or during periods of good sunshine. This might include scheduling the weekly ironing on the same day as vacuuming and doing laundry. Since most PV systems have a built in battery charging circuit, whenever these high power appliances are operating from the generator, the system's battery bank is receiving a boost charge as well.

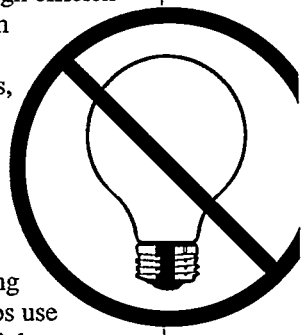




Energy Conservation

Energy conservation requires an awareness of how you use your appliances. Conservation measures can range from simply turning off lights that are not in use to buying efficient appliances.

Numerous new energy efficient products have been developed for use with PV-powered homes. Many companies supply high efficiency and special appliances for use in remote homes such as propane or super efficient electric refrigerators, compact fluorescent lights, TVs, pumps, evaporative coolers and radio telephones.



Choosing the correct light bulbs can have a major impact on your energy use. Similar to larger heating appliances, incandescent light bulbs use resistive heating coils to produce light.

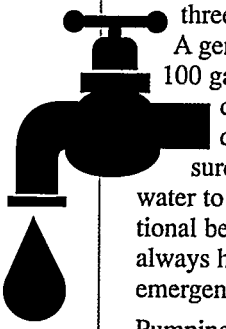
The newer compact fluorescent light bulbs use approximately one quarter the energy and last as much as ten times longer than incandescent bulbs. With a PV system, the energy saved by switching to these bulbs can save you thousands of dollars in PV system costs. For example, four rooms can be illuminated for the same energy as one room lit with incandescent bulbs.

Energy Monitoring

Most PV systems are offered with a system status indicator. The indicators are usually in the form of a meter which is mounted inside the home or facility. These meters range in type and complexity. Most will indicate, at a minimum, the battery state of charge and include an alarm to alert the homeowner when the stored energy is reaching a low level. Other monitors include data readouts which indicate the amount of charge current coming from the PV array or the amount of power being delivered to the load. In general

Domestic Water Systems

Very few remote homes have access to community water systems. Most remote homeowners obtain their water from streams, artesian springs, or from bore hole wells. Wells are by far the most common source of domestic water and generally require a pump to deliver water to the home.



Where possible, water should be stored in a tank that is large enough to contain at least three days anticipated water requirement. A general rule of thumb is to store at least 100 gallons per person per day. If the tank can be located uphill from the residence, gravity will provide the pressure necessary for the delivery of the water to the faucets and showers. An additional benefit of a gravity feed system, is always having water pressure available for emergencies, such as putting out fires.

Pumping water out of the well can be accomplished by one of the following means:

- A separate PV system without batteries can be dedicated to powering the well pump. This system only pumps when there is sunshine and delivers the water to a storage tank. An additional booster pump may be required to deliver the water to the home and this pump can be powered from the home PV system.
- The well pump may be powered only when the generator is operating. A float switch in the storage tank can control the level of water in the tank by requiring the generator to turn on when the water is low. This water system may also require a booster pump to make the final delivery.
- The well pump with a captive air storage tank may be powered directly, and on demand, from larger residential PV systems.

It is more cost-effective to store water than electricity. The choice of the water delivery system will be partly dictated by the depth and recovery rate of the well and the size of the residential PV system. In some cases an [illegible] mersible well pump in the well. Existing model pumps may be oversized for the application and may not be as efficient as newer model pumps. As with older model refrigerators and other appliances, it may be more cost effective to replace the old pump with a newer model than to increase the size of the PV system.

Many electric utilities and PV vendors carry a wide variety of PV powered pumping systems. Those assisting you with your system selection will advise you as to which method would make the most sense.

PV System Types and Sizes

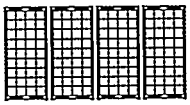
The choice of the type and size PV system that is required to meet your needs is primarily a function of its intended use. The first and most obvious selection criteria is based on the size of the residence you wish to power. The second is based on the number of people that will live there and the planned use of the dwelling.

Seasonal or small cabins generally require smaller PV systems. This is based not only on the size of the structure but on the length of time it is occupied. As the size of the dwelling increases and the occupancy increases, the required size of the PV system increases proportionally. Of course all this depends on the type and quantity of electrical appliances used.

The system examples shown on the following pages reflect four common residential system scenarios. Each example lists the type of dwelling and the size, capacity, and cost range of the PV system recommended for that dwelling. Also listed are those electric loads that would normally be powered by the PV system and those which would be more effectively operated on propane or an engine generator. Finally, estimates of the system's anticipated capacity are provided for several locations across the country. These estimates shown as a percentage describe that system's ability to provide the daily energy requirement based on available PV energy only (no generator).

System Example #1 Small or Seasonal Cabins

System Description :



Daily system energy output (PV only)	600-1,000 W-hr/day
PV array size	200-300 watts
Power capability (continuous rating)	500-1,500 watts
Battery storage	3-5 kWh
Available operating voltages	12 VDC/120 VAC
Recommended generator size	1-2.5 kW
Typical price range	$4,000 - $7,000

Loads Recommended for Use on PV System

lights	small kitchen appliances	cell phone/radio phone
small TV and stereo	small household appliances	laptop computer/ printer

Loads Recommended for Use on Engine Generator Power

supplemental battery charging	power tools	washer/dryer
water pump	microwave oven	vacuum cleaner

Loads Recommended for Use on Propane

refrigerator	hot water heater
cook stove	space heater

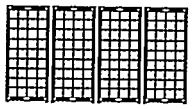
*Variations in Capability to Power Recommended PV System Loads**

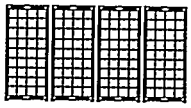
	Albany, NY	Austin, TX	Bismarck, ND	Boise, ID	Boulder, CO	Tucson, AZ
Winter	50%	80%	60%	50%	80%	105%
Summer	100%	115%	115%	130%	115%	130%
Annual	80%	95%	90%	95%	100%	120%

*Based on Daily System Energy Output (PV only)

System Example # 2 Small Full Time Home

System Description :





Daily system energy output (PV only)	1,000-2,000 W-hr/day
PV array size	300 - 600 watts
Power capability (continuous rating)	1,500-2,500 watts
Battery storage	5-10 kWh
Available operating voltages	12 VDC/120 VAC
Recommended generator size	2.5-4.0 kW
Typical price range	$9,000 - $11,000

Loads Recommended for Use on PV System

lights	small kitchen appliances	cell phone/radio phone
TV/VCR and stereo	small household appliances	computer/ printer
vacuum cleaner	small microwave oven	

Loads Recommended for Use on Engine Generator

supplemental battery charging	power tools	washer/dryer
water pump		

Loads Recommended for Use on Propane

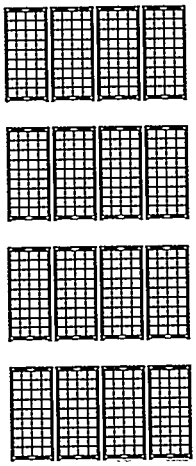
refrigerator	hot water heater
cook stove	space heater

*Variations in Capability to Power Recommended PV System Loads**

	Albany, NY	Austin, TX	Bismarck, ND	Boise, ID	Boulder, CO	Tucson, AZ
[illegible]	50%	80%	60%	50%	80%	105%
[illegible]	[illegible]	[illegible]	115%	130%	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	35%	[illegible]	[illegible]

System Example # 3 Medium Full Time Home

System Description :



Daily system energy output (PV only)	3,000-4,000 W-hr/day
PV array size	900 - 1200 watts
Power capability (continuous rating)	1500 - 2500 watts
Battery storage	15 - 20 kWh
Available operating voltages	120 VAC
Recommended generator size	4.6 - 6.5 kW
Typical price range	$16,000 - $19,000

Loads Recommended for Use on PV System

lights	kitchen appliances	cell phone/radio phone
TV/VCR and stereo	household appliances	computer/ printer
vacuum cleaner	microwave oven	small efficient refrigerator

Loads Recommended for Use on Generator Power

supplemental battery charging	washer/dryer
water pump	power tools

Loads Recommended for Use on Propane

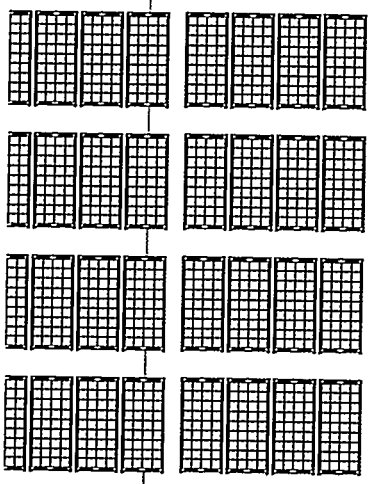
refrigerator	hot water heater
cook stove	space heater

*Variations in Capability to Power Recommended PV System Loads**

	Albany, NY	Austin, TX	Bismarck, ND	Boise, ID	Boulder, CO	Tucson, AZ
Winter	50%	80%	60%	50%	80%	95%
Summer	100%	115%	115%	130%	115%	130%
Annual	80%	95%	90%	95%	100%	120%

System Example # 4 Large Full Time Home

System Description :



Daily system energy output (PV only)	5,000-8,000 W-hr/day
PV array size	1,500 - 2,400 watts
Power capability (continuous rating)	4,000- 8,000 watts
Battery storage	25 - 30 kWh
Available operating voltages	120 / 240 VAC
Recommended generator size	6.5 - 12 kW
Typical price range	$23,000 - $31,000

Loads Recommended for Use on PV System

lights	kitchen appliances	cell phone/radio phone
TV/VCR and stereo	household appliances	computer/ printer
vacuum cleaner	microwave oven	small efficient refrigerator
minimal clothes washing	water pump	small power tools

Loads Recommended for Use on Engine Generator

supplemental battery charging	washer/dryer	water pump

Loads Recommended for Use on Propane

hot water heater	cook stove	space heater

Variations in Capability to Power Recommended PV System Loads*

	Albany, NY	Austin, TX	Bismarck, ND	Boise, ID	Boulder, CO	Tucson, AZ
Winter	50%	80%	60%	50%	80%	105%
Summer	100%	115%	115%	130%	115%	130%
Annual	80%	95%	90%	95%	100%	120%

Selecting a PV System Size

The size and subsequently the cost, of a photovoltaic system depends upon two factors: the electrical energy requirements of the appliances powered by the system and the amount of sunlight available in your region. The amount of sunlight in your area is known by your system supplier and is a fixed design point. What is under your control is the type and quantity of appliances you plan to use.

Therefore, the first step in selecting a system size is estimating your daily energy use - your loads. This is usually followed with an adjustment to the estimate. Once completed, the final estimated daily load requirement can be used to review various system size options.

Determine the Daily Energy Use

Determine your total daily energy using the following steps:

- Identify all the electrical devices that will rely on the system for power;
- Determine each device's power usage (in watts);
- Make an estimate of the average daily use of each device in hours per day;
- Multiply each device's wattage by the hours of daily use to get watt-hours per day (Wh/day); and,
- Add together the watt-hours for all devices to get the total daily energy requirement.

An example of this calculation for a typical home is shown on page 14. If the energy requirement varies from season to season, the calculation must be made for each season to determine the largest requirement. Residences tend to use more energy in winter when the days are shorter, since lights and other appliances such as televisions are on longer.

The wattage of a device is usually stamped or printed on a nameplate or identification plate on the rear of the unit. If the unit lists VA (volts x amps), that number approximates the wattage. If only amps are listed, multiply the amps by the voltage (i.e., 120V) listed to find the approximate wattage. Name plate ratings are generally maximum design limits of the device, which could be two to four times the actual power consumed. If possible, measure (or have a technician measure) the actual power of every electrical load to be used. The wattages of typical appliances are provided for reference in the book [illegible]

Making Adjustments to Loads

After reviewing and calculating your daily load requirements, adjustments to the loads may enable a more cost-effective PV system selection. Adjustments may include:

- Fuel Switching: as mentioned previously, some appliances may be most cost-effectively powered on propane or a generator. Review your intended list of loads for those that may be switched to another energy source.
- Energy Efficient Appliances: where possible, plan on replacing existing low efficiency appliances (such as incandescent lights, old refrigerators, etc.) with newer more efficient models.
- Task Scheduling: this is a good time to begin looking at which electric loads might be operated when the generator is running.

After reviewing your original load list, attempt to eliminate those loads that fall into the above categories. Revise your daily load estimate and use this revised number to help you select a system which is within your budget.

Remember that most systems will include an engine generator for supplemental energy and that most people tend to overestimate their load usage. These two factors together enable you to choose a system which appears to be slightly smaller than your load estimate would suggest. If you have questions on the final system size selection, consult your utility representative or system supplier for assistance.

Obtaining a PV System

There are three basic methods for obtaining, installing and maintaining a PV system:

1. obtain a system from the local electric utility;
2. purchase a system from local PV vendors; or
3. mail order components from a PV catalog.

The local electric utility

In many cases the same electric utility [illegible] by that provided you with an estimate [illegible]

native. It is the mission of electric utilities to provide you with electricity, and the PV alternative is consistent with that mission. Depending on the nature of their PV service program, utilities may offer you several choices.

PV Energy Services: this option is similar to the way they provide traditional grid - powered electricity. The utility owns, installs, and maintains your PV system. They bill you on a monthly basis the same as for regular electric service. The bill is based on the initial cost of the installed system and also includes their anticipated cost of maintenance and replacement parts. The bill does not include any charges for the amount of energy produced or consumed. This service option is usually the least cost option offered by the utility and eliminates most of the technical and financial risk to the homeowner.

Financing: the utility may provide access to the equipment they can buy in volume and offer it to you with a financing package. They also may provide you with an optional extended warranty (service and maintenance contract). In this option you will end up owning the hardware and may be responsible for future component replacement costs.

There are many advantages to obtaining a PV system from the local utility. The systems offered by utilities have been designed and built to meet high utility standards. Most come pre-packaged and fully assembled to simplify delivery and installation without any hardware mounted in or on your dwelling. The ability for the utility to finance the system may also be of tremendous value to those who are unable to accumulate enough funds for a direct purchase.

The utility is in the business of providing electricity and has been in some cases for nearly a century. They are aware of proper design and safety issues and they can provide you with quick and efficient service.

To obtain a PV system from a utility follow the procedure suggested below:

- Contact your local utility for a line extension group and ask them if they also offer PV services.
- If they do offer PV services, simply follow their service procedure to receive [illegible] for the [illegible] they offer.
- If your local utility does not offer PV services, there are many other utilities that do. The Photovoltaic Services Network (PSN) is an organization of many utilities across the country that offer PV services. Since PV represents electricity without wires, many of these utilities offer PV services regardless of utility service territory boundaries. You may call the PSN for assistance at 303-980-1969.

Local PV Vendors:

In some areas of the country, local PV vendors can be found. These vendors have built their businesses on providing PV systems to regional customers.

PV vendors can assist you with the design of your system and have access to many brands of hardware. Some vendors also staff licensed electricians that can be hired to install and maintain your system.

Most systems offered by PV vendors are cash sales and are custom designed to meet your exact needs. These systems are usually installed on your home with the batteries and controls located in a separate building or in your garage. The vendor can work with you to decide on the best installation configuration for your particular situation.

To help locate a PV Vendor near you contact:

Solar Energy Industries Association
122 C St., NW 4th Floor
Washington DC 20001-2109
(202) 383-2600

Independent Power Providers
PO Box 231
North Fork, CA 93643
(209) 841-7001 or (916) 475-3402

Do-it-yourself Catalog Cash Sales::

Many PV companies have produced catalogs that list all the components necessary to build and install a complete system. Some catalogs also offer kits that are sized in graduated increments. This option usually requires you to have the ability to design and size the appropriate components as well as install and maintain your system. Although a thorough knowledge of the local electric code may be required for you to safely install and successfully pass a local building inspection, most catalog companies can provide some technical assistance over the phone.

Calculating the daily energy requirement

Example

Appliance	Watts		Daily Hours of Use		Daily Watt-hours
Fluorescent light	40	x	6.00	=	240
Compact fluorescent light	20	x	6.00	=	120
Compact fluorescent light	11	x	4.00	=	44
Incandescent light	60	x	2.00	=	120
Microwave oven	1,243	x	.25	=	310
Refrigerator, 19 cf super efficient	64	x	12.00	=	770
Water pump (1/2 hp centrifugal)	1,280	x	.50	=	640
Vacuum cleaner (3/4 hr/week)	800	x	.10	=	80
Washing machine (2 loads/week)	920	x	.20	=	184
Computer	80	x	2.00	=	160
Television (19" color, no remote)	58	x	4.00	=	+ 232
				Total daily energy requirement:	2,900 (2.9 kWh)

Worksheet

Appliance	Watts	Daily Hours of Use	Daily Watt-hours
		x	=
		x	=
		x	=
		x	=
		x	=
		x	=
		x	=
		x	=
		x	=
		x	=
		x	=
		x	=
		x	=
		x	=
		x	=
		x	=
		x	=
		x	=
		x	=
		x	=
		x	=
		x	=
		x	=
		x	=
		x	=
		Total daily energy requirement	

Appliance wattage chart

Appliance	Rated Watt	Measured Watts
BATHROOM		
Hair dryer -		
High	1200	1176
Medium	650	710
Low	300	282
Curling iron	150	140
ENTERTAINMENT		
TV, 19" Portable		
Off (w/remote control)	-	6
On	95	58
VCR		
Off (w/remote control)	-	10
Play	27	25
Radio, Portable	15	3.6
KITCHEN		
Coffee Pot; 10 Cup	825	798
Coffee Pot; 4 Cup	625	620
Gas Range;		
Clock/Controller	-	3
Ignitor	-	1
Glow Plug	400	398
Microwave, 600 Watt		
Off (Clock controller on)	-	4
On	1200	1243
Toaster	1050	1110
Refrigerator, super efficient - 16 ft^3		
Refrigerator section	64	68
Freezer section	64	66
Refrigerator; conventional-18 ft^3	600	432
LIGHTS		
7 Watt Fluorescent (25 W equiv.)	7	5
13 Watt Fluorescent (60 W equiv.)	15	11
18 Watt Fluorescent (75 W equiv.)	20	20
40 Watt Incandescent	40	36
60 Watt Incandescent	60	59

Appliance	Rated Watt	Measured Watt
MISCELLANEOUS		
Clock; LED, Alarm	5	2
Evaporative Cooler	396	-
Evaporative Cooler, 1/2 hp	875	897
Fan; 18" Portable	660	586
Ground fault circuit interrupter (7)	-	5
Security system	1	1
Telephone, Cordless	10	4.2
Vacuum; Canister	1080	818
Vacuum; Upright,	-	297
Vacuum; Shop	660	586
Washing Machine	920	-
Water Pump; 1/2hp centrifugal jet	1495	1280
OFFICE EQUIPMENT		
Computer, 286	150	61
Computer, 486	220	83
Computer, 14" Color Monitor	120	76
Computer, 386 Notebook	144	
Off (charging battery)	-	16
On. idle	-	31
On; hard drive on	-	41
Printer, Dot Matrix	180	11
Printer, LaserJet	576	
Warm-up	-	408
On, idle	-	28
Printing	-	456
Printer, DeskJet	48	
Off	-	13
On, idle	-	16
On, printing	-	31
Facsimile, idle	140	13
SHOP TOOLS		
Saw, Radial Arm, 10"	1200	583
Saw, Circular, 7"	1200	841
Saw, Miter, 10"	1440	751
Planer, 3.5"	480	355
Drill, 3/8" VSR	246	151
Drill, 1/2" VSR	408	214
Router, 1 hp	746	490
Sander, Belt	624	445

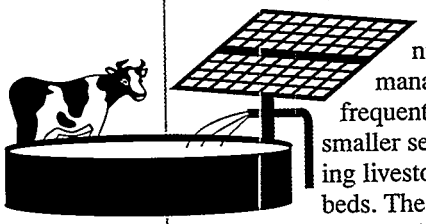
Additional PV Applications

Along with remote homes, there are many other applications that can be cost-effectively powered by a PV system. Two of them are discussed below.

Water Pumping

When reliable water is needed a long distance from the electric line, more and more people are looking to photovoltaics for cost-effective power. Whether for your home or ranch, PV power is a good alternative to traditional methods of remote pumping such as windmills and engine generators.

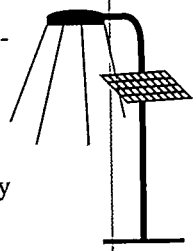
Ranchers are beginning to water their cattle with PV-powered pumping systems because in many cases, it is not only the least cost solution but also the most convenient. New grazing techniques for better range management require more frequent rotations of livestock on smaller sections of land and fencing livestock away from stream beds. These methods require more numerous sources of water and a way to deliver water from fenced streams. Since range lands are often far from the electric grid, PV is usually the best option for pumping water in these situations.



PV pumping systems require less maintenance, are quick and easy to install and can easily be transported to use at more than one well site. Some utilities lease PV systems on trailers to make it even more convenient to follow the pasture rotations. PV pumping systems also produce the most water on sunny, hot days when livestock need it the most and the wind is not blowing. In most situations, these systems are quite cost competitive with windmills and generators.

Remote Lighting

PV power systems are also being used more frequently for remote lighting applications. Due to the cost of trenching and running cable, many PV lighting systems are even cost competitive with nearby electric line connections. Some examples of PV lighting systems include:



- Remote security lighting
- Sign lighting, particularly remotely located bill boards
- Pathway lighting
- Lighting for remote out buildings such as shops, barns or restrooms
- Street lighting

PV lighting systems offer many of the same maintenance and cost advantages as water pumping systems. Hardware for both of these applications have been manufactured for many years (water pumping and lighting) and may be available from your utility or local supplier as packaged systems.

In addition to these applications PV systems can be cost-effective for many electric loads requiring low to moderate power and requiring small amounts of energy. Your imagination is the only real limitation to the application of this growing technology.

This booklet is provided to you by:

Photovoltaic Services Network

Why are electric utilities getting into off-grid photovoltaics?

All around the country, electric utility companies are beginning to realize that offering photovoltaic (PV) services to customers with small remote or difficult to serve loads is a smart business decision. Here are the reasons why:

Lower cost of service:

When new or rebuilt lines to small remote loads don't pay for themselves, electricity rates go up for all customers. By using PV, utilities can better control their line construction and maintenance costs and still provide consumers with quality service at a competitive price.

Increase in customer base:

By offering a wider range of services such as PV power systems for remote applications, it is possible to serve a larger and more diverse customer base.

Local economic development:

When utilities offer PV customer services, they often rely on local businesses to support their PV programs. This support means more jobs for the community and a more stable local economy.

Image as progressive utility:

By offering PV, a solar technology with few environmental impacts, utilities can let their customers know that they care about the future.

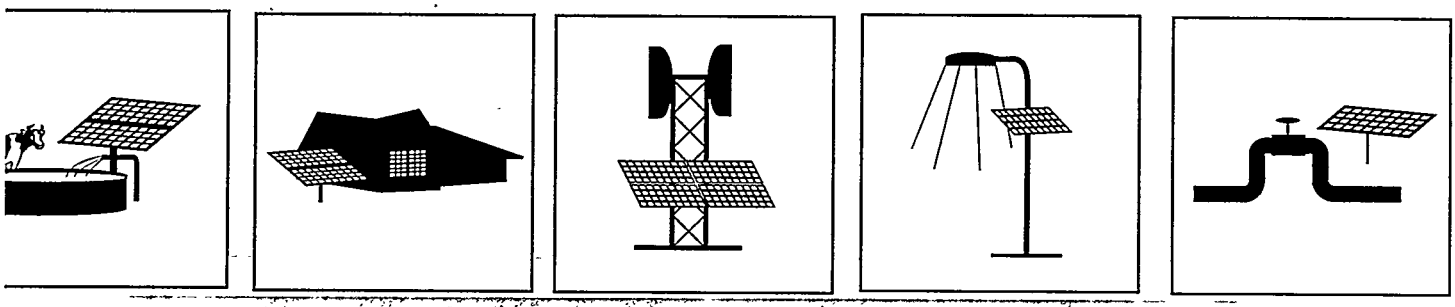
PV is happening with or without utility involvement:

Many industries such as railroads, telecommunications, oil and gas, and ranching, as well as individuals recognize the value of a reliable source of remote electric power. Consequently, they are installing PV systems themselves or leasing them from utilities at an accelerating pace. These installations represent lost opportunities for utilities that don't offer PV services.

How can the PSN help?

The Photovoltaic Services Network, Inc. (PSN) is an independent, not-for profit organization of electric utilities. The founding PSN members recognized a need for professional assistance in PV education and training and a forum for off-grid PV application issues. They also recognized a need for high quality packaged PV systems that meet utility standards for performance and reliability. To address their needs, several rural electric cooperatives joined together to form the PSN, an organization that makes quality PV support services and products available to all electric utility members.

If you feel that the use of photovoltaics could be of value to your utility, the PSN can help by providing assistance for successful PV pilot projects and customer service programs. All members are provided with the PSN's PV Services Guidebook, a guide for implementing PV customer service programs based on the experience of utilities with active PV programs. The PSN also offers members the capability to purchase high-quality, low-cost PV systems from the PSN Product Lists, a catalog of pre-qualified packaged PV systems that meet utility requirements for performance and reliability.



Who is the PSN?

The PSN is made up of electric utilities of all types including rural electric cooperatives, municipal utilities, public power districts, investor owned utilities and power marketing agencies. It was formed to assist member utilities with off-grid PV by 1) providing education, training, and installation support as required; 2) establishing a forum for information exchange on PV program implementation and marketing methods; 3) creating standardized PV system specifications for a variety of applications; 4) negotiating volume discounts for group PV product purchases; 5) identifying funding sources (both public and private) for service support, product development and testing; and 6) pursuing alliances with other organizations active in PV.

Some key PSN members are the utilities whose representatives serve on our Board of Directors and we'd like you to know who they are. Please feel free to call any of them if you would like to discuss the PSN or have any questions.

President	-	Rolland Skinner, Northwest Rural PPD, Nebraska (308) 638-4491
Vice President	-	Peggy Plate, Western Area Power Administration., Colorado (303) 490-7227
Treasurer	-	William Wood , San Isabel Electric, Colorado (719) 547-2160
Secretary	-	Gary Garber, Carbon Power & Light, Wyoming (307) 326-5206
Member	-	Tom Miller, McKenzie Electric Co-op., North Dakota (701) 842-2311
Member	-	Paul Bony, Plumas-Sierra REC, California (916) 832-4261
Member	-	Gary Jurkin, Arizona Electric Power Co-op, Arizona (520) 586-5280
Member	-	Thomas Hickman, Arizona Public Service Co., Arizona (602) 250-2826
Member	-	Martin Gordon, National Rural Electric Co-op. Assn., Virginia (703) 907-5840

The PSN is supported by NEOS Corporation, the PV services contractor that takes care of the daily business of running the organization. Although some of the board members may be difficult to reach, you can almost always get in touch with Kirk Stokes or Terry Schuyler of NEOS to answer any questions you may have. (Phone: 303-980-1969, Fax: 303-980-1030)

What are the membership options?

Although the PSN was created specifically for the benefit of electric utilities, other organizations, individuals and the PV industry are encouraged to participate as well. There are five ways to participate in the PSN: three membership levels, a PSN sponsorship, and a subscription to PSN information. These options are described below and on the following pages.

Utility Membership

This basic membership level is for electric utilities that are directly involved in serving retail customers and want direct access to PSN benefits such as educational and technical PV service support and the capability to purchase packaged PV systems directly from the PSN. Utility members could include rural electric cooperatives, municipal power companies, public power companies, investor owned utilities, G & Ts, and any other electric utility that has a need for PV service support and to purchase PV products. The majority of the PSN's membership is at this level.

Membership Fee:

The utility membership fee is $500 (for a full calendar year membership).

Benefits:

The following benefits are available to PSN members at the utility level:

- An on-site PSN orientation workshop plus five hours of cost-shared service support (at $25/hour). Additional support services are available at the full service rate;
- Receipt of the PSN's PV Product List catalog and Utility PV Services Guidebook;
- Capability to make PV system purchases directly from the PSN Product Lists;
- Notice of and participation in coordinated volume purchases of PV systems;
- Ability to act as a regional PSN product "wholesaler" to other utilities or companies;
- A vote on major PSN decisions such as election of the Board of Directors;
- Eligibility to serve on the Board of Directors;

PSN
Photovoltaic Services Network, Inc.

Membership Application Form

Organization name: _____

Primary Contact: _____ Phone: _____ Fax: _____

Secondary Contact: _____ Phone: _____ Fax: _____

Address: _____

City: _____ State: _____ Zip: _____

For which PSN membership option are you applying?

___ Utility Member
___ Associate Organization Member
___ Satellite Utility Member ⇒ Affiliated PSN member: _____
___ PSN Information Subscription
___ PSN Sponsor (contact PSN directly)

Please go to the appropriate membership level below to complete the application.

Utility and Satellite Memberships

1) On a scale from 1 to 10 how much off-grid PV experience does your utility have? (1 = none; 10 = a great deal)

1 2 3 4 5 6 7 8 9 10
none some a great deal

2) How interested is your utility in each of the following PV applications? *(Please rate each from 1 to 5 with 1 = no interest and 5= very interested.)*

___ Residential systems
___ Telecommunications
___ Cathodic protection
___ Other: _____
___ Water pumping
___ Lighting

3) Does your utility have an existing PV service program?

___Yes ___No

If not, is that a goal for the near future?
___Yes ___No ___Don't know

4) How important are the following PSN benefits to your utility? *(Please rate each from 1 to 5 with 1= not important and 5 = very important.)*

___ Coordinated PV system purchases
___ On-call PV service expertise
___ Utility grade PV product development
___ Information exchange (e.g. PSN newsletter)
___ Other: _____

Associate Organization Membership

1) On a scale from 1 to 10 how much off-grid PV experience does your organization have? (1 = none; 10 = a great deal)

1 2 3 4 5 6 7 8 9 10
none some great deal

2) How will your organization be involved with PV? (Check all that apply.)

___ Purchase PV products
___ Provide PV services to retail customers
___ Support your member's PV service programs
___ Other: _____

3) How important are the following PSN benefits to your utility? *(Please rate each from 1 to 5 with 1= not important and 5 = very important.)*

___ Coordinated PV system purchases
___ On-call PV service expertise
___ Utility grade PV product development
___ Information exchange (e.g. PSN newsletter)
___ Other: _____

4) Would you like to make an additional contribution to support the PSN beyond the minimum membership fee of $1000?

___Yes ___No

PSN Information Subscription

1) What type of organization do you represent?

___ PV industry ___ Government agency
___ Electric utility ___ Individual
___ Other_____

2) What kind of PSN information interests you most? *(Please rate each from 1 to 5 with 1= not interested and 5 = very interested.)*

___ PV product specifications
___ PV product evaluation reports
___ Information on utility PV activities
___ Volume purchases of PV products
___ Other: _____

3) If you are a PV industry organization, what are your areas of business? ***(Check all that apply.)***

___ PV module manufacturing
___ PV component manufacturing
___ Systems integration
___ PV service (installation & repair)
___ Equipment sales
___ Consulting
___ Other: _____

- Make checks payable to the Photovoltaic Service Network -

Fold here

Fold here

_____
_____
_____
_____

Stamp

Photovoltaic Services Network, Inc.
165 S. Union Blvd., Suite 260
Lakewood, CO 80228

- Review of utility grade PV product specifications and development;
- Information exchange with other PSN members and with the PV industry;
- Attendance at annual membership meetings;
- Receipt of the PSN's newsletter and other information such as PSN developed product specifications and product evaluation reports; and
- An opportunity to show support of a cost-effective renewable energy technology.

To join the PSN at the utility level, simply fill out the application form enclosed with this brochure and mail it with a check for $500 to the PSN.

Satellite Utility Membership

This membership level is for electric utilities that are affiliated with a PSN utility member and wish to receive all PV service support and/or PSN products through that designated PSN member. Although the list of benefits is similar to utility members, satellite members do not receive two key benefits directly from the PSN: 1) cost-shared PV service support; and 2) purchase of PV systems from the Product List catalog. Satellite utility members could include any electric utility such as rural electric cooperatives, municipal power companies, public power companies and investor owned utilities as long as they are affiliated with a PSN utility member.

Membership Fee:

The satellite utility membership fee is $250 (for a full calendar year membership).

Benefits:

The following benefits are available to PSN members at the satellite utility level:

- Receipt of the PSN's PV Product List catalog and Utility PV Services Guidebook;
- Capability to purchase PV products from the PSN Product Lists through an affiliated PSN utility member;
- Capability to purchase PV service support from the PSN at the full service rate.
- A vote on major PSN decisions such as election of the Board of Directors;
- Eligibility to serve on the Board of Directors;
- Review of utility grade PV product specifications and development;
- Information exchange with other PSN members and with the PV industry;
- Attendance at annual membership meetings; and
- Receipt of the PSN's newsletter and other information such as PSN developed product specifications and product evaluation reports.

To join the PSN at the satellite utility level, simply fill out the application form enclosed with this brochure and mail it with a check for $250 to the PSN.

Associate Organization Membership

This membership level is for organizations that are involved in the electric utility trade but are not directly involved in serving retail PV customers. Such organizations could include generation and transmission companies, electric utility trade associations, power marketing associations and organizations involved with electric power research. This membership level provides organizations with an opportunity to acquire PSN membership benefits and to support utility involvement in PV by cost-sharing the PSN's service and product support to member utilities. This cost sharing support is provided by choosing to contribute more than the minimum annual dues as described below.

Membership Fee:

The minimum associate organization membership fee is $1000 (for a full calendar year membership). However, additional contributions are welcome and encouraged. For contributions over the minimum fee, your organization will provide cost-sharing PSN support services to utility members. If an associate organization chooses to contribute $5,000 or more, the contribution can be designated for support of specific PSN members (e.g. a wholesale utility may choose to cost-share services for a retail utility member or their customers).

Benefits:

The following benefits are available to PSN members at the associate organization level:

- Fifteen hours of cost-shared service support (at $25/hour). Additional support services are available at a the full PSN service rate. (No orientation workshop)
- All other benefits are the same as for utility members.

To join the PSN at the associate organization level, simply fill out the application form enclosed with this brochure and mail it with a check for a minimum of $1,000 plus any additional contribution to the PSN. If you wish to contribute $5,000 or more and would like to designate how it is used, please call Kirk Stokes at 303-980-1969 to discuss options for the contribution.

PSN Sponsorship

This option is for any organization or individual that wishes to support utility involvement in PV by cost-sharing the PSN's service support activities. The minimum contribution level is $1,000. However, additional contributions are welcome and encouraged. If a sponsor chooses to contribute $5,000 or more, the contribution can be designated to support specific PSN members, activities, PV applications, or geographic regions. Sponsors of PSN support activities include national laboratories, utility research organizations and state energy offices.

Benefits:

The following benefits are available to PSN sponsors:

- Support of utility involvement with off-grid PV systems through cost-sharing of PV support services. (For each dollar contributed by a PSN sponsor, at least one dollar will be spent by a PSN member on either PV equipment or support services.)
- Information exchange with PSN members and the PV industry.
- Attendance at annual membership meetings.
- Receipt of the PSN's newsletter and other information such as PSN developed product specifications and product evaluation reports.

If you wish to become a PSN sponsor, please fill out the application form enclosed with this brochure and return it to the PSN. PSN staff will call you to discuss sponsorship options.

PSN Information Subscription

The PSN information subscription level is for any organization or individual who wishes to keep abreast of PSN activities and opportunities. Companies affiliated with the PV industry are especially encouraged to subscribe since we anticipate interactions and information exchanges with all sectors of the PV industry to promote development of PV products that meet utility specifications. In addition, PSN members are encouraged to form alliances with local service providers to support them in providing PV customer services. PSN publications include the bi-monthly newsletter, PSN developed PV product specifications and product evaluation reports.

Subscription Fee:

The PSN information subscription fee is $150 (for a full calendar year).

If you wish to subscribe to the PSN, simply fill out the application form enclosed with this brochure and mail it with a check for $150 to the PSN.

For more information on the PSN, please call or write:
Photovoltaic Services Network, Inc.
165 S. Union Blvd., Suite 260
Lakewood, CO 80228
Phone: (303) 980-1969
Fax: (303) 980-1030

Printed on recycled paper

PHOTOVOLTAIC SERVICES

Network News

Volume 1 No. 1

July/August 1995

The PSN is up and running!

On behalf of the Photovoltaic Services Network's (PSN) board of directors and support services personnel, I would like to welcome aboard all new members and subscribers. Since this is the first issue of the PSN newsletter "Network News", I want to take this opportunity to better inform our readers about the PSN. As a result, this following article describes the PSN's mission and initial activities as well as explains how the PSN intends to interact with members and with the PV industry. In the future, feature articles will cover the progress the PSN is making towards its many goals and will provide information about individual member utility projects and activities.

I'm excited about being able to provide this kind of information to you on a regular basis, and I hope it stimulates your excitement in utility opportunities for PV.

Kirk Stokes, PSN Manager

.....

What is the PSN?

The Photovoltaic Services Network (PSN) is an independent, not-for-profit organization comprised of all types of electric utilities including rural electric cooperatives, municipal utilities, public power districts, investor-owned utilities, and power marketing agencies. The PSN was created specifically for the benefit of electric utilities and their customers. However, PV industry companies and trade associations are encouraged to participate through the PSN's information subscription, since the subscription will serve as a the main channel of communication between PSN utility members and these organizations. Other organizations (e.g., federal or state agencies and facilities; private non-profit organizations, etc.) that are not electric utilities but want more involvement than a PSN subscription are encouraged to participate by collaborating with their local electric utility.

The PSN's mission is to work pro-actively to promote utility involvement in PV through education and training. The PSN also intends to work on behalf of

Continued on page 2

Introducing Network News...

Network News is a bimonthly newsletter of the Photovoltaic Services Network. This newsletter will be used to keep members and subscribers up-to-date on PSN and member activities. In addition to feature articles on PV projects, PSN activities and member PV service programs, the newsletter will consist of the following regular sections:

PV Market Place

This section will provide descriptions of packaged PV products newly available through the PSN and a listing of products purchased by members during the past two months.

Network in Action

Network in Action will offer a listing of future events and a brief overview of past PSN activities.

PSN Profiles

PSN profiles will spotlight a PSN board member, member utility representative, or technical representative.

Membership Corner

On the last page of each issue, the Membership Corner will present the latest tally of members, sponsors and subscribers as well as list current PSN contributors.

Inside...

Photovoltaic Services Network News is a bimonthly publication of the Photovoltaic Services Network (PSN). The PSN is an organization of electric utilities that have joined together to make PV services and products readily accessible to its utility members. PSN members receive the Network News as a benefit of membership. For non-members, subscriptions are available to the Network News plus other PSN publications for $150 per year.

Editors:
Patricia Saito
Pauline Valenzuela

News items or comments may be sent to:
Photovoltaic Services Network
165 S. Union Blvd., Suite 260
Lakewood, CO 80228
Phone: (303) 980-1969
Fax: (303) 980-1030

member utilities to ensure that the PV systems they purchase and install meet established design criteria, are competitively priced, and meet utility customer expectations for cost, performance, and reliability. To fulfill this mission, PSN activities will be divided into two primary areas: service support and product support.

Service Support

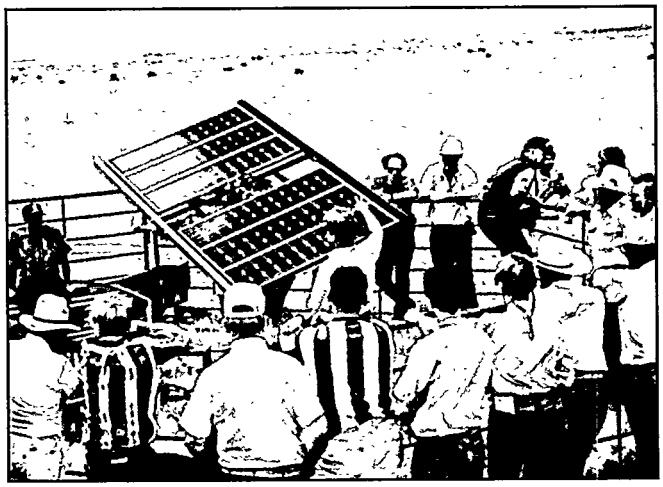
To assist utilities in learning about the potential PV may have for their customers, the PSN service support focuses on education, training, and information exchange. The PSN offers education and training for utility member employees, board of directors, customers, and local trade allies through a series of workshops and other on-site support. Utilities have the choice of classroom seminars or field training on subjects ranging from PV technology basics to system installation, operation and maintenance.

Further PV information is distributed by the PSN in three primary forms: 1) consultation with PSN technical service representatives; 2) literature generated by the PSN (e.g., product evaluation results, product lists, utility PV market reports, PV service implementation guidelines, the bimonthly Network News, etc.); and 3) literature published by other organizations (e.g., PV technology fundamentals, solar resource information, PV application examples, manufacturer's PV product literature, etc.).

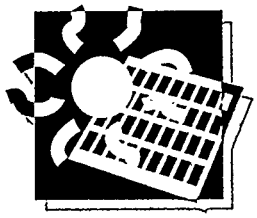
Depending on member requests, the PSN can provide small and large scale feasibility studies for proposed PV projects. These studies might include PV system design support that range from system cost estimates to detailed system specification and procurement. Suggestions regarding specific components and prospective suppliers will be made based on the latest information available.

The PSN can also provide assistance to members in developing PV customer service programs. This PSN assistance focuses on facilitating information transfer from utilities that have existing programs to those

Continued on page 3



Terry Schuyler, PSN technical representative, trains ranchers and utility personnel on a PV pumping installation.



Network in Action

A Look Ahead

July 23-25

The PSN will present a booth at the NRECA's annual Marketing, Member Services and Communication Conference in Portland, Oregon. PSN board member Paul Bony will be there to discuss the PSN with potential members. If you plan to attend the meeting, look for the PSN in booth number 200 (across from NRECA's booths).

July

A PSN mailing will be sent to selected sectors of the PV industry to encourage them to subscribe to this newsletter and other PSN publications. Since the PSN subscription mailing list is our primary channel of communication with the PV industry, we need to encourage PV system manufacturers, suppliers and local PV contractors to keep in touch with PSN activities by subscribing.

August

The PSN will be mailing a detailed member information survey to all utility members to determine what services and

Continued on page 3

products are most needed by our members. If you are a member, please look for the survey in mid-August and take a moment fill it out.

Activities Recap

May 31

The PSN business plan has been finalized (although it is a "living document") and approved by the Board of Directors. The business plan development effort was supported by the Utilities PhotoVoltaics Group. A summary of the business plan is available to members and subscribers upon request.

June 13-14

Member utility Southwestern Public Service installed a Golden Photon Inc. (GPI) PV-powered AC water pumping system for testing field performance at the USDA agricultural test facility in Bushland, Texas. This facility has all the instrumentation and equipment necessary to thoroughly test the performance and reliability of the GPI system.

June 16

A PSN technical representative traveled to Hay Springs Nebraska to assist Northwest Rural Public Power District in determining the cause of a pumping system failure. He found that the intermittent problem

Continued on page 4

that do not. Through this process, support can be provided in such areas as service territory audits, PV tariff development, PV vendor qualification, PV system procurement, and PV service program marketing. In addition, for utilities that have little or no previous experience with their local PV community, the PSN can assist in identifying PV vendors and service providers.

To make the PSN support services easily accessible to utility members, a technical service representative is assigned to each new member as they join. The responsibilities of the technical service representatives are: 1) becoming familiar with the particular member's unique situation and needs, 2) responding to the member's requests for information and on-site service support, 3) and coordinating the member's product purchases.

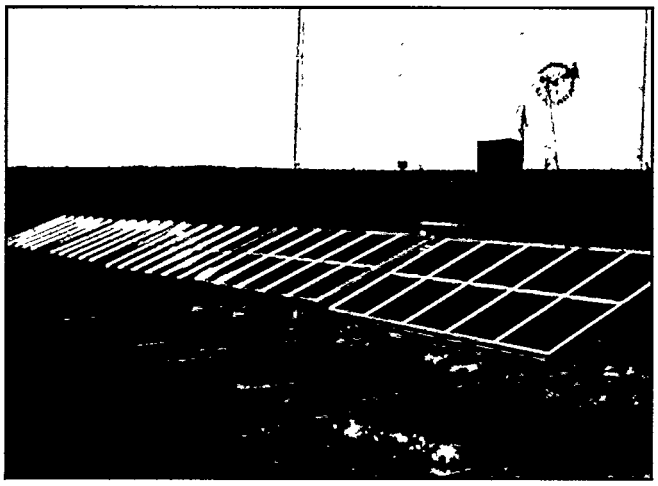
Each utility member is treated as an individual client of the PSN, and service request procedures are standardized to ensure that the PSN responds to the needs of its members in a timely and cost-effective manner.

Product Support

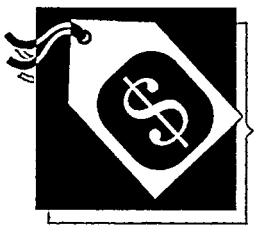
The PSN's product support activities include consolidating information on existing packaged PV systems and facilitating the development as required of new PV product packages that meet utility-defined specifications for cost, performance, and reliability. In addition, the PSN will coordinate both individual and aggregated volume purchases of PV products by utility members.

The PSN's initial product support efforts will be focused on commercially available packaged PV systems for a variety of off-grid applications. The PSN will develop functional specifications for each application with input from utility members and the PV industry and then evaluate available products using manufacturers' product literature and independent laboratory testing. Prices for products available through the PSN will be negotiated competitively

Continued on page 4



Pumping system being evaluated by the PSN and member Southwestern Public Service near Amarillo, Texas.



PV Market Place

PSN Goes Shopping

Check this section in future newsletters for descriptions of new products available for purchase through the PSN. The PSN is currently involved in negotiations with suppliers for volume pricing on several PV-powered water pumping systems. We'll keep you informed.

What's Selling

The following commercial PV systems were the first purchased by member utilities through the PSN:

- A Robison PV-powered pumping system that includes a150 watt PV array, a Robison model RPII-150 submersible diaphragm pump with controller and 100 feet of pump cable.
- A Shurflo pumping system that includes a Shurflo model 9300 submersible diaphragm pump, a Photocomm model PC-1 controller and 210 feet of pump cable.

seemed to be caused by malfunctions in both the array and pump motor.

June 20-21

Member utility Nebraska Public Power District (NPPD) installed a GPI pumping system at a NPPD customer site in Duncan, Nebraska. All pumping system test results will be published by the PSN at the end of the AC pumping system evaluation project.

June 27-29

Two members, San Isabel Electric and West Plains Energy, cosponsored the installation of seven different PV-powered water pumping systems on the Fort Carson army base near Colorado Springs, Colorado. The PSN coordinated an installation workshop with on-site installations and will assist Ft. Carson in monitoring the systems.

June 30

The PSN PV buying service is up and running! PSN members have already placed two orders for PV-powered water pumping systems.

with prospective system suppliers. These product evaluations with negotiated prices will be provided to utility members in the form of a "consumer report' style product list.

In parallel with this effort, if no products exist that meet the PSN's functional specifications, the PSN will initiate the second phase of product development support process by encouraging the development of new packaged systems. It is the PSN's intention to work closely with the PV industry in a cooperative effort to develop systems that are cost-effective and meet the operational and quality standards to which utilities are accustomed. As required, PSN product development activities can include five key steps:

- Distributing functional specifications to initiate interest for developing a product;
- Supporting product development organizations in further specifying and developing prototype prod ucts;
- Testing prototype products in an independent laboratory and comparing test results to the func tional specifications;
- Verifying the prototype products' performance and reliability with utility field tests; and
- Publishing the comparative evaluation of the products for use by utility members when making purchasing decisions.

Once the five step process is complete, the "evaluated" product will be added to the PSN's product list with the negotiated price and distributed to all utility members for the PSN's coordinated purchase activities.

Through these service and product support activities, the PSN anticipates engaging all segments of the PV industry, thus providing benefits to PV system suppliers as well as local PV service contractors. The direct benefits to the PSN's utility members and their consumers will be savings on existing PV system costs and the development of PV systems better suited to their needs.

The PSN's service and product support are now available and the PSN is presently implementing numerous tasks and coordinating purchases of existing packaged systems for several utility members.

PSN Profile

For most of you familiar with PV, Rolland probably doesn't need an introduction since he's always been on the forefront of utility PV services. Northwest Rural Public Power District (NRPPD) has leased PV-powered pumping systems to it's customers for over five (5) years and is now expanding into other applications such as residential PV. As general manager, Rolland has been personally responsible for initiating NRPPD's PV services. Rolland's experience with PV and utility operations makes him ideally suited to be president of the PSN's Board of Directors.

PSN Question:
Why is NRPPD offering PV services?

Rolland Skinner: "A utility's involvement in PVs make sound business sense. With the

Continued on page 5

Rolland Skinner
President, PSN Board of Directors and General Manager, Northwest Rural Public Power District

consolidation of farms, existing residences eventually turn into just stock watering locations. Our existing distribution system, which is aging, is serving many of these locations. We hope to replace these services with PV installations and prevent the rebuilding of many long line extensions.

"The other business issue is the existence of over 1,000 aging windmills that are potential customers of NRPPD. These can provide a revenue stream to help offset the diminishing rate base created by farm and ranch consolidations. NRPPD's desire is to continue to be the supplier to our customers by providing energy at remote sites with leased PV equipment instead of extensive and costly line extensions."

Seven PV Pumping Systems Installed

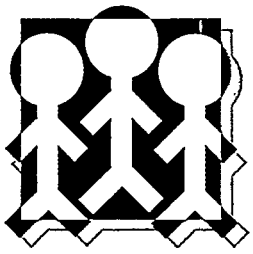
A good example of the PSN's on-going service and product support activities occurred recently in Colorado when the PSN provided technical support to member utilities San Isabel Electric Association and Mountain View Electric for a PV pumping workshop. The workshop, cosponsored by the two utilities and regional Soil Conservation Service offices, was held for local ranching customers interested in using PV for watering livestock. It was held at Chico Basin Ranch, a working Colorado state owned ranch located between Pueblo and Colorado Springs. PSN technical service representative Terry Schuyler assisted in organizing the workshop, scheduled speakers representing seven different PV pumping systems, gave a presentation on PV pumping basics and provided hands-on pumping system installation training.

Among the more than 60 attendees were representatives from Graham County Electric and Westplains Electric (both PSN members), Colorado Springs Municipal Utility, several PV service providers, and a host of interested utility customers and ranchers. After the workshop classroom session, which was held in the ranch's barn, the group enjoyed a catered lunch and then traveled to a nearby pasture where one of the PV pumping systems had recently been installed. Schuyler's on-site training included fine-tuning the centrifugal submersible pumping system, testing its water production (5.5 gallons per minute), and demonstrating the system's features.

This workshop dovetailed nicely with a US Army project to install up to 40 PV water pumping systems on the Ft. Carson Army Base. The base, located near Colorado Springs, is served by several of the PSN member utilities present at the workshop. The Directorate of Environmental Compliance and Management (DECAM) at Ft. Carson agreed to purchase one each of seven different PV pumping systems that are presently being investigated as part of the PSN's water pumping initiative.

All the systems are either new to the market or prototype in nature and include submersible pumps. The seven systems included two DC diaphragm pumps, two DC centrifugal pumps, one low voltage AC centrifugal pump, and two standard AC centrifugal pumps. The representatives from the various PV pumping systems were on hand to assist the PSN and the Army with the installations. In the near future, the PSN will assist DECAM in outfitting each of the seven systems with data acquisition systems to monitor their short and long term performance. These data will be incorporated into the PSN's PV pumping system comparative assessment activities.

PV water pumping workshop held at Chico Basin Ranch.



Membership Corner

Membership Totals

Utility Members	25
Rural Electric Cooperatives	16
Municipalities	0
Other Public Utilities	4
Investor Owned Utilities	5
Utility Association Members	2
Subscribers	10
Sponsors	4

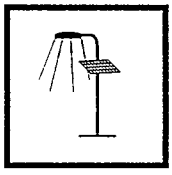
PSN Contributors ($5,000 or more)

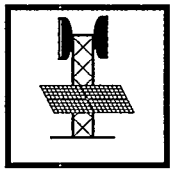
Colorado Office of Energy Conservation
National Renewable Energy Laboratory
Sandia National Laboratories
Utility PhotoVoltaics Group
Western Area Power Administration

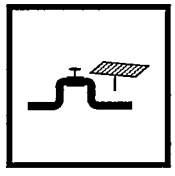
For information on how to become a PSN member, write or call:
Photovoltaic Services Network
165 S. Union Blvd., Suite 260
Lakewood, CO 80228
Phone: (303) 980-1969
Fax: (303) 980-1030

printed on recycled paper

Photovoltaic Services Network
165 S. Union Blvd., Suite 260
Lakewood, CO 80228







PHOTOVOLTAIC SERVICES

Network News

Volume 1 No. 5

Summer 1996

Lessons from the Field

Plumas-Sierra Rural Electric Cooperative (PSREC), always on the cutting edge of utility PV services, recently installed a packaged off-grid residential PV system purchased from the PSN Product List. The PSN-PC1-R system provided by Photocomm, Inc. includes 510 watts of PV, a 2500 watt sine wave inverter and almost six days of battery storage. PSREC contracted with a local Photocomm dealer, Blackhawk Solar and their licensed electrician for installation and service support.

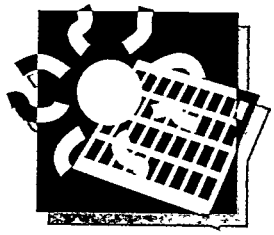
The PSREC residential system enclosure is lifted onto its foundation

The PSN monitored this installation closely to make certain that the delivered product meets PSN specifications. In the process, we found there were some important lessons to be learned.

One lesson was verification of the concept that packaged PV systems make sense for utilities. PSREC's system arrived with the PV array pre-assembled, wired and ready to go in one crate and the batteries, inverter and balance of system neatly mounted and wired in a white powder coated steel enclosure. It took little time to secure the array and enclosure onto the concrete foundations and wire

Continued on page 2

Inside...



Network In Action

A Look Ahead

Summer

Contingent upon anticipated funding from the Utility PhotoVoltaics Group, the PSN will be working on a customer education booklet for PV-powered water pumping similar to the one developed for residential PV: "Solar Electricity, an Alter-native to Utility Power Lines".

September/October

The PSN plans to send out RFPs to PV suppliers that can provide packaged lighting systems for the upcoming PSN PV Lighting Product List.

October 15-18

The Utility Photo-Voltaics Group will be holding it's annual Utility PV Experience Exhibition and Conference in Denver this year. The PSN will have a display at the exhibit and many utilities (including PSN

Continued on page 2

Photovoltaic Services Network News is a bimonthly publication of the Photovoltaic Services Network (PSN). The PSN is an organization of electric utilities that have joined together to make PV services and products readily accessible to its utility members. PSN members receive the Network News as a benefit of membership. For non-members, subscriptions are available to the Network News plus other PSN publications for $150 per year.

Editor:
Patricia Saito

News items or comments may be sent to:
Photovoltaic Services Network, Inc.
165 S. Union Blvd., Suite 260
Lakewood, CO 80228

Phone: (303) 980-1969
Fax: (303) 980-1030

the array to the enclosure. (The customer built the foundations to minimize installation costs.)

However, another part of the same lesson is the fact that when PV systems are packaged and pre-assembled, they can be bulky, heavy and take special equipment to move and install. These packaged systems were designed to transported and handled by the large boom and flatbed trucks that utilities typically own (see photo below). Local PV suppliers and electrical contractors that support utility PV programs usually don't own the equipment necessary to move large packaged PV systems (although they can rent trucks as needed). Important considerations for delivering and setting up packaged PV systems are installation sites that are easily accessible to trucks and proper attachment points for lifting the enclosure and large arrays. (The PSN requires all residential systems on the Product List to come with the proper lifting attachments.)

Crated array is unloaded with PSREC's boom truck.

Continued on page 3

members) will present the progress, results, lessons learned and products resulting from their PV projects. This is a great opportunity to keep up with utility involvement in the acceleration and commercialization of PV.

Activities Recap

Spring

The PSN has been providing member utilities (WestPlains Electric; Plumas-Sierra REC; KC Electric) with copies of the PSN Product Lists modified for their use. Modifications include the utility's name on the cover and the replacement of PSN prices with the utility's retail prices to customers. This service is available to all PSN members. Call Pat or Kirk at 303-980-1969 if interested.

April 16-17

Plumas-Sierra REC (PSREC) with assistance from the PSN held a meeting/workshop for residents of Secret Valley, an off-grid community near Susanville Calif. The purpose of the meeting was to explain PSREC's PV service program to potential PV service customers. Several presentations that were developed for this meeting may be of interest to other utilities: "Living in a Solar Electric Home",

Continued on page 3

"Residential PV Systems" and "To PV or Not to PV (How to make the decision)". Call Pat at 303-980-1969 for more details.

April 10

The PSN attended a meeting with the Nebraska Natural Resources Conservation Service (NRCS) and Nebraska Public Power District (NPPD) to help establish a "PV link" between the two organizations. The Nebraska NRCS has adopted PV pumping systems as a vital component in the concept of "whole farm conservation". As a result of the meeting, the NRCS plans to procure PSN pumping systems through NPPD.

May 29-30

The PSN in conjunction with its utility members in Arizona and Solarjack, a PSN system supplier, co-sponsored a workshop on PV water-pumping geared for utilities and utility customers. A total of 30 people attended with 10 from utilities and 20 from regional offices of the BLM and NRCS. An additional workshop may be scheduled in Denver if there is enough interest.

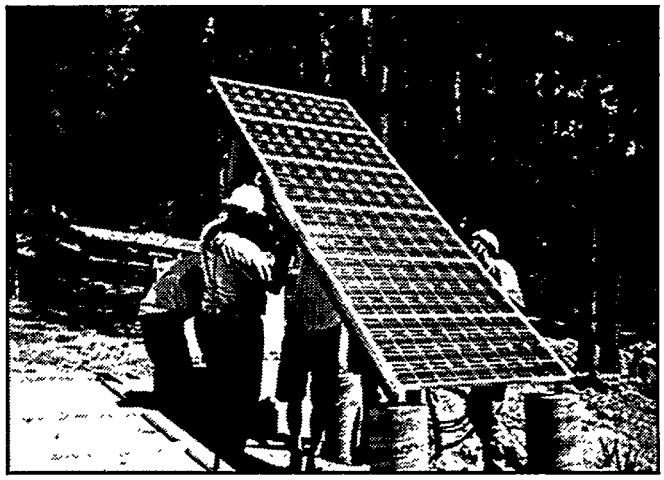
June

The customer education booklet "Solar Electricity, an Alternative to Utility Power Lines" was completed and printed. This booklet,

Continued on page 4

Another lesson is the fact that although packaged PV systems themselves require little installation time, a substantial amount of work is required to connect the PV system to the house distribution panel, customer owned generator and the in-house PV system monitor. These connections typically require trenches to bury the electrical cable or conduit for the cable. (Electrical codes usually require the monitor wire to be run in its own separate conduit.)

Utilities can deal with these connections in several ways. For the PSREC installation, the customer dug the required trenches and installed conduit ahead of time to minimize the installation costs. The electrician provided by Blackhawk Solar ran the electrical and monitor wire and made all the connections. The costs for the electrician's time and materials are paid by PSREC and recovered in the customer's monthly lease fee. Other utilities may choose to install the trench, conduit and wiring themselves and charge the customer a one time fee, include the costs in the customer's monthly service charge or not charge the customer at all if the utility traditionally pays for service drops.



Installation crew raises the array.

Because off-grid residences typically rely on engine generators for power, most residential PV customers already own generators they want to use for charging the PV system batteries and running large loads. Unfortunately, these customer-owned generators are often of an unknown quality that may or may not interface well with the PV system. (Most PSN residential systems contain inverters that will accept input from any properly operating generator and include built-in system protection.)

Continued on page 4

PV Market Place

PSN Goes Shopping

The PSN will go shopping next for packaged PV-powered lighting systems to include in a Lighting Product List. The first step will be to gather information on PV lighting products that are now commercially available. To that end, we will be sending a lighting product survey and request for literature to all PV system manufacturers within the next month. In addition, the PSN will also send surveys to our member utilities requesting information on their requirements for lighting systems.

What's Selling

The following is a sampling of the PV systems purchased by PSN member utilities since the last issue of Network News:

- Six Solarex grid-tied residential PV systems with a total of 24 kW of PV;
- A Photocomm residential PV system with 510 watts of PV ;
- A Solarjack centrifugal pumping system with 110 watts of PV;
- Ten Solarjack diaphragm pumping systems with a total of 944

Continued on page 4

which explains solar electricity and residential PV systems, was mailed to all PSN members and subscribers in early July. Additional copies can be purchased for $1.00 each. Call JoAnn at 303-980-1969 to place an order.

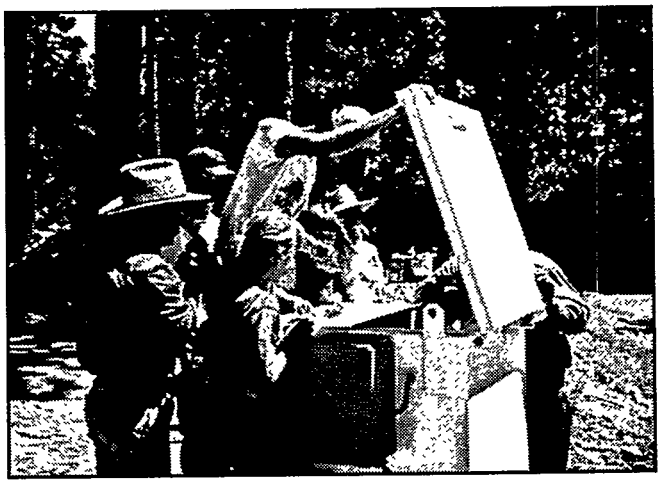
July 30

Plumas Sierra REC (PSREC) installed a residential PV system from the PSN Product List for an off-grid member in Janesville, Calif. The system, supplied by Photocomm, was installed by the PSREC line crew and Bill Rockett of Blackhawk Solar, a PSREC PV Program Partner. See cover article for details.

• • • • • • • •

watts of PV;
• Two Grundfos centrifugal pumping systems with a total of 600 watts of PV;
• A Direct Power PV power supply for a Direct TV system with 225 watts of PV; and
• Miscellaneous PV modules, pumps, motors, controllers and parts.

What PSREC learned from this installation is that if the customer's generator does not operate within the parameters accepted by the PV system, a lot of time can be spent by the installers in trying to make the two work together. What is the solution? Paul Bony, Member Services Manager with PSREC, feels strongly that the customer needs to be told in advance (perhaps in the PV service contract) what is required of their generator to interface successfully with the PV system (voltage, frequency and current). Paul wants to make certain the customer understands that the generator is their responsibility. (Residential systems on the PSN Product List may be purchased with a generator integrated as part of the package.)



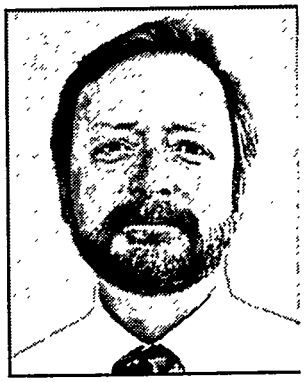
The customers get acquainted with the system.

Continued on page 5

PSN Profile

We'd like you to meet a new member of the PSN Board of Directors, Gary Jurkin. Gary is in charge of demand-side programs, including PV power services for AEPCO, a generation and transmission cooperative in southern Arizona. AEPCO and its six member distribution cooperatives serve a region with some of the highest solar insolation levels in the United States. Yes, it's hot there, but that bright sun also brings down the cost of using photovoltaics.

Two years ago, AEPCO and Gary recognized the tremendous potential for using PV systems to serve remote customers and decided to "get their feet wet" by implementing two remote PV projects. AEPCO participated in an NRECA research



Gary Jurkin
PSN Board of Directors
Demand-Side Programs Manager, Arizona Electric Power Cooperative (AEPCO)

Continued on page 5

project to install and test Golden Photon water pumping systems and they installed a packaged residential system for a remote off-grid customer.

AEPCO is now ready to support their distribution cooperatives' use of PV by providing financing for PV systems leased to remote customers. Two member RECs in particular, TRICO Electric and Sulphur Springs Valley Electric are offering residential and water pumping PV systems as a customer service. According to Gary, the PSN Product Lists play an important role in their PV programs by serving as a reference for system specifications and prices whenever a customer inquires about PV service.

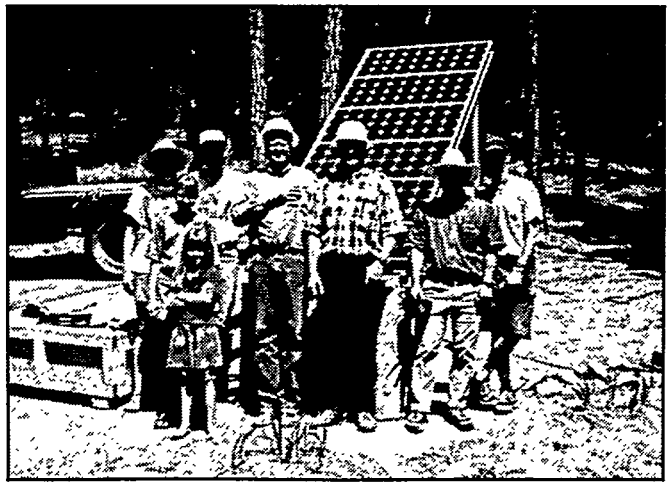
AEPCO is fortunate to be located in a region that not only has a great solar resource but has a supportive regulatory agency as well. The Arizona Corporation Commission encourages utilities to install PV and has set renewable energy goals for electric utilities as part of an IRP order. The goal for AEPCO and their distribution cooperatives is to install one megawatt of renewable energy capacity by the end of the year 2000. In Arizona, PV is the renewable energy source that makes the most sense.

PSN Question:
What role does AEPCO's PV Power Service Program play in the PV market?

When the customer is notified of generator requirements in advance, they can have their generator tested and adjusted, tuned-up or replaced as necessary before the PV system installation. At the time of the installation, the installer should have meters available to verify that the customer's generator output is within the specified parameters. The utility may also choose to bring a properly operating portable generator on site to test the PV system/generator interface in case the customer-owned generator is not operating properly.

A final lesson is one that is true for any new purchase. Delivered systems need to be checked to verify that specifications have been met. One of the PSN's roles in this installation has been to do just that. We have worked closely with PSREC, the installers and the customer to make certain that the delivered system both met their expectations and PSN specifications. Through this process, the PSN has also verified the importance of providing utilities with a system acceptance checklist to assist them in taking delivery of PSN systems. These checklists are now being developed and will be sent to utilities whenever an order is placed.

Everyone involved, PSREC, Photocomm, the customer and the PSN, concluded that this was a successful installation and all are satisfied with the outcome. The system was easy to install compared to PV kits or separate components and the customer has a well functioning system that is professional in appearance. The installation has also been a valuable learning experience for everyone involved and PSREC looks forward to their next PV customer.

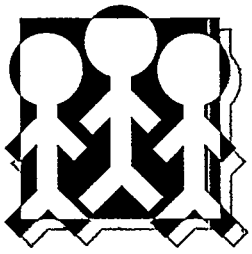


The satisfied customers (left four) and installation crew. (Paul Bony third from right.)

Gary:
People living far from power distribution lines, typically must rely on engine-driven generators for their power needs. These generators are not only expensive to operate and maintain, they are noisy and dirty - attributes quite inconsistent with the quality of life in remote areas. Also, ranchers are frequently required to haul generators to pump water at remote livestock watering wells.

PV systems can supply remote power less expensively in the long run and much more conveniently to these remote residents and ranchers but they often cannot afford the initial purchase price. AEPCO's Power Service Program is designed to overcome that price barrier by offering PV systems on a long term lease basis. For a flat monthly fee proportional to the installed cost of the system, AEPCO in concert with the distribution cooperatives will provide a PV system and maintain it over the lease period.

We believe that this PV program is a natural extension of our core business which is not the generation, transmission and distribution of electricity, but the delivery of end-use services such as light, cooling and electromotive power, that electricity provides.



Membership Corner

Membership Totals

Utility Members	43
Rural Electric Cooperatives	30
Municipalities	1
Other Public Utilities	3
Investor Owned Utilities	9
Utility Association Members	3
Subscribers	24
Sponsors	5

PSN Contributors ($5,000 or more)

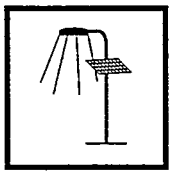
Colorado Office of Energy Conservation
Sandia National Laboratories
U. S. Army Construction and Engineering Research Labs
Utility PhotoVoltaics Group
Western Area Power Administration

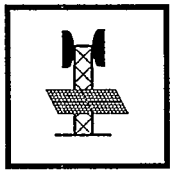
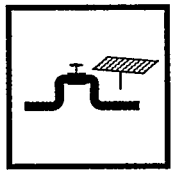
For information on how to become a PSN member, write or call:

Photovoltaic Services Network, Inc.
165 S. Union Blvd., Suite 260
Lakewood, CO 80228
Phone: (303) 980-1969
Fax: (303) 980-1030

printed on recycled paper

Photovoltaic Services Network, Inc.
165 S. Union Blvd., Suite 260
Lakewood, CO 80228



PHOTOVOLTAIC SERVICES

Network News

Volume 1 No. 6

Fall 1996

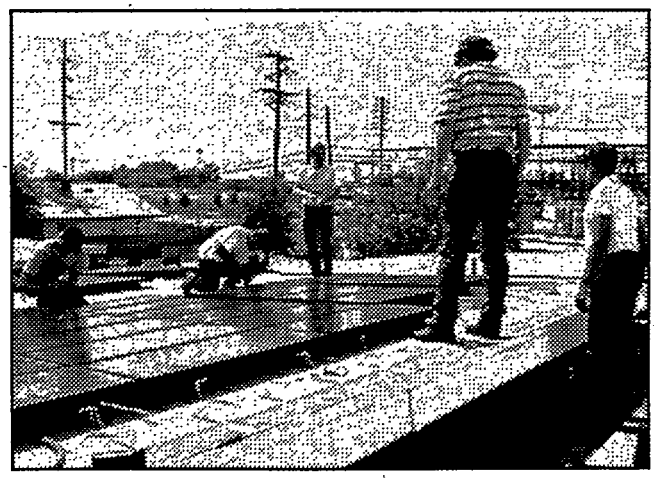
Inside...

PSN Behind the Scenes

What does the PSN technical support staff do when they're not in the office taking orders for PV systems (or writing articles for this newsletter)? They're in the field supporting PV system installations and providing utility/contractor/customer training. PSN members are all well aware of the PV system purchasing opportunities available through the Product Lists, but not everyone is aware of the on-site technical support the PSN provides. So, to get everyone caught up, here is a look at some of the PSN field activities of the past year.

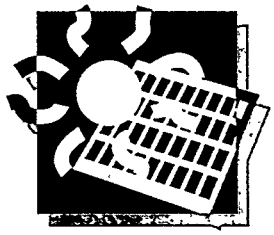
Nevada Power - *UPVG TEAM-UP system installation*

PSN technical representatives Cary Lane and Terry Schuyler traveled to Las Vegas in September to oversee the installation of the first of five residential grid-tied systems cost-shared by the Utility PhotoVoltaics Group's (UPVG) TEAM-UP project. The four kW system was installed on a customer's flat roof located next to a Nevada Power sub-station (see photo). Nevada Power sub-contracted the installation work to local PV service suppliers with the PSN technicians on site to train the contractors and supervise the installation.



PSN technical reps Cary Lane and Terry Schuyler (right and second from right) assist with Nevada Power grid-tied system.

Continued on page 2



Network In Action

A Look Ahead

February 11 & 12

Mark your calendars and make your reservations. The PSN Annual Meeting is coming up soon! The PSN meeting will be held once again in Denver, Colorado on February 11th and 12th (prime ski season). The new Lighting Product Lists will be introduced and the updated Residential and Water Pumping Lists will be released at this meeting. Come meet the PV suppliers who provide the PSN with high quality systems and learn about the PV activities of other PSN members. Meeting announcements with registration forms were sent out in November. If you have not received yours in the mail, call JoAnn at 303-980-1969.

Continued on page 2

Photovoltaic Services Network News is a bimonthly publication of the Photovoltaic Services Network (PSN). The PSN is an organization of electric utilities that have joined together to make PV services and products readily accessible to its utility members. PSN members receive the Network News as a benefit of membership. For non-members, subscriptions are available to the Network News plus other PSN publications for $150 per year.

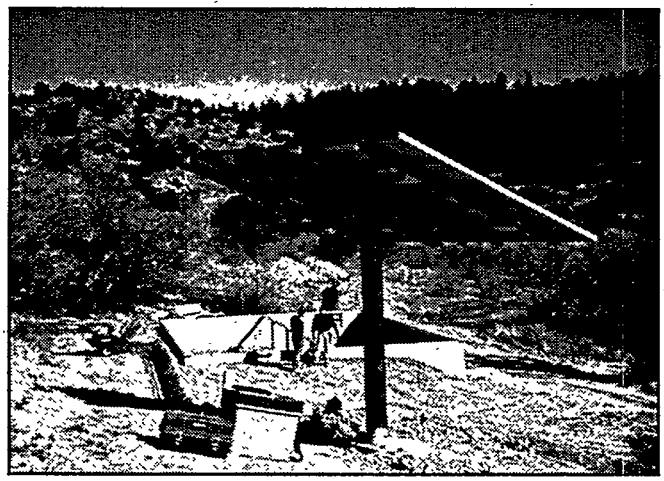
Editor:
Patricia Saito

News items or comments may be sent to:
Photovoltaic Services Network, Inc.
165 S. Union Blvd., Suite 260
Lakewood, CO 80228

Phone: (303) 980-1969
Fax: (303) 980-1030

WestPlains Energy - BP residential system installation

WestPlains Energy based in Colorado Springs, Colorado was the first PSN member to purchase a BP Solar residential PV system. Because this was one of the first BP residential systems to be installed in the United States, BP sent one of their technicians to install the system with assistance from PSN technical representative Cary Lane, WestPlains engineer Ed Wiedenmann and a WestPlains electrician. Cary's role was oversee the installation of the system and to train the customer in proper operation and maintenance.



The array was installed just before the West Plains customer's prefabricated house was set on its foundation.

Plumas-Sierra REC - Customer Education Workshop

In May, Plumas-Sierra sponsored a special workshop to educate the residents of Secret Valley (an off-grid community) about Plumas-Sierra's PV service program and PV systems. PSN technical representatives Pat Saito and Terry Schuyler developed and coordinated the workshop and traveled to Susanville, California to present information on residential PV systems, how to live in a PV home, and PV basics.

Intermountain REA - PV pumping system for Forest Service campground

The Pike National Forest was the recipient of a $5,000 grant for a PV water pumping system from the Public Service Company of Colorado's Renewable Energy Trust through Intermountain

Continued on page 3

March 16-19

The PSN will host a booth at the NRECA TechAdvantage 97 Electric Expo in Las Vegas. This important meeting which will be well attended by co-op managers and member services personnel, is an excellent op-portunity for co-ops to gain exposure to the PSN. We will set up a working PV pumping demonstration and will have service representatives on hand to answer questions. If you will be attending this meeting, please stop by the PSN booth (#1339) and share your reasons for joining the PSN with other co-ops.

Activities Recap

October 15-18

The Utility Photo-Voltaics Group held its annual Utility PV Experience Exhibition and Conference in Denver this year. During the meeting, the PSN was awarded a new contract that funds activities such as development of the Lighting Product List, development of a PV contractor database, and continued marketing support for member PV programs.

November

The PSN has been working on a customer education booklet on PV-powered water pumping similar to the one developed for residential PV: "Solar

Continued on page 3

Electricity, an Alternative to Utility Power Lines". This new booklet, "Solar Electricity for Livestock Water Pump-ing", will be printed in late December and will hopefully be distributed to PSN members by the end of the year.

November 15

The new PSN solicitation for PV-powered outdoor area and sign lighting systems were sent to PV suppliers that expressed an interest in providing packaged lighting systems for the upcoming PSN PV Lighting Product List. The solicitation deadline is December 17th.

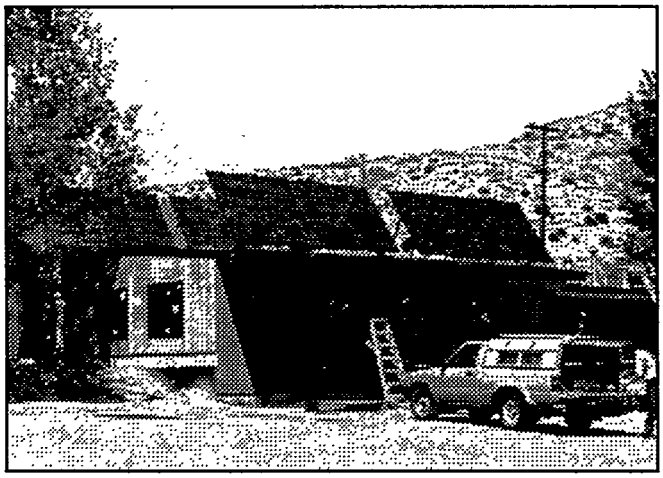
November 27

Solicitations for PV-powered residential and water pumping systems to renew the existing Product Lists were sent to PV system suppliers on November 27th. Although the PSN anticipates few major changes to the Lists, this is an opportunity for existing vendors to update system specifications and prices. This is also an opportunity for new suppliers to be added to the Product Lists. The solicitation deadline is January 7th.

Rural Electric Cooperative. A Grundfos centrifugal pumping system with a 640 watt PV array was installed in November and will pump water for both the Meadows and Buffalo Creek campgrounds. PSN's technical service representative, Cary Lane went to the well site to instruct Intermountain REA and forest service personnel on proper installation and testing procedures.

WestPlains Energy - UPVG TEAM-UP system installation

WestPlains Energy also received funding from UPVG's TEAM-UP program to install grid-tied PV systems. Their first of five systems went up on an addition to the City of Pueblo's Nature Center. The four kW array was installed by a city electrician, John Rote, with phone support from the PSN. After the system was installed, PSN technical representatives Cary Lane and Terry Schuyler went on site to train local electrical contractors and additional City of Pueblo electricians on PV installation and to oversee system startup, testing and troubleshooting.



This grid-tied PV system on the Pueblo Nature Center has a battery back-up system to provide electricity during power outages.

PV Market Place

PSN Goes Shopping

Solarex is having a sale on grid-tied PV systems and the PSN is passing the savings on to member utilities. See article "Solarex Grid-Tied Systems on Sale" on page 5.

The new Outdoor Area and Sign Lighting Product Lists and the updated Residential and Water Pumping Lists will be sent to PSN members in early 1997. The prices in the old Product Lists will remain in effect through 1996. Although we do not expect any significant price increases, there will be some price changes in the updated Lists. If you are considering a purchase, place your orders now to lock in 1996 prices.

What's Selling

1996 PSN PV systems sales to date.

Pumping Systems
- 49 Systems
- 10.4 kilowatts
- $130,000

Off-grid Residential
- 7 Systems
- 3.2 kilowatts
- $51,000

Grid-tied Residential
- (UPVG cost-shared)
- 10 Systems
- 40 kilowatts
- $230,000

Free Photocomm Workshops

Photocomm, one of PSN's system suppliers, is scheduling free training workshops on the PV systems they offer through the PSN (both residential and water pumping systems). If you are interested in attending a workshop, please call to state a preference for a date and location. Call Pat Saito with the PSN at 303-980-1969.

Texas PV Coalition Joins the PSN

The PSN has a new member and ally: the Texas Photovoltaic Coalition (TxPVC). In many ways similar to the PSN, the TxPVC was formed to help electric utilities in Texas capitalize on the growing PV market by integrating off-grid PV into their regular portfolio of service options. Texas, with its immense land area, bright, year round sunshine and many livestock ranches, represents one of the largest potential markets for PV applications in the U.S.

Both the PSN and the TxPVC will benefit from this alliance. The TxPVC, just formed in 1996, will have quick access to the high quality, utility grade PV systems available through the PSN and the PSN has the potential to increase its sales volume and to gain new members in Texas. (The TxPVC is already purchasing a trailer mounted PV system through the PSN for demonstration purposes.) Although the TxPVC presently has four members (Rio Grande Electric Cooperative, Wise County Electric Cooperative, Tri-County Electric, and Lubbock Power & Light), with eighty rural electric co-ops in Texas, the TxPVC has a great potential for fast growth.

The TxPVC is managed by Planergy, Inc., an independent energy services company. John Hoffner, director of advanced technologies for Planergy, will be responsible for the TxPVC's strategic development and implementation of initiatives. Mr. Hoffner, previously managed the Austin Electric Utility's alternative energy programs for 13 years. According to Mr. Hoffner, "By working together to develop necessary experience and infrastructure for grid-independent utility PV services, the TxPVC and the PSN will help build a viable PV service market in Texas."

PSN Profile

Martin Gordon was elected to the PSN board of directors during the 1996 annual meeting. Like Peggy Plate, with Western Area Power Administration, he fills one of the two PSN board seats reserved for representatives of utility associations. Mr. Gordon is senior program man-ager of the National Rural Electric Cooper-ative Association's Rural Electric Research (RER) program. He is responsible for managing research in the areas of transmission, distribution, automation, telecommunications, electric motors and engineering aspects of EMF.

The focus of the RER is to provide research on topics of particular value to rural electric cooperatives (co-ops).

Martin Gordon
PSN Board of Directors
Senior Program
Manager of NRECA's
Rural Electric Research
Program

Continued on page 5

What sets co-ops apart from other utilities is the nature of their distribution systems. Unlike municipalities and investor owned utilities whose customer bases include a large percentage of commercial and industrial customers, the majority of co-op customers (80-95%) are residential and agricultural. In addition, these customers are typically dispersed over large geographic areas. It is not unusual for co-ops to have average customer densities of only one or two customers per mile of line. This dispersed nature of many small scale customers often presents co-ops with special challenges in providing cost-effective and reliable electric service.

Photovoltaics is one possible solution to remote power needs that the RER is currently investigating. Accord-ing to Mr. Gordon, in areas of the country with low population density and high solar resource, (such as in the high plains region and desert southwest), it makes good economic sense for co-ops to serve some remote customer applications with PV systems. Livestock water pumping and remote residences are two PV applications in which the RER has sponsored field studies. One study monitored the performance and reliability of a residential PV system installed by La Plata Electric Assn. for a customer near Durango, Colorado. The other study involved the installation and monitoring of PV powered water pumping systems by thirteen co-ops with ranching customers.

PSN Question:

The PSN like the NRECA, is an organization of electric utilities that came together to support each other in a common venture. What value do you believe the PSN offers to co-ops with a need to serve remote customers?

Martin:

Co-ops have limited staff time to investigate new products and technologies. They must often rely on information from product vendors when there is no independent source of information available. The Rural Utility Service (RUS) (formerly the Rural Electrification Administration) is one source of independent information with its list of materials acceptable to RUS for use on systems by RUS borrowers. The PSN offers similar benefits by setting high standards for utility grade PV systems and evaluating the PV products offered by vendors. The PSN is a source of independent information on PV systems for co-ops that want to find more cost-effective ways of serving remote customers.

Solarex Grid-Tied Systems On Sale

A number of PSN member utilities have expressed interest in exploring PV energy services for grid-tied consumers through "green" pricing or DSM programs. In fact, several members have already installed prototype grid-tied, systems. (See cover article "PSN Behind the Scenes".) Because of this interest, the PSN and Solarex Corporation have negotiated a deal to make their PV-VALUE grid-tied systems available to all PSN members.

Solarex, one of the largest module manufacturers in the United States, is now in the process of identifying prospective utility participants for their new PV-VALUE project. In this project, Solarex and the Utility PhotoVoltaic Group are providing co-funding to lower the cost of a limited number of grid-tied systems to the first utilities to make a commitment of installing ten systems each. However, Solarex has agreed to sell these same systems to PSN members with no minimum purchase as long as the systems are purchased through the PSN. Details of the PSN offer include:

- Prices as much as 40% lower than current market prices for comparable systems;
- Complete packaged systems with everything needed for installation;
- UL listed, tandem junction amorphous modules with 20 year power warranties;
- Two year system warranties;
- Optional battery back-up; and
- Quantity discounts (5% for 5-9, 10% for 10+).

The table below describes the two of systems offered.

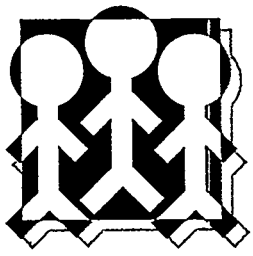
Model #	AC Output*	Array Size (DC nom.)	# of Modules	Price (approx.)
SLX-SMGT	1.6 kW	1.8 kW	36	$7,229
SLX-LGGT	2.6 kW	3.0 kW	60	$11,778

*** @ PVUSA conditions**

Project requirements and details include the following:

- System orders must be placed soon. (A limited number of these systems will be available at the reduced prices so PSN members should place orders early.)
- Systems will be delivered in spring/summer of 1997.
- Utilities are responsible for making certain that the systems they purchase are installed prop-erly. (The PSN can assist with installation training as required.)
- Utilities are responsible for system maintenance. (Maintenance responsibilities may be assigned to contractors or customers at the utility's discretion.)
- Ownership of installed systems will be decided by utilities and their customers.

For more information, call Terry Schuyler. at 303-980-1969.



Membership Corner

Membership Totals

Utility Members	51
Rural Electric Cooperatives	36
Municipalities	1
Other Public Utilities	3
Investor Owned Utilities	11
Utility Association Members	4
Subscribers	24
Sponsors	5

PSN Contributors ($5,000 or more)

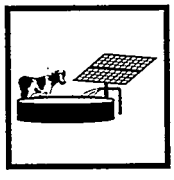
Colorado Office of Energy Conservation
Sandia National Laboratories
U. S. Army Construction and Engineering Research Labs
Utility PhotoVoltaics Group
Western Area Power Administration

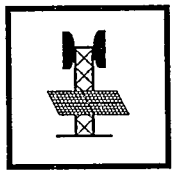
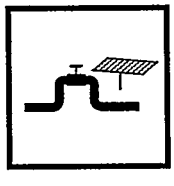
For information on how to become a PSN member, write or call:

Photovoltaic Services Network, Inc.
165 S. Union Blvd., Suite 260
Lakewood, CO 80228
Phone: (303) 980-1969
Fax: (303) 980-1030

printed on recycled paper

Photovoltaic Services Network, Inc.
165 S. Union Blvd., Suite 260
Lakewood, CO 80228

PV Partner Qualification

Photovoltaic Customer Service Program

Plumas-Sierra REC

August 1996

1. Introduction

The cost of supplying traditional electrical energy to remote areas can be prohibitive due to the high cost of installing and maintaining electrical lines over large distances. In many cases, the high cost for line extension construction is not affordable from the customers perspective and the annual costs for the line extension maintenance is not cost-effective from the utility's perspective. In such cases, the consumers with remote loads rely on alternative sources of power such as gas or propane generators and windmills. The ability of photovoltaic (PV) power systems to supply electrical energy quietly and reliably without the need for refueling makes them a natural alternative power source either by themselves or in conjunction with a generator. Plumas-Sierra Rural Electric Cooperative (PSREC) is offering a PV service alternative that will benefit both the customer and the utility by providing more convenient electric power at a lower initial cost and less maintenance than line extensions to remote locations.

PSREC's photovoltaic electric service is offered to its members through a regional network of PV service providers that are pre-qualified to be PSREC's PV "program partners". It is PSREC's intent to limit participation in the program to only experienced PV service providers with the capabilities to install and maintain packaged PV systems purchased by PSREC through the Photovoltaic Services Network (PSN). However, PSREC also desires to qualify enough PV program partners to establish a competitive environment. A program partner may be pre-qualified by PSREC to sell and service either residential PV systems or PV water pumping systems or both.

This document describes PSREC's PV service program and explains the process and qualifications required to become a PSREC PV program partner.

Contents

2. PV Program Implementation

Plumas-Sierra Rural Electric Cooperative (PSREC) has structured it's PV service program to provide maximum benefits to customers with remote power needs, to the local PV industry and to PSREC itself. The benefit to customers is easy access to a reliable, alternative power source for remote loads. The benefit to the local PV industry is an alternative opportunity for marketing and servicing PV systems and increased local PV activity. The benefit to PSREC is expanded services for their members without a great expenditure of their personnel's time. Being a small rural electric cooperative, PSREC does not have the personnel, expertise, or desire to design, specify, install or service PV systems themselves. Therefore, PSREC intends to purchase pre-qualified PV systems from the Photovoltaic Services Network (PSN) and contract with local PV service providers (PV program partners) for marketing, installation and maintenance support.

The PV systems on the PSN's Product Lists are designed, specified and packaged by PSN selected manufacturers with utility customers in mind. In addition, they have been pre-evaluated by the PSN to meet utility standards for high quality components, reliability, and easy installation and maintenance. Therefore, PSREC prefers to pre-qualify as PV program partners, PV service providers who have or are willing to form alliances with one or more manufacturers of these PSN systems.

The role of PSREC's PV program partners is to market pre-approved PV systems, assist customers in selecting systems, site and install selected systems, provide system operation training to customers, perform periodic maintenance and answer customer calls for service and repair.

Sales & Marketing

Potential customers who contact PSREC with an interest in the PV service will be given an information package that includes a PSREC PV program brochure and fact sheet, and a list of approved program partners for residential and water pumping PV systems. (A program partner's name may appear on both lists if qualified.) Customers are free to work with any of the program partners on the lists and may obtain quotes from more than one program partner. However, if a PV program partner independently finds a customer for PSREC's PV service program, that program partner will be the service provider for the referred customer and the customer will not be given the PSREC's program partner list.

Once a program partner is contacted by a potential PV service customer, the partner will assist the customer in selecting the PSREC/PSN PV system best suited to their needs and budget limitations. (See Attachment 1 for sample pages from the PSN Product Lists.) This system selection assistance may be provided either by phone or on a customer site visit. During this process, the program partner will collect customer information on PV service information forms provided by PSREC (see Attachment 2). When a system selection is made, the partner will contact PSREC or the PSN for a firm price quote that includes freight charges and an estimated shipping lead time. The partner will then add his estimated installation charge to the system price and calculate a monthly service charge for the customer.

Monthly charge = .015 x (PSREC system price + freight + install charge - $150) + $13.95

f the customer is interested in purchasing the system, the program partner will provide a firm ystem quote including freight. The customer may or may not choose to work with the program artner for installation of a purchased system.

f the customer decides to go ahead with the PSREC service program, the program partner rovides the customer with a PSREC letter of intent to sign and collects a $150, non-refundable lown payment on the service. (Checks should be made out to the program partner). The rogram partner then completes the PV service information form and submits it and the letter of ntent to Plumas-Sierra. Once PSREC receives the letter of intent, the system will be ordered and a customer service contract will be prepared. The $150 down payment will be deducted from the partner's installation invoice to PSREC. If the customer defaults on the agreement, the partner will keep the $150 down payment to compensate him for his time in working with the customer.

As an incentive for program partners to provide sales and marketing support to PSREC's PV service program, PSREC intends to provide a commission of 5% of the cost of each sold system or service to the partner that facilitates the sale. In addition, the same program partner will be contracted to provide installation, maintenance and on-call support for the service.

PSREC will provide PV program partners with materials required to market and sell PSREC's service or systems. These materials include:

- PSREC's PV service overview/marketing brochure; (See Attachment 3.)
- PSREC's PV Service Program Fact Sheet that describes the different leasing and purchasing options and customer obligations; (See Attachment 4.)
- A list of PV products available to customers through PSREC. This list includes PSREC system prices but not the costs for freight or installation;
- Residential and water pumping PV service information forms;
- Customer load estimation worksheets;
- PSREC PV service letters of intent;
- PV education materials; and
- A map of PSREC's service territory.

Installation

Once the PSREC PV service customer contract is signed and approved, the program partner will be notified by PSREC and a contract will be signed with the program partner for installation and maintenance of the PV system.

The PV service partner will be contracted to perform the following installation activities.

- Delivery of the system and necessary foundation or other installation materials to the customer site;
- Siting of the PV system for proper solar access and customer convenience;
- Preparation of the site as needed (site leveling or preparing foundations as required);
- Properly installing and testing the PV system according to manufacturer instructions and local codes; and

- Training the customer on proper system operation. (Customer operation manuals will be included with systems.)

The customer will be responsible for connecting the PV service to their home via a buried or overhead drop wire. However, the customer may elect to hire the partner or supporting electrical contractor to perform this service. If so, this service should be quoted as a separate item on the system installation quote. It will also be the customer's responsibility to provide proof that the house wiring has passed local electrical inspection. (If the house wiring does not comply with local code, PSREC may provide financing to bring it up to code. Contact PSREC for details.)

Once the program partner has installed and tested the system and instructed the customer on its use, the partner will go over the installation test results with a PSREC representative. The representative will then inspect the system and survey the customer on satisfaction with the system, installation service and instruction. The program partner will be paid for installation and the 5% system commission after the system passes this inspection.

Maintenance

Twice yearly maintenance visits are required for each system. Maintenance visits will be scheduled by the program partner with the PV customer at the customer's convenience. Maintenance activities include the following:

- Visual inspection of the entire system;
- Battery maintenance (depends on type of battery provided with system);
- Array cleaning (if required);
- System testing (same test as performed at installation); and
- Interaction with the customer to answer any PV system questions and to determine the customer's level of satisfaction with the service (a questionnaire will be provided by PSREC).

The service provider must also be available to provide on-call support in case of system malfunction or failure. On-call support may range from giving simple operating instructions to the customer over the phone to a site visit for system testing and repair as required. The following response times are required for on-call support:

- Phone response time: within 12 hours of notification by PSREC.
- Site visit (if necessary): within 48 hours of notification by PSREC.

Plumas-Sierra is willing to pay PV partners $40 per hour for maintenance and on-call support plus $1.00 per mile for travel to the site (one way). If the PV partner is under contract to maintain more than one PV service in the same area, the PV partner will be responsible for minimizing travel by scheduling one or more maintenance visits on the same trip if possible. The regularly scheduled maintenance activities listed above should take approximately two hours to complete for residential PV systems and one hour for water pumping PV systems (no batteries). If replacement components are needed, Plumas-Sierra should be notified of the requirement. Plumas-Sierra may purchase the replacement component(s) from the PV partner if convenient, or order the component(s) from the PSN.

3. Program Partner Qualification Process

This section describes the necessary steps that must be taken by PV service providers that wish to be pre-qualified to provide PV marketing, installation and maintenance support to PSREC's PV service program.

1. A PV service provider who is interested in participating in the program must review this document, fill out a PSREC PV Program Partner Application Form (Attachment 5) and submit it to PSREC with all necessary supporting documentation.
2. PSREC will review the application form and documentation, and verify the information. If there are any omissions or questions as to the information contained in the form or documentation, the PV service provider will be contacted by PSREC for clarification.
3. PSREC will notify the PV service provider when the application has been approved or disapproved. If the application is not approved, the PV service provider will be informed of areas in which qualifications are deficient. A second application may be submitted after the deficiencies have been corrected.
4. Once the PV service provider is notified of qualification, an appointment must be made with PSREC to sign a qualified PV program partner contract and to receive materials for implementing the program.
5. Once the qualified program partner contract with PSREC is signed and the program implementation materials are received, the program partner is free to market the PV service to any potential customers in PSREC's service territory .

4. Program Partner Requirements

The minimum qualification criteria outlined below apply to all PV program partners participating in the PSREC PV service program and include any additional parties subcontractors, equipment manufacturers, distributors) utilized in completing the work. The qualification criteria is divided into three areas:

- Experience;
- General Requirements; and
- Terms and Conditions.

A. Experience

The following experience criteria must be met for each PV application (residential or water pumping) for which the PV service provider is seeking qualification.

1. The PV service provider must have a minimum of two years experience with the installation, maintenance and repair of residential PV power systems and/or PV water pumping systems.
2. The PV service provider must provide the following documentation of experience.
   a. The background, qualifications and experience of all personnel who will work on PSREC PV contracts.
   b. A listing of four client references which include a brief description of the of the PV system and the names of the personnel involved with installation and maintenance. Include a telephone number where the client can be reached.

If a PV service provider is supported by equipment distributors or subcontractors in, installation, maintenance or repair, their experience may be substituted for in-house experience.

B. General Requirements

1. The PV service provider must be capable of installing, maintaining and repairing high quality packaged PV systems.
2. PV system installers must have a current electrical contractor's license within the state of California and/or Nevada as applicable.
3. The PV service provider must be able to install systems within a reasonable time frame after they are received from the PV system manufacturer and must be able to respond to service calls by phone within 12 hours of notification by PSREC and on-site within 48 hours of notification by PSREC.
4. The PV service provider must agree to provide a firm cost proposal for system installations, two annual maintenance visits and on-call support.
5. The PV service provider must be willing to provide maintenance and on-call support for any PV service sold and installed by the service provider for a period of up to five years following installation.
6. The PV service provider's company must be stable and reliable as substantiated by the number of years in the PV business. (Minimum of 2 years in business prior to application.)

3. Terms and Conditions

1. The program partner must comply with all applicable State and Federal laws, rules and regulations, involving non-discrimination on the basis of race, color, religion, national origin, age, or sex.
2. The program partner must be an independent contractor with sole control over the manner and means of each and every part of the installation of the contracted PV power system.
3. The program partner can not be an employee of PSREC and can not be entitled to any benefits provided by PSREC and its employees including but not limited to compensation insurance, unemployment insurance, group insurance and pension plan.
4. PSREC may cancel or terminate qualified program partner status with or without any reason by giving thirty days written notice to the program partner. Any unresolved customer complaints or allegations of questionable marketing practices involving the program partner may result in automatic and immediate termination of the contractor at the sole option of PSREC.
5. The program partner must agree to indemnify and hold harmless PSREC from and against all demands, claims, suits, costs of defense, liabilities and other expenses for damage or damages to property or for injury or injuries to or death.
6. The program partner must provide and keep worker's compensation (and show proof of such insurance) and unemployment compensation insurance in the amounts required by law, and shall be solely responsible for the acts of the program partner, its employees and agents. The program partner acknowledges that the program partner and its employees are not entitled to unemployment insurance benefits unless the program partner or a third party provides such coverage and that the state does not pay for or otherwise provide such coverage.
7. PSREC reserves the right to inspect any job site where the program partner has installed a PV system. If it is determined that the work performed by the program partner does not meet or comply with established terms, criteria, requirements and specifications, PSREC shall immediately inform the program partner of such noncompliance, deficiencies and defects. Within 10 days of notification from PSREC of such noncompliance, deficiencies, and defects, the program partner shall respond with a plan to take all necessary action and corrective measures to cure such non-compliance, deficiencies and defects at no cost and no obligation to PSREC and its customers. If it is necessary for PSREC or its customers to take corrective action, the program partner hereby expressly agrees that, upon demand from PSREC, the program partner will pay, indemnify, fully reimburse PSREC or its customers for all of PSREC's or its customers' costs in the taking of corrective action. If the program partner fails within 15 days after demand from PSREC to pay and reimburse PSREC or its customers for these costs and PSREC is required to enforce this provision or to seek recovery of damages for the program partner's breach of this provision, the program partner expressively agrees to pay all damages, expense, court costs, and reasonable attorney's fees.
8. The service provider must provide PSREC with written proof of all required insurance at the time of application for program partner qualification. The PV service provider shall purchase and maintain such comprehensive general liability and other insurance as is appropriate for the work being performed and furnished and as will provide protection from claims set forth below which may arise out of or result from the program partners obligations under this agreement whether performed by the program partner, any subcontractor, by any one

directly or indirectly employed by any of them or by anyone for whom acts of any of them may be liable:

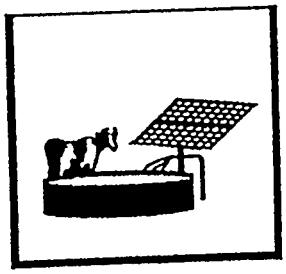
- Claims under workers or workmen's compensation, disability benefits, and other similar employee benefits acts;
- Claims for damages because of bodily injury, occupational sickness, or disease, or death of the program partner's employees;
- Claims or damage because of bodily injury, sickness, or disease, or death of any person other than the program partners employees;
- Claims for damages insured by personal injury liability coverage which are sustained (1) by any person as a result of an offense indirectly or indirectly related to the employment of such person by the program partner, or (2) by any person for any reason;
- Claims for damages, other than to the work performed, because injury to or destruction of property wherever located, including loss of use resulting therefrom; and
- Claims for damages because of bodily injury or death of any person or property damage arising out of ownership, maintenance, or use of any motor vehicle.

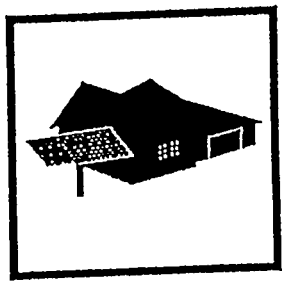
9. The comprehensive general liability insurance shall include complete operations insurance in the amount of $1,000,000. All of the policies of insurance so required to be purchased and maintained shall contain a provision or endorsement that the coverage afforded will not be canceled, materially changed, or renewable refused until at least thirty days' prior written notice has been given to PSREC. In addition, the program partner shall maintain such completed operations insurance for a least two years after final payment and furnish PSREC with evidence of continuation of such insurance at final payment and one year after. The comprehensive general liability insurance shall include contractual liability issuance.

10. The program partner must indicate if a contract has been terminated for default in the last five years. Termination for default is defined as notice to stop performance due to the program partner's non-performance or poor performance.

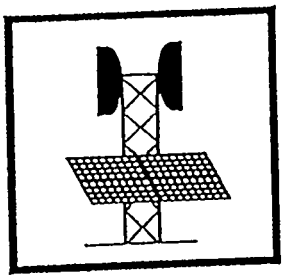
Attachment 1: PSREC/PSN Product List Sample

SAMPLE

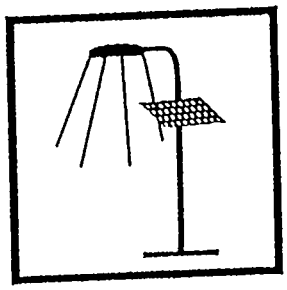


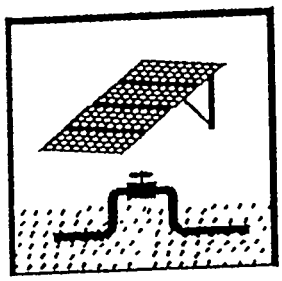


Solar Electric Systems



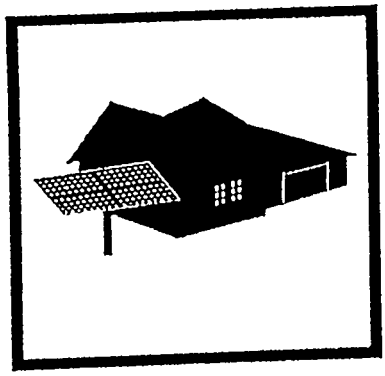
Plumas-Sierra REC Product List





PSN

otovoltaic Services Network, Inc.



Residential Product List

Residential Product List

A wide variety of remote residential PV systems were evaluated for the Residential Product List. The systems selected for the list represent the best combinations of high quality equipment, price, and system manufacturer experience, capabilities and support.

To ensure that the systems on the Residential Product list are of high quality and meet utility needs for performance, reliability and convenience, the PSN used the minimum requirements below as a preliminary screening tool in evaluating proposed pumping systems.

Minimum Requirements

All of the PV-powered residential systems selected for the PSN list meet the following minimum system and supplier requirements:

- ✓ Systems are designed to provide 1, 3, 5, or 8 kWh/day of AC energy based on an average annual insolation of 5.5 kWh/m² at fixed latitude tilt.
- ✓ Systems are capable of supplying the design energy for at least 3 days based on the low voltage disconnect (LVD) set point during winter temperatures and have a minimum two year battery lifetime under typical cycling load to LVD.
- ✓ Systems provide 115 VAC, 60 Hz, single phase power.
- ✓ Systems have the following continuous power capabilities; 1 kWh - 1500 W; 3 kWh - 3000W; 5 kWh - 4000W; 8 kWh - 6000W.
- ✓ Systems are supplied complete and self contained with all necessary installation hardware and no components mounted in or on customer structures.
- ✓ System are designed for 20 year life with minimum maintenance.
- ✓ Systems are as pre-assembled and wired as feasible and cost-effective for shipping.
- ✓ Systems are capable of operating in temperature of -20° to 45°C and winds of 100 mph for 20 years.
- ✓ Array structures provide a minimum of two foot ground clearance.
- ✓ Systems meet all applicable National Electric Code requirements to ensure installer/operator safety including: a manual disconnect switch, proper grounding, proper size wire and disconnects, and hazard warning signs. However, UL (or equivalent) listed components are not required since few PV-powered systems on the market today meet that requirement.
- ✓ PV modules meet PVUSA IQT and UL 1703 standards and include a minimum 10 year, 90% power rating warranty.
- ✓ System components have proven and documented records of field performance in similar applications.
- ✓ Systems have NEC approved means for accepting auxiliary 115 VAC power for battery charging.
- ✓ Systems are supplied with complete installation, operation and maintenance manuals for utility personnel and a user manual for the customer/member.
- ✓ Systems have adequate protection against lightning and load induced voltage surges.
- ✓ System energy outputs are warranted for a minimum of 2 years and the supplier is the point of contact for PSN claims. (Utilities process all warranty claims through the PSN)
- ✓ The system manufacturer has documented experience in supplying similar packaged residential systems.
- ✓ The price quotes contained in the Residential Product List are effective through December of 1996.

Residential System Selection

Four sizes of residential systems are included in the Product List: 1 kWh/day, 3 kWh/day, 5 kWh/day and 8 kWh/day. These systems were designed to provide the rated energy when exposed to average daily insolation levels of 5.5 kWh/m² (consistent with the Boulder, CO TMY site) with the PV array at latitude tilt. If your local insolation differs considerably from this design point, refer to the System Information sheets at the back of this section for system output in two other locations.

When selecting a residential system for a specific application, first estimate your daily energy requirements in kWh/day. Then turn to the appropriate page of the Residential System Comparisons charts (1, 3, 5 or 8 kWh/day) for information about the systems offered.

The systems on the charts are listed from left to right in order of cost. When reviewing the systems, please remember that there may be significant differences between the listed systems that may justify a higher cost (such as a larger PV array, higher quality batteries or trailer mounting). For additional information on any system (including system energy output by month), refer to the PSN System Information sheets at the end of the section.

The following information is included on the Residential System Comparisons charts.

System configuration describes how each system is packaged and mounted for portability and *Enclosure type* describes the construction materials of the equipment enclosure.

Foundation required describes the necessary site preparation prior to installing the system. *Site preparation time* is an estimate of the time required for site preparation such as leveling of the ground and setting poles in concrete. *Installation time* is an estimate of the time required for actual installation and wiring of the system itself and *Maintenance Interval* is the manufacturer suggested maintenance interval.

Maintenance interval is an estimate of recommended time between periodic maintenance visits. *In-house monitoring* tells whether the system includes a system monitoring device for use within customer homes.

Array watts is the size of the PV array in peak watts and *PV module make/model* is simply the name of the module manufacturer and model number. *Module field history* lists the number of years that each make and model of PV module has been commercially available and installed in the field. *Array mount* describes the type of mounting structure used for the PV array. *PV power module warranty* lists the module manufacturer's warranty on the power output.

Available capacity is the battery capacity in days of storage and *Battery type* describes the type of battery technology used such as flooded lead acid and sealed valve regulated . *Estimated battery life* is the system manufacturer's estimate of the battery's life when used according to recommendations.

Inverter voltage/waveform describes the inverter's nominal output voltage and the type of waveform supplied. *Continuous power rating* gives the nominal wattage for continuous operation.

System manufacturer is the name of the company that supplies the system to the PSN and *System warranty* lists that manufacturer's warranty for the system. *Shipping lead time* describes the length of time system manufacturers require to ship a system after receipt of order and *Residential PV experience* lists the system manufacturer's experience with residential PV-systems.

Generator option is the approximate cost for an optional engine generator sized to function with the system. *$/watt PV* is the cost of the packaged system without the generator option divided by the *Array watts*. *Quantity discount* gives the additional price discount(s) that some manufacturers are willing to offer for quantity purchases and *System Price* is the PSN system price to member utilities.

Residential System Comparisons

Size: 3 kWh/day

System ID	PSN-BP3-R	PSN-SES3-R	PSN-PC3a-R	PSN-DP3-R	PSN-SW3-R
System Information					
System					
System configuration	TBD	enclosed trailer	skid mount	skid mount	skid mount
Enclosure type	TBD	aluminum trailer	powder coat steel	5052-H32 aluminum	galv. steel/polyprop.
Foundation required	level site+3 poles	level+ground anchors	level site	level site	level+4-8" gravel
Site preparation time (est.)	2 hours	1 hour	1 hour	1 hour	2 hours
Installation time (est.)	4 hours	4 hours	5 hours	6 hours	4 hour
Maintenance interval	12 months	12 months	12 months	6 months	12 months
In-house monitoring?	yes w/TV or computer	yes	yes	yes	no
PV Array					
Array watts	900	900	1360	1386	900
PV module make/model	BP Solar BP275	Siemens PC4JF	Solavolt SV8500	Solarex MSX77	Siemens PC4JF
Module field history	15 years	4 years	10 years	20+ years	4 years
Array Mount	3 pole mounts	A-frame on trailer	A-frame on skids	pole mount to skid	A-frame on skids
PV module power warranty	10 years	10 years	12 years	20 years	10 years
Batteries					
Available capacity (est. days)	3.2 days	3.0 days	5.4 days	6.7 days	6.1 days
Battery type	valve regulated	valve regulated	flooded	flooded	flooded
Estimated battery life	10 years	5 years	5-7 years	2.5-4 years	6-7 years
Inverter					
Voltage/waveform	115/230/sine	115/sine	115/sine	115/sine	115/sine
Continuous power rating	3200	4000	4000	4000	4000
Make/model	Vanner TB32-24	Trace SW4024	Trace SW4024	Trace SW4024	Trace SW4024
System Mfr. Information					
System Manufacturer	BP Solar	Solar Electric Specialities	Photocomm	Direct Power & Water	SunWize Energy
System warranty	2 years	5 years	2 years	2 years	2 years
Shipping lead time	48 hours	2 weeks	6-8 weeks	5-7 days	8 weeks
Residential PV experience	8 years	15 years	14 years	3 years	10 years
System Price Information					
Generator Option (approximate)	Call for prices	$4000	Call for prices	Call for prices	$3400
$/watt PV (w/o generator)	$16	$18	$13	$16	$27
Quanity discount	5+/2%	5+/2%, 10+/3%	5+/5%, 10+/7.5%	0%	2+/2%, 5+/4%
System Price w/o generator	**$15,460**	**$17,285**	**$18,170**	**$22,605**	**$25,482**

Plumas-Sierra Product List

6/17/96

Water Pumping Product List

Water Pumping Product List

A wide variety of PV-powered water pumping systems were evaluated for the PSN Water Pumping Product List. The systems selected for the list represent the best combinations of high quality equipment, price and system manufacturer experience, capabilities and support. The selection of pumping systems on the Product List was narrowed to include only those with submersible pumps, since that is what the majority of pumping applications encountered by electric utilities require. However, the PSN can price and negotiate the purchase of jack and surface pumps as well on request for any PSN member.

To ensure that the systems on the Pumping Product list are of high quality and meet utility needs for performance, reliability and convenience, the PSN used the minimum requirements below as a preliminary screening tool when evaluating proposed pumping systems.

Minimum Requirements

All of the PV-powered pumping systems selected for the PSN pumping list meet the following minimum system and supplier requirements:

- ✓ Systems include two distinct sub-systems 1) a fully integrated PV power supply and all hardware necessary for installation (excluding water delivery pipe and pump cable) and 2) the associated pump/motor unit.
- ✓ Systems are as pre-assembled and wired as feasible and cost-effective for shipping.
- ✓ Pump/motor units are submersible to a minimum of 50 feet under water.
- ✓ Systems meet all applicable National Electric Code requirements to ensure installer/operator safety including: a manual warning signs. However, UL (or equivalent) listed components are not required since few PV-powered systems on the market today meet that requirement.
- ✓ PV modules meet PVUSA IQT and UL 1703 standards and include a minimum 10 year, 90% power rating warranty.
- ✓ Power supplies include bypass diodes according to module mfr. recommendations.
- ✓ Systems are capable of operating in temperatures of -20° to 45 °C, withstand winds of 100 mph with the array at 55 ° tilt and have a minimum two foot ground clearance.
- ✓ Systems can withstand exposure to above conditions for 20 years without maintenance.
- ✓ Systems are supplied with complete installation, operation and maintenance manuals for utility personnel and a user manual for the customer/member.
- ✓ The system manufacturer warrants water output for a minimum of two years and the supplier is the point of contact for PSN claims. (Utilities process all warranty claims through the PSN)
- ✓ The system manufacturer has documented experience in supplying similar packaged pumping systems.
- ✓ The price quotes contained in the Water Pumping Product List are effective through December of 1996.

Pumping System Selection

When selecting a pumping system for a specific application, first consult Chart 1: Performance Nodes. Use Chart 1 to select a performance node (labeled intersection) that is closest to your combination of pumping head (total vertical lift) and required gallons per

Next turn to Chart 2: Pumping System Comparisons and go to the page labeled with your selected node. This page will give you information about the pumping systems offered by the PSN that are appropriate for that particular head and GPD. If your application is between nodes, also check Chart 2 for the nodes immediately before and after your required head and GPD.

The systems on the charts are listed from left to right in order of system cost. When reviewing the systems, please remember that there may be significant differences between the listed systems that can justify a higher cost (such as lower maintenance pumps). For additional information on any refer to the PSN System Information sheets at the end of the section.

On Chart 2 under System Information is each pumping system's water delivery in ***Gallons per day*** at average solar insolation levels of 6 peak sun hours or kWh/m^2 per day. This water output can be expected during the summer months in most locations.

Pump Type describes the type of pumping mechanism used to move the water. All the systems on the list are either diaphragm or centrifugal pumps. Diaphragm pumps are positive displacement pumps that require periodic replacement of the flexible diaphragms and rebuilding of the brushed DC motors. Centrifugal pumps require no periodic maintenance of the pumping mechanisms and have brushless (maintenance free) motors.

Field history describes how long each pump has been commercially available and installed in the field. ***Maintenance interval*** gives the pump manufacturer's recommended time between periodic maintenance services and ***10-year maint. cost*** gives the estimated cost for replacement parts (no labor is included).

Array watts is the size of the PV array in peak watts. ***Module field history*** gives the number of years that each make and model of PV module has been commercially available and installed in the field.

Site preparation time gives estimates of the time required for civil works such as concrete foundations, footings and ground leveling. All the pumping systems on the Product List require concrete footings or poles set in concrete at least one day prior to system installation.

Installation time gives estimates of the time required for installing the PV power supply (installation of the pump and down hole equipment is not included).

Mount type describes the type of mounting structure used for the PV array. The structures are fixed (non-tracking) ground mounts, fixed pole mounts or tracking pole mounts. If a tracker is used, ***Tracker make*** lists the manufacturer of the tracker as either Zomeworks (passive tracker) or Wattsun (active tracker).

System warranty lists the system manufacturers warranty for the packaged pumping system. ***PV power module warranty*** lists the PV module manufacturer's warranty on the modules' power output.

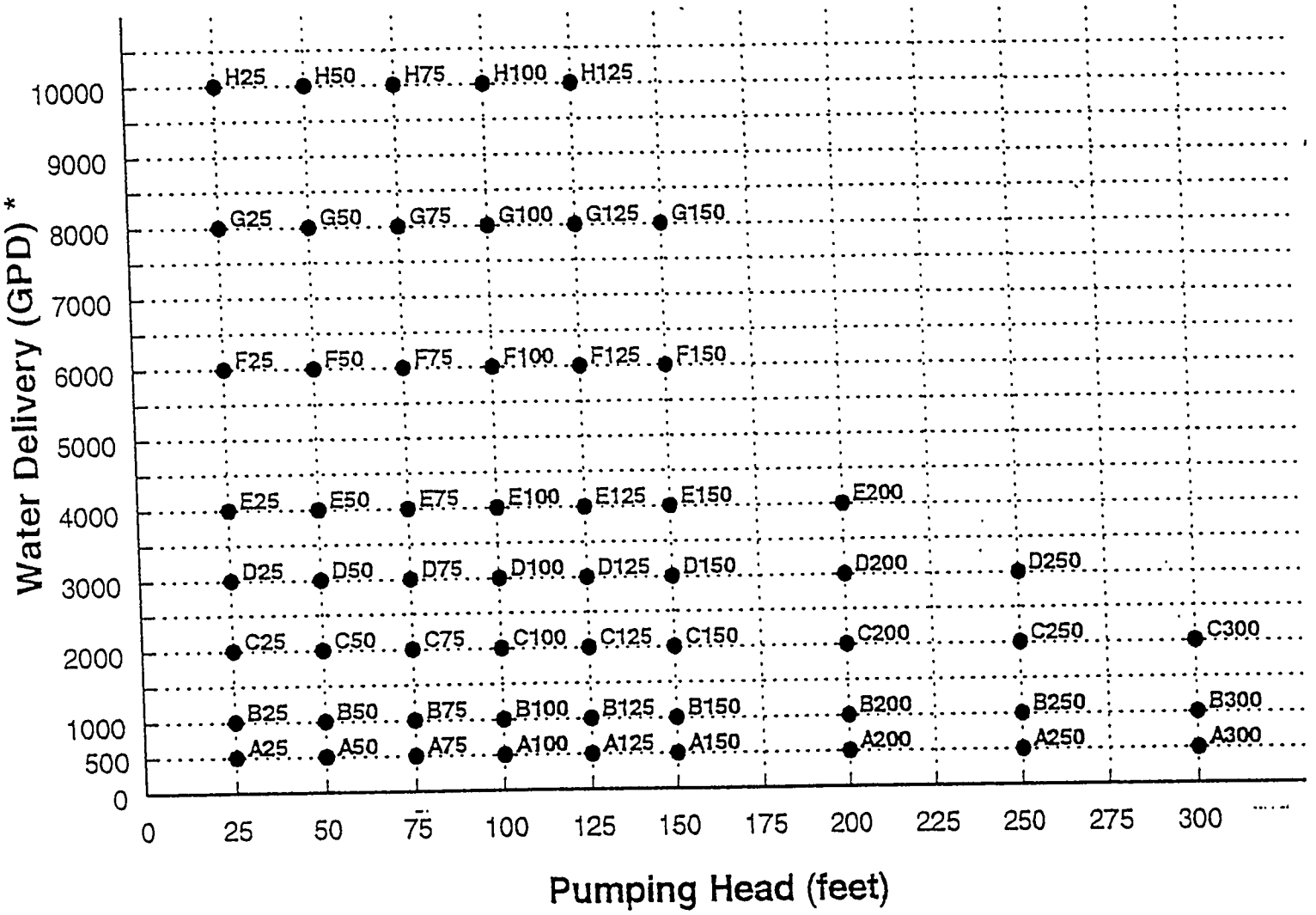
Local pump availability states whether the pump/motor unit is available from local pump dealers. ***Shipping lead time*** describes the length of time each system manufacturer requires to ship a system after receipt of order and ***PV pumping experience*** lists the years of experience each system manufacturer has with PV-powered water pumping.

Quantity discount gives the additional price discount(s) that some manufacturers are willing to offer for quantity purchases. ***Pump/motor price*** lists the price of the pump/motor unit by itself (without a controller) and ***System Price*** is the PSN system price to member utilities.

Only systems manufactured by Energy Photovoltaics are presently capable of accepting generator back-up power. However, other manufacturers are working on that capability.

Pumping System Selection

Chart 1: Performance Nodes



* Water delivery based on insolation of 6 sun hours

Chart 2: Pumping System Comparisons

Node B100 (100 ft, 1000 GPD)

System ID	PSN-SJ35-P	PSN-DP18-P	PSN-AP05-P	PSN-SJ36-P	PSN-EPV01-P	PSN-AY08-P
System Information						
Gallons per day	1153	1310	1000	1201	1266	1563
Pump/Motor						
Pump type	Diaphragm	Diaphragm	Centrifugal	Centrifugal	Centrifugal	Centrifugal
Manufacturer	SolarJack	SolarJack	Grundfos	SolarJack	Any standard pump	AY McDonald
Model	SDS-Q-128	SDS-Q-128	SP1A-9	SCS3-200	3 phase, 3/4 hp	211019DK
Field history	6 years	6 years	1 year	2 years	30+ years	11 years
Maintenance interval	2 years	2 years	not applicable	not applicable	not applicable	not applicable
10-year maint. cost (no labor)	$520	$520	$0	$350	$470	$2,059
PV Power Supply						
Array watts	180	154	300	280	400	300
PV module make/model	Solec S-90	Solarex MSX 77	ASE-50-AL	Solec S-70	Solec SQ-80-4	Siemens PC4JF
Module field history	10 years	8 years	1 year	10 years	4 years	4 years
Site preparation time	2 hours	2 hours	1 hour	2 hours	4 hours	1/2 hour
Installation time	2 hours	2 hours	2 hours	2 hours	1 hours	1 hour
Array Mount						
Mount type	fixed/pole	tracking/pole	fixed/pole	fixed/pole	fixed/ground	fixed/pole
Tracker make	not applicable	Wattsun	not applicable	not applicable	not applicable	not applicable
System Mfr. Information						
System Manufacturer	Solarjack	Direct Power & Water	Applied Power	Solarjack	EPV	A.Y. McDonald Mfg.
Warranty						
System warranty	2 years	2 years	2 years	2 years	2 yr./1 yr. $ back	2 years
PV module power warranty	10 years	20 years	10 years	10 years	10 years	10 years
Local pump/motoravailability	no	no	no	no	yes	no
Lead time to ship (ARO)	24 hours	48 hours	48 hours	24 hours	48 hours	24 hours
PV pumping experience	10 years	3 years	14 years	10 years	1 year	14 years
Price Information						
Quantity discount	0%	0%	6+/13%	0%	0%	0%
Pump/motor price	$628	$940	$668	$1,393	$523	$2,554
System Price	**$1,922**	**$2,471**	**$3,759**	**$3,856**	**$3,944**	**$4,763**

Plumas-Sierra Product List - Node B100

6/17/96

Attachment 2: PV Service Information Forms

Residential PV Service Information

ogram Partners: To initiate a new service, collect a $150 non-refundable deposit from the customer, fill ut this form completely, and submit this form with a signed customer letter of intent to PSREC.

General Information

V Partner name & company: _____ Date: _____

ustomer name: _____ Phone: _____

ddress: _____

ity: _____ State: _____ Zip: _____

V service address: _____

istance from the PV partner place of business to the PV service address: _____ miles

elected PV system model number: _____ Price: _____

stimated monthly charge quoted to customer: $_____ Desired install date: _____

Customer Information

. How did customer hear about this service?

_____

. Has the customer been quoted a price for a utility line extension?

No _____ Yes _____ → What price?$_____

. Is the customer the owner of the home at the service address?

Yes _____ No _____

If yes, please attach proof of ownership.

If no, please provide owner information below:

Name: _____

Address: _____

_____

Phone: _____

The owner must sign the letter of intent and contract for PV service.

4. Has customer ever lived in an off-grid home?

Yes _____ No _____ If yes please explain.

_____

5. When will the system be used?

Continuously _____ Weekends: _____
Summer _____ Spring: _____
Fall _____ Winter _____

6. Has the house wiring passed electrical inspection?

Yes _____ No _____

If yes, please attach proof of code compliance.

If no, please explain _____

_____

_____

_____

7. Does the customer require 240 volt service?

Yes _____ No _____

If yes please list 240V appliances.

_____

_____

_____

_____

What type of refrigerator will be used?

_____

How is water for the home obtained?

_____

_____

0. Will customer be connecting an engine generator to the PV system?

Yes _____ No _____

If yes please fill in the following information.

Generator make, model & year_____

_____

Type of fuel used:

Gas _____ Diesel _____ Propane _____

Power rating: _____kW

Output voltage(s):

120V _____ 240V _____ Both _____

Does the customer want to use a generator with auto-start?

Yes _____ No _____

Is the output power sufficient for use in charging the selected PV system?

Yes _____ No _____

11. Where would the customer like to locate the PV system relative to the house? (please draw a rough sketch below)

12. How far is the PV site from the house electrical distribution panel? _____ft.

13. Does the location have unobstructed south facing solar access?

Yes _____ No _____

If no, can anything be done to prevent shading of the array (such as cut down trees)?

_____

_____

14. Is the site accessible by truck?

Yes _____ No _____

15. Please check all that apply to the site:

level ground _____ sloped ground _____

flat surface _____ uneven surface _____

sandy/soft soil _____ rocky/hard soil _____

16. Additional Comments:_____

_____

_____

_____

_____

Location sketch: North↑

Installation & Maintenance Price Quotes

Installation

Please indicate with an X the party who will be responsible for each of the following installation activities. If the responsible party for an activity is the PV Partner, fill in the cost quote for that activity.

	PV Partner	Customer	Other (write in)
System delivery to customer home	X $____	____	____
Ground/foundation preparation	$____	____	____
Installation of house drop cable & monitor wire (including wire, civil works or trenching & backfill)	$____	____	____
Interconnection of system to house electrical panel	$____	____	____
Interconnection of customer-owned generator	$____	____	____
Set-up and wiring of PV array & enclosure	X $____	____	____
System testing and reporting to PSREC	X $____	____	____
Customer training for system operation	X $____	____	____

Total price quote for PV Partner installation activities indicated above: $____

Maintenance

Maintenance includes a visit to the customer site visit every six months to perform the following activities:

- Visual inspection of the entire system;
- Battery maintenance (depends on type of battery provided with system);
- Array cleaning (if required);
- System testing (same test as performed at installation); and
- Interaction with the customer to answer any PV system questions and to determine the customer's level of satisfaction with the service (a questionnaire will be provided by PSREC).

Price quote for two maintenance visits:

2 x ($1.00/mile x ____ miles + $40/hour x 2 hours) = $____

Maintenance also includes supporting the PV service customer on an on-call basis. On-call support may range from giving simple operating instructions to the customer over the phone to a site visit for system testing and repair as required. Plumas-Sierra will pay the PV partner $10 for every 15 minutes of phone support time and $40/hour plus travel at $1.00/mile for on-site repair visits. The following response times are required for on-call support:

- Phone response time: within 12 hours of notification by PSREC
- Site visit (if necessary): within 48 hours of notification by PSREC.

PV Partner signature:_____ **Date:**_____

Water Pumping PV Service Information

Program Partners: To initiate a new service, collect a $150 non-refundable deposit from the customer, fill out this form completely, and submit this form with a signed customer letter of intent to PSREC.

General Information

PV Partner name & company: _____ Date: _____

Customer name: _____ Phone: _____

Address: _____

City: _____ State: _____ Zip: _____

PV service address: _____

Distance from the PV partner place of business to the PV service address: _____ miles

Selected PV system model number: _____ Price: _____

Estimated monthly charge quoted to customer: $_____ Desired install date: _____

Customer Information

1. How did customer hear about this PV service?

   _____

2. Has the customer been quoted a price for a utility line extension?

   No _____ Yes _____ → What price?$_____

3. Is the customer the owner of the property at the service address?

   Yes _____ No _____

   If yes, please attach proof of ownership.
   If no, please attach proof of easements for utility access.

4. What is the end use for the pumped water?

   ____Domestic household use

   ____Livestock watering.

   Type of livestock: _____

   Number of head: _____

   ____Irrigation

   ____Other - Please specify:

   _____

5. How much water is needed daily?

   Spring: _____Gallons/Day

   Summer: _____Gallons/Day

   Fall: _____Gallons/Day

   Winter: _____Gallons/Day

6. What is the water source?

   ____Stream or pond

   ____Drilled well

   Inside diameter of well casing: _____inches

   Total depth of well: _____feet

   Max. pumping rate: _____Gal./Min.

   Has there been a recent well test?

   Yes ____ No ____

   ____Other water source- Please specify:

   _____

7. Is the water source presently being used?

   Yes ____ No ____

   If yes, how is it being pumped? _____

   _____

8. What type of water storage will be used?

___Above ground tank. - Size: _____Gal.

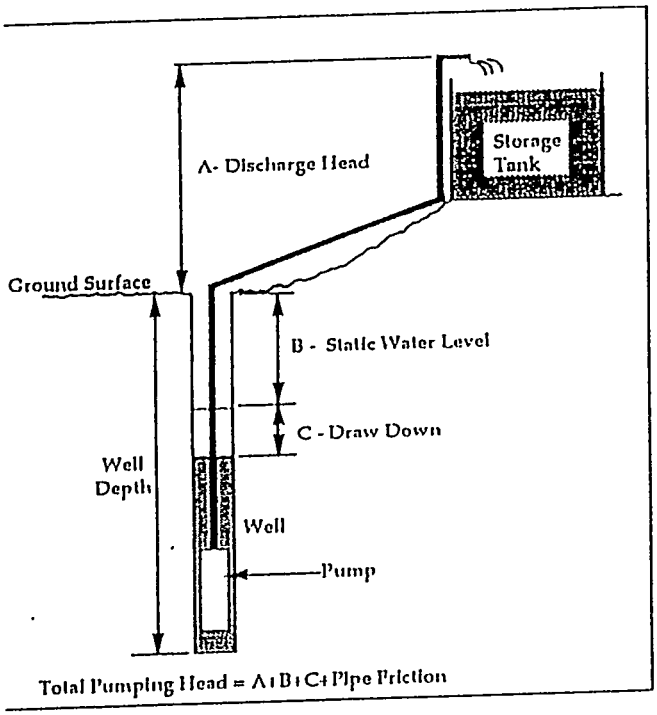
___Below ground tank. - Size: _____Gal.

___Pressure tank. - Pressure: _____psi.

___Other (please specify)

_____

See drawing below for questions 9 - 12.



9. What is the Static Water Level? (Vertical distance from ground surface to water)

_____Feet

10. What is the Water Draw Down? (Distance water level drops while pumping)

Pumping rate _____GPM _____Feet

11. What is the Discharge Head? (Vertical distance water is pumped uphill to tank.)

_____Feet

12. What is the Total Pumping Head: (add the three distances above)

_____Feet

13. How far is the water piped from the source to storage or distribution? _____Feet

14. Does the water contain:

Silt Yes _____ No _____

Sand Yes _____ No _____

Rust Yes _____ No _____

15. How is the overall water quality?

___Very Good

___Good

___Fair

___Poor

___Very Poor

16. Where does the customer want to locate the PV system relative to the water source? (please draw a rough sketch below)

17. How far is the PV site from the water source?

_____Feet

18. Does the PV site have unobstructed south facing solar access?

Yes _____ No _____

If no, can anything be done to prevent shading of the array (such as cut down trees)?

_____

_____

19. Is the PV site accessible by truck?

Yes _____ No _____

20. Please check all that apply to the site:

level ground _____ sloped ground _____

flat surface _____ uneven surface _____

sandy/soft soil _____ rocky/hard soil _____

21. Additional comments: _____

_____

_____

_____

_____

_____

Installation & Maintenance Price Quotes

Installation

Please indicate with an X the party who will be responsible for each of the following installation activities. The activities that are the sole responsibility of the program partner are already marked with an X. If the PV partner is responsible for an activity, fill in the cost quote for that activity.

	PV Partner	Customer	Other (write in)
System delivery to customer home	X $____	____	____
Ground/foundation preparation	$____	____	____
Installation of pump and all down well work	$____	____	____
Set-up and wiring of PV array & enclosure	X $____	____	____
System testing and reporting to PSREC	X $____	____	____
Customer training for system operation	X $____	____	____

Total price quote for PV Partner installation activities indicated above: $____

Maintenance

Maintenance includes a visit to the customer site visit every six months to perform the following activities:

- Visual inspection of the entire system;
- Array cleaning (if required);
- System testing (same test as performed at installation); and
- Interaction with the customer to answer any PV system questions and to determine the customer's level of satisfaction with the service (a questionnaire will be provided by PSREC).

Price quote for two maintenance visits:

2 x ($1.00/mile x ____ miles + $40/hour x 2 hours) = $____

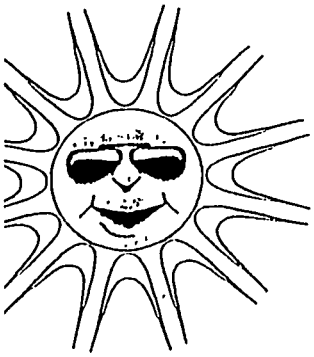
Maintenance also includes supporting the PV service customer on an on-call basis. On-call support may range from giving simple operating instructions to the customer over the phone to a site visit for system testing and repair as required. Plumas-Sierra will pay the PV partner $10 for every 15 minutes of phone support time and $40/hour plus travel at $1.00/mile for on-site repair visits. The following response times are required for on-call support:

- Phone response time: within 12 hours of notification by PSREC
- Site visit (if necessary): within 48 hours of notification by PSREC.

PV Partner signature:____ Date:____

Attachment 3: PSREC PV Program Brochure

Introducing Plumas-Sierra's Solar Electric Service Without a Wire



Who says you need a utility line to get electric service?

Plumas-Sierra Rural Electric Cooperative serves some of the most picturesque country in California and Nevada. With good reason, many families want to live as far away from "civilization" as possible - but they still want convenience in their lives and that takes electricity.

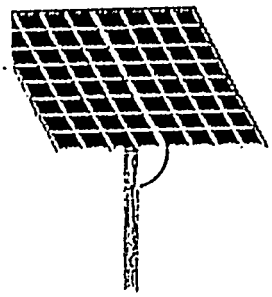
Until now, there have only been three ways to get electricity in the remote parts of our service territory:

- Pay us to extend a power line to your property for an average cost of $20,000 per mile, assuming utility easements are available ($40,000 per mile for rugged terrain).
- Purchase an engine generator and fuel. (And perform regular oil changes and tune-ups.)
- Purchase an alternative energy system such as a solar electric power system (ranging in price from $10,000 to $30,000 for a home site; $2,000 to $10,000 for water pumping).

Now there is a fourth option available - obtain solar electric service from Plumas-Sierra!!

That's right. Rather than using your precious capital to bring in electric service, you pay Plumas-Sierra a flat monthly charge that includes installation and all maintenance and replacement components as needed.

hat is a Solar Electric System?



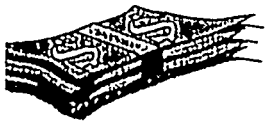
Also known as photovoltaics systems, solar electric systems convert sunlight directly into electricity that can be used as is to run a pump, for instance, or can be stored in batteries to serve a wide variety of household and ranching needs.

These systems are built to last and perform reliably when they are properly designed and installed. They also come in many sizes to suit a wide variety of electricity needs.

A photovoltaic system can power almost anything that uses electricity, but the cost does add up. The best place to start is to do a thorough analysis of your electricity needs to ensure that the appropriate sized system is obtained for the job. Some typical uses are:

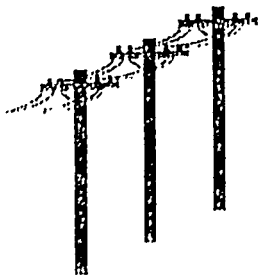
- Household power needs (stereos, TVs, computers, lights, cooking and cleaning appliances).
- Water pumping for livestock, small irrigation or household needs.
- Outdoor lighting for area, security and sign lights.

(so what will it cost me?



It all depends on the size and cost of the system installed. The exact fee can be determined after a system is selected for your application and quotes for installation costs are obtained. The monthly fee is based on a payment of 1.5% of the installed cost of the system plus the standard Plumas-Sierra monthly customer service charge of $13.95. For instance, a customer with a mid-sized PV system costing $10,000 installed would pay about $164 each month ($10,000 x .015 + $13.95).

at seems like a lot for a monthly bill!

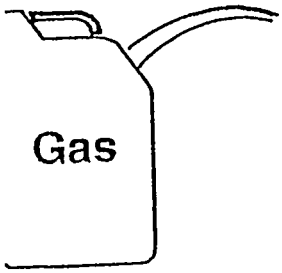


Maybe so, but let's compare that to the other options available:

Pay us to extend a power line to your property.

A power line costs you $20,000 to $40,000 per mile and the total amount must be paid up front before construction begins. If your home is located within public lands, a power line may not be possible at all due to right-of-way restrictions. In addition to the construction costs, residential customers pay an average of $85 per month for electric service.

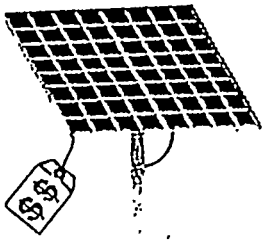
Purchase an engine generator and fuel.



Although the up front costs for a generator may be less than for a PV system, they are still expensive. A good quality, continuous duty propane generator costs approximately $4,500 for a 6.5 kilowatt model and the fuel and maintenance costs add up.

In fact, when equivalent size PV/generator hybrid systems and just engine generators are compared on a life cycle costing basis, the PV hybrid systems come out ahead. This means energy from PV systems is less expensive in the long run. In addition, with a PV system, noise and exhaust from a generator can be minimized or eliminated.

Purchase a photovoltaic system yourself.



Since PV systems make a great alternative to line extensions and generators why not just buy one? - Because like line extensions, they are expensive. If you have an extra $10,000 to $30,000 and don't mind spending it, then purchasing a PV system is an easy solution. But many people either don't have the money or don't want to invest it in photovoltaics. They would rather have it in the bank collecting interest and available for emergencies, or invest it in their home. They also may not want the responsibility of maintaining a PV system or finding a knowledgeable and reputable PV dealer.

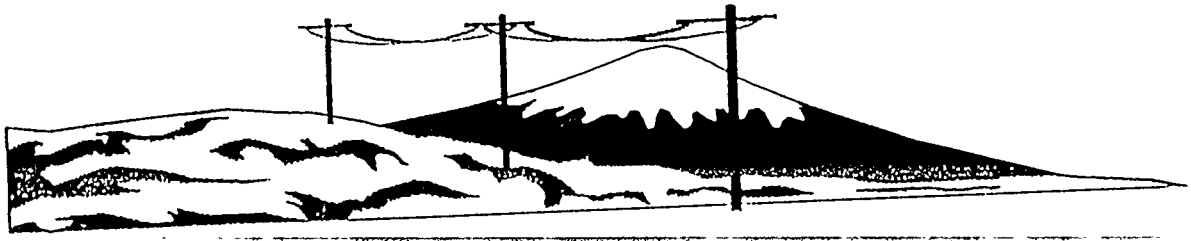
) why is Plumas-Sierra doing this?

1??

If we extend our electric grid to non-profitable remote areas, we create a number of problems for ourselves and our customers:

- Miles of expensive and difficult to install lines due to terrain and public land right-of-ways;
- Miles of expensive and difficult to maintain lines that require significant yearly upkeep;
- Miles of unsightly lines that obstruct our magnificent views; and,
- Rate increases to pay for upkeep of unprofitable lines.

To ensure that our PV customers receive the same level of service we provide our other customers, we have developed stringent guidelines so that the PV systems we procure are of the highest quality for reliable electrical service and minimum maintenance. And PV systems are very durable, costing much less to maintain than miles of utility lines.



there anything else I should know?

Will Serve

Yes! Obtaining conventional financing to build a home without electric utility service can be difficult. Most lenders require a utility "will serve" letter for their most attractive loan terms. If you sign up for Plumas-Sierra's solar electric service, we can provide a "will serve" letter to you or your lender.

(, so how do I get the service I need?

1. Contact the Member Services Department at Plumas-Sierra, (916) 832-4261, and ask for a list of PV Program Partners.
2. Meet with the Program Partner of your choice to help you select the Plumas-Sierra PV system that best meets your needs and budget. The Program Partner will collect information about your electricity needs for system selection and Plumas-Sierra's files.
3. If the selected system and monthly payment are acceptable, sign a letter of intent for the PV service and write a deposit check for $150 to the Program Partner.
4. Sign a contract for the PV service at the Plumas-Sierra office in Portola within 90 days of signing the letter of intent.
5. Plumas-Sierra staff will order the PV system and schedule the installation with you and the Program Partner.
6. Once the installation is complete, Plumas-Sierra staff will inspect the system. If all is in order, the Program Partner will be paid for the installation and you will receive monthly billings for your solar electric service.
7. The Program Partner and Plumas-Sierra will be responsible for all maintenance and replacement parts, including a maintenance visit every six months.

THIS INFORMATION BROUGHT TO YOU COURTESY OF:

Attachment 4: PSREC PV Program Fact Sheet

Plumas-Sierra PV Service Program Fact Sheet

Plumas-Sierra Rural Electric Cooperative's (PSREC) solar electric or photovoltaic (PV) service program provides customers with the option of using high quality residential or water pumping PV systems for remote electric loads. Local PV service providers (called PSREC PV Program Partners) assist PSREC in implementing the PV program by providing installation, maintenance and repair service support. These Program Partners have met rigorous requirements participate in PSREC's PV program. This fact sheet describes the details of the PV service program.

Who is eligible for the PV service?

The PV service is available to home or land owners in Plumas-Sierra's service territory who do not have easy access to line connected power. To be eligible:

- A residential PV service customer must be the owner of the property where the PV service is to be located or the owner must agree to sign the PV service contact.
- A water pumping PV service customer must either be the owner of the property where the service is to be located or the customer must obtain utility access easements from the owner.
- The PV service location must not have easy access to a power line extension; and
- The PV service location must be within Plumas-Sierra's service territory; in an adjacent area that is not served by another electric utility; or in an adjacent area served by a utility which will grant PSREC permission to provide PV service.

What kind of systems are offered?

Five sizes of residential power systems are available with PV arrays ranging in size from 300 to 3700 watts. All residential systems include PV modules, batteries, inverters and all necessary electronics in a compact, easily installed package. These systems can accept input from customer-owned engine generators for auxiliary battery charging, but generators are not included as part of the service.

The available water pumping systems can deliver from 500 to 10,000 gallons of water per day at a depth of 25 to 300 feet of pumping head. The pumping systems include a PV array, a pump, a pump controller and a solar tracker as required. Batteries are not included with PV pumping systems to deliver water on demand; therefore, customers must use large tanks or reservoirs to store water.

What does the service include?

The monthly charge for the PV service includes use of the contracted PV system, system installation, periodic maintenance, component replacements as required and on-call service and repair. Residential PV service includes a regular maintenance visit every six months (usually in the spring and fall to optimize the PV array tilt angle). The water pumping PV service includes a maintenance visit once every twelve months as required. These regular maintenance visits are scheduled by a PSREC Program Partner at the customer's convenience.

If there are any system operation questions or malfunctions, a PSREC Program Partner is required to respond to the customer by phone within twelve hours of notification by PSREC and to perform on-site repairs within 48 hours if required. The customer always contacts the customer service dept. of PSREC for assistance and PSREC dispatches a Program Partner for service or repairs.

How much will it cost?

When a customer signs up for PSREC's PV service program, the customer is charged a monthly service fee equivalent to 1.5% of the

Attachment 5: PSREC PV Program Partner Application Form

PSREC Program Partner Application

Applicant Name:_____ Date:_____

Company Name:_____

Address:_____

City:_____ State:_____ Zip:_____

Telephone:_____ Fax:_____

PV Program Partner application for:

___ Residential PV service

___ Water pumping PV service

___ Both residential and water pumping

General Information

1. How many years has your company been in business? _____

2. How many years has your company been in the PV business? _____

3. Please list the names of employees or support personnel involved with PV system installations who are licensed electricians.

   Name _____ Company:_____

   Address & Phone _____

   Name _____ Company:_____

   Address & Phone _____

   Name _____ Company:_____

   Address & Phone _____

4. Please list your company's insurance coverage below:

Type	Amount	Insurer	Phone Number
Comprehensive liability	_____	_____	_____
Bodily injury	_____	_____	_____
Workers compensation	_____	_____	_____

To PV or Not To PV?

Addressing Management Questions

PSN

Introduction

The Questions

- What is PV?
- When is PV used?
- Why offer PV services?
- Why would consumers want utility PV services?
- What is the potential market?
- How much time is required to develop a PV program?

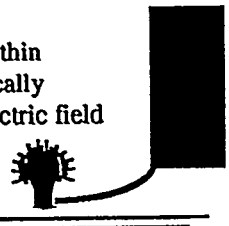
PSN

What is PV?

PSN

Technology Basics

- Photovoltaics or PV is an energy conversion technology that converts light energy directly to electricity
- PV cells are made of thin silicon wafers chemically treated to form an electric field



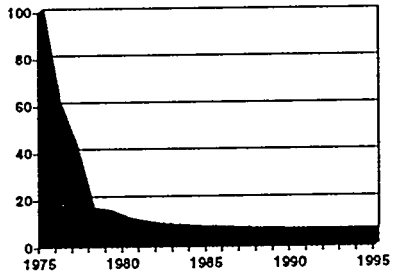
PSN

Brief History of PV

- NEED HISTORY SLIDE W/ SATELLITE GRAPHIC

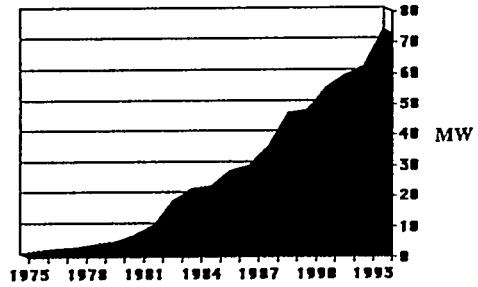
PSN

Cost of PV Modules



PSN

PV Modules Shipped



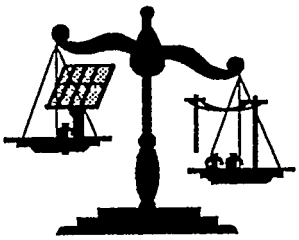
PSN

When is PV Used?

PSN

PV is Cost-Effective Today

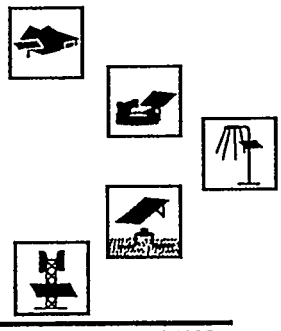
- "Remote" loads with small energy requirements
- When line extensions and other power sources are impractical
- When available power lines are high voltage



PSN

Typical Rural Applications

- Remote Residential
- Water Pumping
- Stand-alone Lighting
- Cathodic Protection
- Communications



PSN

Typical Urban Applications

- Grid-independent
  - Lighting (area, sign, etc.)
  - Communications (e.g., RTU, DAS, etc.)
  - Irrigation controls
  - Sectionalizing switches
- Grid-connected
  - DSM - peak clipping
  - Residential/commercial - "green pricing"
  - Electric vehicle re-charging
  - Back-up power supplies (e.g. UPS)

PSN

Why Offer Utility PV Services?

PSN

Utility Benefits

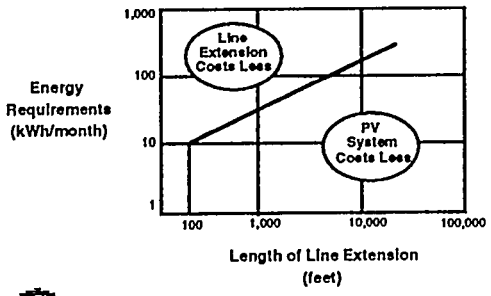
- Lower cost of service for remote loads
- Avoided line reconstruction costs
- More customer service options / energy solutions
- Increased customer base in a competitive market
- Local economic development
- Image as progressive, "green" utility
- PV is happening with or without utility involvement (lost business opportunities)

PSN

Why Would Consumers Want Utility PV Services?

PSN

Lower Cost Than Line Extension



PSN

Guaranteed PV System Financing

Utility "will serve letter" can enable remote land owners to obtain lower cost, conventional financing

Example:

Homeowner PV	Utility PV
Private lender	Conventional Loan
20-30 % down	5-10% down
loan rate: prime+4%	loan rate: prime+2%

Economic Development:
Opens up new markets for both utilities and real estate developers

PSN

PV System Portability

- Systems can be designed to relocate easily
- Systems can be used for temporary applications
  - Homes under construction
  - "Short-term" service until lines extend close enough for low cost hook-up
- Systems can be used for emergency power

PSN

Increased Reliability

If electric service is prone to disruptions, PV is more reliable for critical applications such as emergency warning sirens and security lighting.

PSN

Improved Aesthetics

No overhead power lines to block views or clutter facilities.

PSN

Fewer Disruptions

- Less environmental impact (land not disturbed by setting poles or burying cable)
- No heavy construction equipment required (line trucks, trenchers, pole setters)
- No need to string power lines across roads or pathways

PSN

Additional Utility Value

- Multiple service options for consumer
- Utility integrity- stability
- Utility expertise - no need for customer to become technology expert

PSN

What is Potential Market?

PSN

Market Opportunities
Livestock Water Pumping

- Target market: over 500,000 operating wells west of Mississippi (National Cattleman's Association)
- McKenzie Electric: avoided line reconstruction
  - 900 grid-tied livestock wells @ 1,100 kWh/yr
  - $27M reconstruction to 35+ year-old lines
  - 500 wells require $6.8M reconstruction ($16.8k ea.)
- Northwest Rural PPD: new service opportunities
  - Over 1,000 windmills in service area
  - Nearly 40 PV service customers since 1994

PSN

Market Opportunities
Livestock Water Pumping

- Target customers
  - Ranchers in western U.S.
  - Federal land management agencies (USFS, BLM, etc.)
- Competition
  - Subsidized line extensions
  - Windmills
  - Engine generators
- Additional market factors
  - Changing environmental regulations
  - Changing range management practice

PSN

Market Opportunities
Remote Residential

- Target market: 150,000 homes nationwide (UPVG market research)
- Southern California Edison
  - Nearly 6,000 existing off-grid homes in service area (1994)
  - Over 80% want Edison to provide PV services
  - Value of service research indicated:
    - Off-grid PV system size in 500 W to 1 kW range
    - Grid-tied homeowners willing to pay "green price"

PSN

Market Opportunities
Remote Residential

- Target customers
  - Rural "telecommuters"
  - Remote new construction
  - Seasonal cabins
- Competition
  - Subsidized line extensions
  - Engine generators
- Additional market factors
  - Telecommunication technology allows rural lifestyle
  - Land costs in undeveloped areas

PSN

How Much Time Required to Develop PV Program?

PSN

PV Program Development
Requirements

- Competitive products
- Operating plan
- Qualified local contractors

PSN

PV Program Development

PSN support minimizes required time:

- Competitive products
  - PV Systems Catalog
  - Special project support
- Operating plan
  - PV Services Guidebook
  - Marketing and technical support
- Qualified local contractors
  - Contractor identification
  - Contractor training & certification

PSN

PV as a Business Opportunity

Implementing Successful PV-Based Energy Services

PSN 2nd Annual Meeting - February 12, 1997

PSN

Introduction

- PV Market Overview
- Utility PV Services - Lessons Learned
- PSN's PV Service Capabilities
- PSN Partnership Proposal

PSN

Key Off-Grid Markets

Water Pumping

Remote Residential

Stand-alone Lighting

Cathodic Protection

Communications





PSN

Livestock Water Pumping

- Over 500,000 operating wells west of Mississippi (see map)
- Number increasing annually
  - Changing environmental regulations
  - Changing range management practice
- Roughly 50/50 grid-connected and stand alone sites

PSN

Livestock Water Pumping

- Grid-independent (new services)
  - 250,000 operating wells
  - Approximately 70% should be considered opportunities (175,000)
    - *20% "lost" to generator/windmill acceptance
    - *10% "lost" to narrow windmill casing
  - At 10% total penetration in next 10 years, potential PV value @ $36M - $88M gross sales on 17,500 systems

PSN

Conservation Reserve Program

- CRP managed by Natural Resources Conservation Service
- NRCS anticipates
  - 23% CRP land returned to grazing
  - 10-year-old water sources will need replacement
- Rule of thumb: 2 water sources per section (640 acres) for grazing
- At 10% total penetration: 2,600+ PV systems ($5.2M - $13M)

PSN

PSN Lessons Learned To Date

The Opportunity:

PSN/Utility Partnerships

PSN

PV Program Requirements

- ♦ Competitive products
- ♦ Operating plan
  - Menu of services
  - Organizational infrastructure
  - Competitive execution
- ♦ Strategic Alliances

WHAT CAN THE PSN OFFER?

PSN

Competitive Products

- ♦ PSN Product List catalog
  - Unique list of pre-qualified packaged "utility grade" PV systems
    - *Meet strict minimum standards
    - *All systems fully integrated and pre-assembled for quick installation
  - Benefits
    - * Easy comparisons of systems and suppliers
    - *Standard system specifications and 2 year warranties
    - *Volume pricing-quantity discounts
    - *Competitive bidding process already completed
- ♦ Technical expertise - engineered products

PSN

Operating Plan - Menu of Services

- ♦ Financing
  - Cooperative Finance Corporation account
    - *"Member-owned" bank of rural electric cooperatives
  - Line of Credit
    - *6.5% interest rate
    - *$200,000 presently ($1M possible)
  - Commercial Paper account
    - *5.5% interest rate
    - *Highest rating possible - Standard & Poor's and Moody's
    - *Collateral for line of credit

PSN

Operating Plan - Menu of Services

- ♦ Installation & maintenance
  - Contractor qualification standards developed
  - Training seminars developed & successfully implemented
  - Contractor database under development (see ad)
  - Technical understanding essential for profitable service agreements (e.g., costs, risks, etc.)

PSN

Operating Plan - Menu of Services

- ♦ Sales strategies
  - Unbundled services!
    - *Take or leave it doesn't work!
    - *No finance doesn't mean no service!
    - *Federal customers different than private customers!
  - PV rate concepts developed
  - Extended warranty concepts developed
    - *2-year system warranty unprecedented
    - *Labor in remote places is the key
    - *Relationship w/ suppliers allows "predictable" costs
  - Technical understanding essential for profitable warranties (e.g., costs, risks, etc.)

PSN

Direct PV → *electric service without a wire*

- Direct "retail" PV services offered to any utility by the PSN as franchised service
- Utility does not need to build in-house program, expend up-front resources
- Both utility and PSN share in cost (for marketing) and revenue (from sales/service)

PSN

Direct PV → *electric service without a wire*

- Utility displays Direct PV banner 1-800 #
  - PSN and utility cost-share marketing
  - PSN handles customer service inqueries for utilities
- PSN manages entire PV service
  - technical sales support with customer
  - Identify and hire installation and service contractor
  - Implements sales/service contract for utility
- Utility manages billing and distr. of revenue

PSN

Photovoltaic Services Network

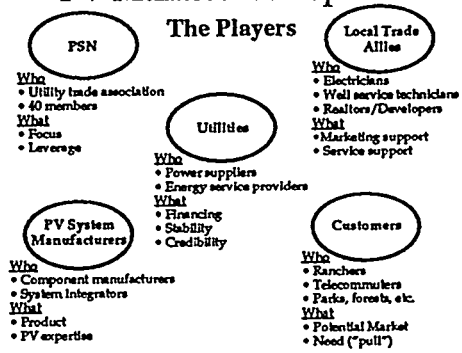
-Forging the Links-

Marketing Utility PV Services to Federal Agencies

PSN

PV Market Development

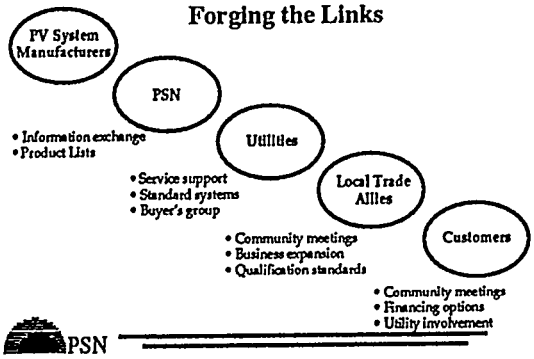
The Players



PSN

PV Market Development

Forging the Links



PSN

PV Market Development

The Potential Links

PSN

Focus on "Customer" Link

Marketing Utility PV Services

- Federal Agencies
  - Bureau of Land Management
  - Department of Defense
  - National Park Service
  - National Resource Conservation Service
  - US Forest Service
- State Agencies
- Nature Conservancy & other private organizations

PSN

Federal PV Procurement

- GSA Schedules
  - Schedules list PV components
  - No available design, installation or maintenance support
- Private Vendors
  - Private company product catalogs
  - Competitive bidding required
  - Service contracts or in-house expertise required (learning curve expensive)

PSN

PSN Utilities - New Option

- Federal agencies encouraged to use utilities for all PV system needs
- Utility "value-added" benefits
  - Packaged PV systems through PSN
  - Service support (i.e., long-term maintenance) replaces required in-house expertise
  - Financing or leasing (i.e., extend capital budget)
  - Minimize procurement hassle (i.e., BOA)
  - Utilities provide stability and quality

PSN

"Make the Link" Opportunities
PSN Policy

- Distribute Product List catalog (retail version) so "customers" can easily identify solution
- Encourage customer to contact local utility or PSN for utility-discounted prices
  - Assess local utility interest in PV
  - Work with local utility to implement PV service
  - Refer customer to "alternate" utility if local utility not interested or capable
- PSN member utility finances, leases, and/or maintains PV pumping system for customer

PSN

"Make the Link" Opportunities
Natural Resources Conservation Service

- Livestock water pumping
- Summer 1995 - Colorado NRCS adopted PV pumping program
- April 1996
  - PSN Product List systems "pre-approved" in Colorado & Nebraska for cost-sharing
  - "Retail Price" version mailed to county conservationists
- Initial projects being developed in both states
- Early 1997 - similar accomplishments in multi-state region

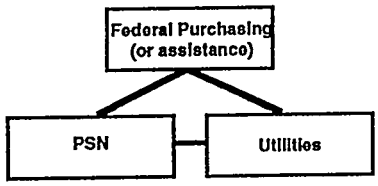
PSN

"Make the Link" Opportunities
National Park Service

- Off-grid water pumping; AC power; lighting
- Over 450 existing PV system installations and more than 600 planned applications
- Intends to purchase systems from utilities and will request service and maintenance agreements for systems > 2 kW in size
- "PSN's standardized approach.....is advantageous at NPS sites where familiarity with renewable power is low or non-existent."
- PSN Product List (retail version) distributed to 150 Parks in near future

PSN

The Link is Made



PSN

Photovoltaic Services Network

Utility PV Services
-Program Development-

PSN

PV Services Guidebook

- Standardized "business plan" approach with specific utility examples (i.e., "franchised" program)
- Facilitate "fast start-up" of successful utility PV service programs
- Handbook developed for board members, managers, and employees of co-ops, PPDs, and municipalities

PSN

PV Services Guidebook

Key Questions

- To PV or not to PV?
- What are the key decisions?
- How is a PV tariff developed?
- How are local contractors qualified?
- How is the program marketed?
- How are PV systems procured?

PSN

PV Services Guidebook

To PV or Not to PV?

- Utility education: decision-makers, board, management, etc.
  - Technology basics - what is PV
  - Cost-effective applications - when should it be used
- Mission: goals & objectives
  - Lower cost of service - least cost / least lost
  - Increased customer service options - new customers
  - Local economic development
  - Public relations - progressive ("green") image
- Market assessment

PSN

PV Services Guidebook

To PV or Not to PV?

- Market assessment - identify customer base
  - Key target markets
  - Market sensitivities
  - Geogmphic / demographic
- Business plan development
  - Key decisions
  - Identify resources
  - Financial plan
  - Operating / implementation plan

PSN

PV Services Guidebook

What are Key Decisions?

Financial plan:

- Initial program budget
  - Research activities
  - Commercial phase
- Five / ten year cost and income
  - Project loss period
  - Projected rate of return
  - Periodic assessment
- Program sustainability
  - Break-even period
  - Project long-term profitability

PSN

PV Services Guidebook
What are Key Decisions?

Operating plan:
- Service options
  - Financing
  - Service & maintenance
  - Sales
- Organizational structure - contracted vs. in-house
  - Sales / marketing - customer screening
  - Installation / maintenance
  - Purchasing
  - Billing / accounting

PSN

PV Services Guidebook
What are Key Decisions?

Operating plan:
- PV rate development
- Contractor identification
- Marketing & educational materials
- Implementation schedule

PSN

PV Services Guidebook
What are Key Decisions?

Operating plan:
- Program assessment
  - Customer tracking / satisfaction
  - System performance / hardware assessment
  - Financial tracking / cost of service
- Program expansion
  - Technology improvements
  - Lower costs
  - Program modification

PSN

PV Services Guidebook
How Develop PV Tariff?

- PUC requirements
- Other utility examples
- Tariff development
  - PV system hardware lifetimes
  - Annual O&M costs
  - Other annual owning costs
  - Construction allowance
  - TIER requirements
  - Rate of return

PSN

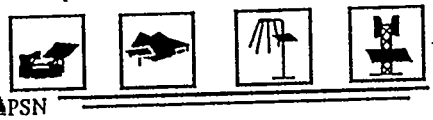
PV Services Guidebook
How Qualify Local Contractors?

- see Plumas-Sierra "PV Partner Guidelines"

PSN

PV Services Guidebook
How Procure PV Systems?

- Product List catalog for standard systems
  - Easy comparisons of systems and suppliers
  - Standard system specifications and warranties (2-yr. system warranties)
  - All system fully integrated and pre-assembled for quick installation
  - Volume pricing-quantity discounts
  - Competitive bidding process already completed

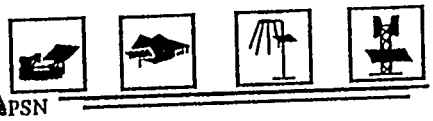


PSN

PV Services Guidebook

How Procure PV Systems?

- Contact PSN for non-standard systems
  - Load assessment / system feasibility
  - System design / specification
  - Competitive bid evaluation
  - Purchasing agreement



PSN

PV Services Guidebook

How Market PV Program?

- Strategic alliances
  - Other utilities
  - End user groups (NRCS, developers, Nature Conservancy, etc.)
  - Contractors / vendors
- Marketing "tools" (e.g., PV electricity brochure)
- Customer outreach / advertising
- Technology demonstrations

PSN

NEOS Corporation

Corporate Headquarters
3569 Mt. Diablo Boulevard, Suite 200
Lafayette, California 94549
510/284-3780, Fax: 510/284-3147

COMMERCIALIZATION OF PV-POWERED PUMPING SYSTEMS FOR USE IN UTILITY PV SERVICE PROGRAMS

PART 2 - Golden Photon System Installation Summaries

Final Report

Prepared by:

NEOS Corporation
165 South Union Boulevard, Suite 260
Lakewood, Colorado 80228

Prepared for:

U.S. Department of Energy
Golden Field Office
1617 Cole Blvd.
Golden, Colorado 80401

Contract No. DE-FC36-95GO10065

March 1997

CONTENTS

The information contained in this part summarizes each of the Golden Photon water pumping projects. As expected, each project had unique attributes relative to site selection, system procurement, system installation, and system monitoring including some project steps that were not implemented. In an effort to standardize the reporting of these projects, a report format was created that includes standard data tables as applicable. If a table was omitted or a dash was inserted into the table, the information was not applicable (or not available) for that utility report.

PROJECT INSTALLATION SUMMARIES

The first project task involved identifying utilities interested in project participation. This was accomplished by first sending project opportunity notices to all NRECA/RER members, as the National Rural Electric Cooperative Association (NRECA) co-sponsored the project installations. The following table shows the utilities that participated in the project.

Participant Name	Headquarters Location
Northwest Rural PPD (TS)	Hay Springs, NE
Arizona Electric Power Coop.	Benson, AZ
Johnson County Electric Coop. Assn.	Cleburne, TX
K.C. Electric Association (TS)	Hugo, CO
Wells Rural Electric Company	Wells, NV
Wheatbelt Public Power District (TS)	Sidney, NE
KEM Electric Cooperative	Linton, ND
Mor-Gran-Sou Electric Cooperative	Flasher, ND
American Samoa Power Authority	Pago Pago Am. Samoa, AS
Southwestern Public Service	Amarillo, TX
Nebraska Public Power District	Columbus, NE
Morgan County REA (TS)	Fort Morgan, CO
Powder River Energy	Sundance, WY
Riverton Valley Electric Assn. (TS)	Riverton, WY
Niobrara Electric Association (TS)	Lusk, WY
WestPlains Energy	Pueblo, CO
Wisconsin Public Service	Green Bay, WI

As is evident, all of the participating utilities were located in eight western and midwestern states except for one which was located in the South Pacific.

NORTHWEST RURAL PUBLIC POWER DISTRICT

Northwest Rural PPD (NRPPD) installed the first system in the NRECA/RER AC Pumping Project on November 29, 1994. NRPPD has an active PV pumping service program with more than twenty PV systems leased to customers. NRPPD is interested in adding AC pumping to their current line of pumping options.

Site Selection

The site that NRPPD selected for its installation was located on the Troester ranch near Marsland, Nebraska. The well was being used for livestock watering and was previously powered by a generator and a windmill combined by installing an AC pump below the windmill cylinder As shown in **Error! Reference source not found.**, the rancher requested 4285 gallons per day.

NRPPD Site Specifications

WATER USE		
Water Demand (gal/day)	End-Use	Storage (gal)
4000/summer	cattle	4,700 gallons

WATER SOURCE				
Description: well				
Static Level (ft)	Drawdown (ft)	Discharge Head (ft)	Total Head (ft)	Max. Rate (gal/
120	20	0	140	9

System Selection

NRPPD System Specifications

	Manufacturer	Model	Description	Cost
Water Works Power Supply	Golden Photon	S150-4	960 Watt AC pump power supply	$7,600
Pump	Goulds	10EJ07	3/4HP, 1 Ph, 230 VAC	existing

The system purchased included a 960 Watt array of Golden Photon CT4 modules, an SPC-2000 pump controller, and all above ground hardware and wiring. The pump and all downhole equipment was already in place at the site. The water output from the purchased system was estimated to be 1800 gallons per day at 140 feet of head with six sun hours per day.

System Installation

The pumping system was installed on the Troester ranch on November 29, 1994.

The system consisted of five MS-10 structures each holding ten CT-4 modules. The structures were arranged in two rows with the north row containing three structures and the south row containing two structure. Fencing was to be provided at a later time by the customer to keep the cattle away from the array. A connector was installed near the well head between the pump and the existing motor controller to allow the pump to be easily plugged into either the portable generator power source or the solar power source. The system installation took approximately four hours to complete.

(See attached photo.)

NRPPD PV-Powered Pumping System

Acceptance Test

NRPPD System Acceptance Test Results

Time	Plane of Array Insolation	PV Voltage	PV Current	DC Power (scaled to 1000 W/m²)	Total Head	Flow Rate
12:00 noon	1015 W/m²	343 volts	2.5 amps	845 Watts	140 feet	7.6 GPM

Monthly Test Reports

Shown in the table below is a summary of the monthly test reports.

NRPPD System Monthly Test Results

Date	Time	POA W/m²	PV Voltage	PV Current	Voc	Isc	Flow Rate	Notes
11/29/94	12:00 noon	1015	343 V	2.5 A	532V	--	7.6 GPM	
1/31/95	11:50 am	800	345 V	2.2 A	431 V	5.9 A	8.6 GPM	
3/1/95	11:25 am	500	320 V	1.7 A	426 V	3.4 A	5.5 GPM	
3/30/95	1:36 pm	700	--	--	418 V	3.5 A	--	
4/14/95	10:30 am	960	315 V	1.8 A	--	1.9 A	6.0 GPM	
6/6/95	3:00 pm	945	311 V	3.2 A	435	5.3	7.5 GPM	50 modules replaced

Customer Log

The customer was generally satisfied with the system performance. This site was not a primary water source and the system was not monitored for several months. However when the system was needed adequate water was provided.

System Maintenance and Modifications

The system performed near expectations on installation, however performance degraded significantly over the first four months of operation. This was blamed on a bad batch of modules which Golden Photon replaced on June 6, 1995. The system delivered the designed water output for the rest of the summer pumping season. The customer did supplement the water output for two weeks with the windmill because the customers needs exceeded the solar pumping systems capacity.

The system was changed from MS-10s to MS-12s during the spring of 1996.. The customer has sense put in a new pipeline system around the ranch and will no longer need to use this water source.

ARIZONA ELECTRIC POWER COOPERATIVE

Arizona Electric Power Cooperative (AEPCO) is a generation and transmission cooperative in Arizona with six member distribution cooperatives spread throughout the state. The AEPCO service area receives some of the highest solar insolation levels available in the United States and is thus ideally situated for PV applications. Mr. Gary Jurkin, Demand-Side Programs Manager with AEPCO was project manager for the project. Mr. Paul Brick assisted with the monitoring activities.

Site Selection

The site that AEPCO selected for its installation was located on the Davis ranch in Sulphur Springs Valley Electric Coop's (a member cooperative) service territory approximately 10 miles south of Tombstone, Arizona. The well site is situated in a valley of a high desert region. The well was being used for both livestock watering and for residential water and was powered by a generator system which powered the entire ranch as well as a neighboring ranch.

AEPCO Site Specifications

WATER USE		
Water Demand (gal/day)	End-Use	Storage (gal)
4285/summer	cattle/residential	26,000/1,500

WATER SOURCE				
Description: well				
Static Level (ft)	Drawdown (ft)	Discharge Head (ft)	Total Head (ft)	Max. Rate (gal/
41	1	15	55	10

System Selection

AEPCO System Specifications

	Manufacturer	Model	Description	Cost
Water Works Power Supply	Golden Photon	S75-2	480 Watt AC pump power supply	$4,550
Pump	AeroMotor	A+8-33	1/3HP, 1 Ph, 230 VAC	existing

The system purchased included a 480 Watt array of Golden Photon CT4 modules, an SPC-2000 pump controller, and all above ground hardware and wiring. The pump and all downhole equipment was already in place at the site. The water output from the purchased system was estimated to produce 1430 gallons per day at 60 feet of head with six sun hours per day.

System Installation

The pumping system was installed on the Davis ranch on December 13, 1994 as part of the installation workshop which was attended by approximately 15 people. Four utilities were represented including: Arizona Electric Power Cooperative, Graham County Electric, Tri Co Electric, and Sulfur Springs Valley Electric Cooperative. As shown in **Error! Reference source not found.**, the PV array was mounted near the well which is just below the windmill tower. The smaller elevated tank is the storage for the residential water system while the larger tank on the ground is the storage for the livestock watering system.

The system consisted of three MS-10 structures each holding ten CT-4 modules. The structures were arranged in two rows with the north row containing two structures and the south row containing one structure. Fencing was to be provided at a later time by the customer to keep the cattle away from the array. A connector was installed near the well head between the pump and the existing motor controller to allow the pump to be easily plugged into either the existing generator power source or the solar power source. The system installation took approximately three hours to complete. A datalogger was installed on this system for the first two months of operation.

(See attached photo.)

AEPCO's PV-Powered Pumping System

Acceptance Test

AEPCO System Acceptance Test Results

Time	Plane of Array Insolation	PV Voltage	PV Current	DC Power (scaled to 1000 W/m²)	Total Head	Flow Rate
1:40 pm	950 W/m²	352 volts	1.6 amps	593 Watts	55 feet	9.7 GPM

The array provided well over the 480 Watt nominal system rating and a flow rate which would well exceed the estimated daily output.

Monthly Test Reports

A total of 16 test reports were provided by AEPCO between December of 1994 and June of 1996. Shown below is a summary of the monthly test reports.

AEPCO System Monthly Test Results

Date	Time	POA W/m²	PV Voltage	PV Current	Voc	Isc	Flow Rate	Notes
12/13/94	1:40 pm	950	352 V	1.6 A	421 V	3.2 A	9.7 GPM	
12/19/94	10:45 am	980	350 V	1.6 A	414 V	--	9.8 GPM	
2/27/95	11:30 am	1109	321 V	0.7 A	342 V	3.5 A	5.7 GPM	
3/10/95	11:00 am	950	298 V	0.9	334 V	3.1 A	--	UNDERSPEED error
3/24/95								All modules were changed by G Photon
4/6/95	1:20 pm	1000	345 V	1.1 A	410 V	3.1 A	good flow	small crack in 1 module
5/4/95	11:55 am	975	350 V	1.2 A	405 V	3.5 A	good flow	
6/16/95	1:00 pm	variable	--	--	396 V	1.5 A	--	cloudy
8/24/95	11:45 am	875	--	--	371 V	3.6 A	--	replaced module; well water lev dropped significantly
10/9/95	11:45 am	1000	310 V	1.0 A	364 V	3.5 A	low flow	
11/17/95	12:10 pm	800	--	--	366 V	3.0 A	--	dry well
12/28/95	1:45 pm	800	--	--	449 V	3.0 A	good flow	system moved (39' head); MS-12 existing 1.0HP pump
1/25/96	10:10 am	760	344 V	1.5 A	441 V	3.1 A	good flow	
2/19/95	1:05 pm	750	--	--	423 V	3.0 A	good flow	
3/1/96	2:30 pm	600	--	--	397 V	2.0 A	--	
6/8/96	10:00 am	500	--	--	397 V	2.5 A	--	changed pump to 1/3 HP (but did not reset memory)
6/10/96	11:30 am	650	318 V	1.0	406 V	3.1 A	good flow	reset controller memory
6/14/96	11:45 am	150	--	--	379 v	0.8 A	--	cloudy

Customer Log Book

The customer log was not used for this utility.

System Maintenance and Modifications

The system performed well above expectations on installation, however performance degraded significantly over the first three months of operation. This was blamed on a bad batch of modules which Golden Photon promptly replaced. The system operated fine for the next several months until the well went dry. A new well site was found near by with a total pumping head of 39 feet. Golden Photon was in the process of upgrading all systems from MS-10s to MS-12s and coordinated this change with the system installation at the new site. This was done on December 28, 1995. The existing 1.0 HP pump was used for six months until June 8, 1996 when a 1/3 HP pump was installed.

JOHNSON COUNTY ELECTRIC COOPERATIVE

Johnson County Electric Coop. installed the third system in the NRECA/RER AC Pumping Project. This system is Johnson County's first experience with PV pumping. They hoped to gain some experience on PV AC pumping and pass the lessons learned on to their customers.

Site Selection

The site that Johnson County selected for its installation was located on the Z Bar ranch near Granbury, Texas. The well was being used for livestock watering and was previously powered by a generator. As shown in Table, the rancher requested 2400 gallons per day in the summer. This is the only site in the NRECA/RER project that had system with a total head greater than 200 feet.

Johnson County Site Specifications

WATER USE		
Water Demand (gal/day)	End-Use	Storage (gal)
2400/summer	cattle	4,000 gallons

WATER SOURCE				
Description: well				
Static Level (ft)	Drawdown (ft)	Discharge Head (ft)	Total Head (ft)	Max. Rate (gal/
222	0	0	222	10

System Selection

Johnson County System Specifications

	Manufacturer	Model	Description	Cost
Water Works Power Supply	Golden Photon	S250-5	1200 Watt AC pump power supply	$9,125

Pump	Grundfos	10S0712	3/4HP, 1 Ph, 230VAC	existing

The system purchased included a 1200 Watt array of Golden Photon CT4 modules, an SPC-2000 pump controller, and all above ground hardware and wiring. The pump and all downhole equipment was already in place at the site.

The water output from the purchased system was estimated to produce 1400 gallons per day at 222 feet of head with six sun hours per day.

System Installation

The pumping system was installed on the Z Bar ranch on March 8, 1995. The system consisted of eight MS-10 structures each holding ten CT-4 modules. The structures were arranged in two rows with each row containing four structures. Fencing was to be provided at a later time by the customer to keep the cattle away from the array. A connector was installed near the well head between the pump and the existing motor controller to allow the pump to be easily plugged into either the portable generator power source or the solar power source. The system installation took approximately four hours to complete.

When the system was turned on for the first time, one module started arcing between the edge of the glass and the module frame. This string was then removed from the circuit and the acceptance test was completed with seven of the eight strings being active.

(See attached photo.)

Johnson County PV-Powered Pumping System

Acceptance Test

Johnson County System Acceptance Test Results

Time	Plane of Array Insolation	PV Voltage	PV Current	DC Power (scaled to 1000 W/m²)	Total Head	Flow Rate
1:50 pm	980 W/m²	350 volts	3.3 amps	1,179 Watts	220 feet	7.5 GPM

Monthly Test Reports

Johnson County System Monthly Test Results

Date	Time	POA W/m²	PV Voltage	PV Current	Voc	Isc	Flow Rate	Notes

3/8/95	1:50 pm	980	350 V	3.3 A	430 V	8.0 A	7.5 GPM	Installation; 7 active strings
3/23/95	10:00 am	--	345 V	2.3 A	405 V	5.25 A	3.6 GPM	8 strings; new controller chip
4/10/95	--	--	--	--	302 V	3.4 A	--	overcast
4/20/95	11:30 am	--	--	--	402 V	7.0 A	--	underspeed error
4/26/95	--	--	--	--	405 V	7.4 A	--	underspeed/overload errors
5/18/95								AV reset controller memory
6/2/95	--	--	--	--	--	--	3.5 GPM	customer reports low output
8/10/95	11:00 am	750	313 V	1.9 A	360 V	6.9 A	0	
10/17/95	--	--	--	--	--	--	5.0 GPM	new pump - 5S10-22; MS-12 upgrade
5/7/96	--	975	349 V	2.2 A	424 V	8.6 A	3.9 GPM	

Customer Log

The customer was not satisfied with the system as it was not meeting his needs during the first pumping season. Golden Photon wanted to change the pump to a 3 phase unit but the customer would not be able to use his generator then and did not trust the PV system enough to be without a backup means of pumping water. The pump was changed to a 1 HP single phase unit with higher head capabilities the second pumping season and the customer is now satisfied with the system.

System Maintenance and Modifications

Two modules were defective on installation and were replaced two weeks after installation. One module had a small crack in the glass and one module had a ground fault condition. The system went into an underspeed and overspeed error condition repeatedly and unexpectedly shortly after system commissioning. This problem continued as long as the original single phase pump was installed which included the entire first pumping season. The MS-10s were upgraded to MS-12s, and the pump was changed to a larger pump with higher head capability in the fall of 1995. This seemed to alleviate the nuisance faults that had been occurring regularly.

KC ELECTRIC ASSOCIATION

Site Selection

The site that KC selected for its installation was located on the Rhodes ranch near Burlington, Colorado. The well was being used for livestock watering and was previously powered by a windmill. As shown in the table, the rancher requested 2100 gallons per day in the spring, 2860 GPD in the summer, and 1700 GPD in the fall.

KC Site Specifications

WATER USE		
Water Demand (gal/day)	End-Use	Storage (gal)
2100/spring;2860/summer;1700 fa	cattle	13,600 gallons

WATER SOURCE				
Description: well				
Static Level (ft)	Drawdown (ft)	Discharge Head (ft)	Total Head (ft)	Max. Rate (gal/
147	4	2	153	12

System Selection

KC System Specifications

	Manufacturer	Model	Description	Cost
Water Works Power Supply	Golden Photon	S150-4	960 Watt AC pump power supply	$7,600
Pump	Red Jacket	75CNS1-CNS12	3/4HP, 1 Ph, 230 VAC	existing

The system purchased included a 960 Watt array of Golden Photon CT4 modules, an SPC-2000 pump controller, and all above ground hardware and wiring. The pump and all downhole equipment was previously installed by the customer.

The water output from the purchased system was estimated to produce 2200 gallons per day at 150 feet of head with six sun hours per day.

System Installation

The pumping system was installed on the Rhodes ranch on March 28, 1995. The system consisted of six MS-10 structures each holding ten CT-4 modules. The structures were arranged in two rows. Fencing was to be provided at a later time by the customer to keep the cattle away from the array. The system installation took approximately four hours to complete. The weather was very cloudy during the installation so no acceptance testing was done during the installation. The acceptance test was completed on May 4, 1995 on a return visit to the site.

(See attached photo.)

KC PV-Powered Pumping System

Acceptance Test

KC System Acceptance Test Results

Time	Plane of Array Insolation	PV Voltage	PV Current	DC Power (scaled to 1000 W/m²)	Total Head	Flow Rate
1:03 pm	925 W/m²	336 volts	2.4 amps	854 Watts	120 feet	6.2 GPM

Monthly Test Reports

KC System Monthly Test Results

Date	Time	POA W/m²	PV Voltage	PV Current	Voc	Isc	Flow Rate	Notes
5/4/95	1:03 pm	925	336 V	2.4 A	--	--	6.2 GPM	
5/4/95	--	1010	--	--	406 V	7.0 A		
5/5/95	12:30	900	333 V	2.4 A	--	--	5.7 GPM	changed low freq. cut out to 33 I
6/12/95	9:45 am	--	380 V	2.4 A	377 V	4.4 A	--	
6/13/95	12:55 pm	1000	327 V	2.4 A	--	--	5.4 GPM	new controller chip
6/20/95	1:00 pm	900	321 V	2.4 A	379 V	--	5.0 GPM	
7/11/95	12:00 noon	825	--	--	--	--	4.5 GPM	
7/25/95	12:30 pm	1004	287 V	3.3 A	--	--	8.7 GPM	12 new modules; 3 Ph motor
7/25/95	--	970	--	--	393 V	6.3 A	--	
8/22/95	--	850	--	--	--	--	8.0 GPM	
6/18/96	--	--	--	--	--	--	--	report of large spots on modules
6/19/96	1:50 pm	947	295 V	3.4 A	424 V	6.4 A	8.6 GPM	8 degraded modules replaced

Customer Log

The system was not producing enough water for the customer as long a the original single phase pump was installed. Once the three phase pump was installed the customer was very happy with the performance. The customer was concerned about hail breaking the modules regularly since large hail is common in this area.

System Maintenance and Modifications

This system had several site visits by KC Electric, NEOS, and Golden Photon personnel within the first four months of operation trying to get the system to operate properly. When the system would pump, the output would be as expected however the controller would shut down with faults regularly, which severely reduced the daily water output of the system. On July 25,

1995 the pump motor was changed to a three phase configuration. The controller then operated flawlessly and produced more water than would have been provided with the single phase motor.

A hail storm broke 7 of the 60 modules in mid-July of 1995. The weather service reported 1 inch hail in the area and 1 1/4" hail in a near by town. The modules were replaced by Golden Photon under warranty however they stated this type of damage should normally be covered by the customers insurance as was done with Morgan County Electric (see Morgan County Electric below).

Several modules developed one to three inch discolored spots on the cells. These modules along with several other weak modules were replaced on June 19, 1996, bringing the system output back up to its rated output.

WELLS RURAL ELECTRIC COMPANY

Site Selection

The site that Wells Rural Electric selected for its installation was located on the Tabor Creek Cattle Co. near Deeth, Nevada. The well was being used for livestock watering and was previously powered by a generator.

Wells Rural Electric Site Specifications

WATER USE		
Water Demand (gal/day)	End-Use	Storage (gal)
6000/fall	cattle	10,000 gallons

WATER SOURCE				
Description: well				
Static Level (ft)	Draw down (ft)	Discharge Head (ft)	Total Head (ft)	Max. Rate (gal/
9	9	10	29	10

System Selection

Wells Rural Electric System Specifications

	Manufacturer	Model	Description	Cost
Water Works Power Supply	Golden Photon	S25-2	480 Watt AC pump power supply	$4,625
Pump	Goulds	10EJ05412	1/2HP, 1 Ph, 230VAC	existing

The system purchased included a 480 Watt array of Golden Photon CT4 modules, an SPC-2000 pump controller, and all above ground hardware and wiring. The pump and all downhole equipment was previously installed by the customer.

The water output from the purchased system was estimated to produce 2500 gallons per day at 29 feet of head with six sun hours per day.

System Installation

The pumping system was installed on the Tabor Creek Cattle Company ranch on April 5, 1995. The system consisted of three MS-10 structures each holding ten CT-4 modules. The structures were arranged in one row. Cattle were not expected to be in this pasture so no fencing was installed.

(See attached photo.)

Wells Rural Electric PV-Powered Pumping System

Acceptance Test

Wells Rural Electric System Acceptance Test Results

Time	Plane of Array Insolation	PV Voltage	PV Current	DC Power (scaled to 1000 W/m²)	Total Head	Flow Rate
1:12 pm	932 W/m²	341 volts	2.3 amps	468 Watts	13 feet	7.5 GPM

Monthly Test Reports

Wells Rural Electric System Monthly Test Results

Date	Time	POA W/m²	PV Voltage	PV Current	Voc	Isc	Flow Rate	Notes
4/5/95	1:12 pm	931	341 V	2.3 A	--	--	7.5 GPM	
4/5/95	1:12 pm	585	--	--	413 V	1.9 A	--	
4/27/95	2:35 pm	--	350 V	1.4 A	413 V	2.2 A		
7/20/95	--	--	--	--	372 V	3.3 A	--	2 broken modules due to cows
9/7/95	3:00 pm	--	--	--	363 V	3.2 A		
9/20/95	--	850	298 V	1.1 A	360 V	3.3 A	3.9 GPM	GPI replaced broken modules; flow restricter installed

Customer Log

The customer has not used the system on a regular basis and no customer reports were received.

System Maintenance and Modifications

Cattle were inadvertently let into the pasture with the array. The structures were turned about 90 degrees, one module was broken, and the AC conduit was damaged. The broken module was replaced and the system was returned to service.

The system was upgraded from MS-10s to MS-12s, but no data is available after the upgrade.

WHEAT BELT PUBLIC POWER DISTRICT

Site Selection

The site that Wheat Belt selected for its installation was located on the Lease Cattle Co. near Bridgeport, Nebraska. The well was being used for livestock watering and was previously powered by a windmill.

Wheat Belt Site Specifications

WATER USE		
Water Demand (gal/day)	End-Use	Storage (gal)
5000/summer-fall	cattle	12,000 gallons

WATER SOURCE				
Description: well				
Static Level (ft)	Draw down (ft)	Discharge Head (ft)	Total Head (ft)	Max. Rate (gal/
25	0	0	25	15

System Selection

Wheat Belt System Specifications

	Manufacturer	Model	Description	Cost
Water Works Power Supply	Golden Photon	S25-2	480 Watt AC pump power supply	$4,625
Pump	Grundfos	16S0505	1/2HP, 1 Ph, 230 VAC	--

The system purchased included a 480 Watt array of Golden Photon CT4 modules, an SPC-2000 pump controller, and all above ground hardware and wiring. The pump and all down hole equipment supplied by the customer.

The water output from the purchased system was estimated to produce 5000 gallons per day at 25 feet of head with six sun hours per day.

System Installation

The pumping system was installed on the Lease Cattle Company ranch on April 7, 1995. The system consisted of four MS-10 structures each holding ten CT-4 modules. The structures were arranged in two rows of two structures each. Fencing was provided by the customer to keep cattle away from the array.

Installation was delayed when it was discovered that the customer had inadvertently installed a 2-wire motor instead of the required 3 wire motor. Utility personnel made a run to the near by town of Scottsbluff and picked up the required pump. After installing this new pump, the system was fully operational.

This exercise proved the local availability and benefits of using standard AC pumps. Ron Pate of Sandia National Labs, attended the installation. The benefits of the AC pumping concept where the utilities provide the power and the customers provide and maintain all down hole equipment were made very evident to Sandia at this installation.

(See attached photo.)

Wheat Belt PV-Powered Pumping System

Acceptance Test

Wheat Belt System Acceptance Test Results

Time	Plane of Array Insolation	PV Voltage	PV Current	DC Power (scaled to 1000 W/m²)	Total Head	Flow Rate
2:45 pm	820 W/m²	337 volts	1.6 amps	658 Watts	25 feet	7.1 GPM

Monthly Test Reports

Wheat Belt System Monthly Test Results

Date	Time	POA W/m²	PV Voltage	PV Current	Voc	Isc	Flow Rate	Notes
4/7/95	2:45 pm	820	337 V	1.6 A	--	--	7.1 GPM	
4/7/95	2:45 pm	982	--	--	410 V	4.4 A	--	
6/6/95	1:00 pm	875	330 V	1.7 A	398 V	--	7.9 GPM	
7/10/95	1:15 pm	900	303 V	1.7 A	370 V	4.0 A	5.6 GPM	
8/8/95	--	425	325 V	--	339 V	0.9 A	0	cloudy
9/5/95	12:00 noon	950	295 V	--	363 V	4.2 A	--	OVERLOAD error

9/13/95	2:00 pm	900	299 V	1.4 A	362 V	3.6 A	5.5 GPM	OVERLOAD error
9/22/95	12:00 noon	940	295 V	1.8 A	368 V	3.9 A	6.8 GPM	OVERLOAD error; not workin
11/2/95								upgrade the 4 MS-10s to MS-12
11/15/95	12:30 pm	750	351 V	1.7 A	452 V	3.7 A	13 GPM	
5/14/96	12:00 noon	900	314 V	1.6 A	414 V	4.5 A	10 GPM	
6/5/96								re-installed: 6) MS-12s, 280', 3
6/5/96	12:0 noon	875	335 V	3.0 A	508 V	6.6 A	4.0 GPM	
6/10/96	12:30 pm	925	328 V	2.8 A	476 V	6.4 A	4.0 GPM	
7/11/96	2:00 pm	800	315 V	2.5 A	494 V	6.1 A	3.0 GPM	
8/1/96	1:00 pm	900	324 V	2.7 A	468 V	6.7 A	3.5 GPM	

Customer Log

The first customer was happy with the system for the first several months of operation. The cattle were then removed from that pasture and the system was not needed for several months, however the customer log indicated the system was not working properly on three occasions. Cattle were to be put back on the pasture for three weeks in October 1995, but the system could not be fixed in time. The system was not needed any more at this site.

The second customer, who received the system June 5. 1996, has had the system operating for two months with no problems and is very satisfied with the system.

System Maintenance and Modifications

When the system showed signs of problems in September 1995, Golden Photon visited the site but was not able to fix the system before the cattle were removed in October, 1995. The system was then upgraded on November 2, 1995 from four MS-10s to four MS-12s.

The system was re-installed with an additional two MS-12 structures on June 5, 1996. The expanded system was installed on a 280 foot well and a three phase pump motor was used.

KEM ELECTRIC COOPERATIVE

Site Selection

The site that KEM Electric selected for its installation was located on the Haibeck ranch near Steele, North Dakota. The well is new and is in a pasture with another water source.

KEM Site Specifications

WATER USE		
Water Demand (gal/day)	End-Use	Storage (gal)
1000/summer	cattle	3,500 gallons

WATER SOURCE				
Description: well				
Static Level (ft)	Draw down (ft)	Discharge Head (ft)	Total Head (ft)	Max. Rate (gal/
38	7	3	48	10

System Selection

KEM System Specifications

	Manufacturer	Model	Description	Cost
Water Works Power Supply	Golden Photon	S50-2	480 Watt AC pump power supply	$4,625
Pump	Grundfos	16S0505	1/2HP, 1 Ph, 230 VAC	--

The system purchased included a 480 Watt array of Golden Photon CT4 modules, an SPC-2000 pump controller, and all above ground hardware and wiring. The pump and all down hole equipment was supplied by the customer.

The water output from the purchased system was estimated to produce 3000 gallons per day at 50 feet of head with six sun hours per day.

System Installation

The pumping system was installed on the Haibeck ranch on April 26, 1995. As shown in **Error! Reference source not found.**, the PV array was installed in the pasture next to the well.

The system consisted of three MS-10 structures each holding ten CT-4 modules. The structures were arranged in one row. Fencing was to be provided at a later time by the customer to keep the cattle away from the array. The system installation took approximately three hours to complete.

(See attached photo.)

KEM PV-Powered Pumping System

Acceptance Test

KEM System Acceptance Test Results

Time	Plane of Array Insolation	PV Voltage	PV Current	DC Power (scaled to 1000 W/m²)	Total Head	Flow Rate

2:05 pm	400 W/m²	300 volts	0.9 amps	--	45 feet	3.5 GPM

Monthly Test Reports

KEM System Monthly Test Results

Date	Time	POA W/m²	PV Voltage	PV Current	Voc	Isc	Flow Rate	Notes
4/26/95	1:40 pm	1200	--	--	--	--	16.6 GPM	cloud enhanced sun
4/26/95	2:05 pm	400	300 V	0.9 A	--	--	3.5 GPM	
5/8/95	--	--	--	--	--	--	--	system not working
5/22/95	--	--	--	--	--	--	--	motor failed, open start winding new pump: 10 GPM with restric
5/23/95	12:30 pm	--	320 V	0.7 A	425 V	--	8 GPM	
6/27/95	11:45 am	--	310 V	--	370 V	--	6 GPM	
7/31/95	12:30 pm	635	290 V	--	361 V	--	5 GPM	
9/4/95	2:45 pm	950	316 V	--	378 V	2.3 A	5.5 GPM	
10/10/95	--	--	--	--	--	--	--	upgrade to MS-12; failed controller
8/6/96	--	--	--	--	--	--	--	GPI replaced controller

Customer Log

The customer was very happy with the system for the four months that it was operational.

System Maintenance and Modifications

The system failed one week after installation. The failure was initially blamed on the controller and a new controller was sent to KEM. It was then determined that the failure was in the pump motor and not the controller. The new controller was left in and the original controller was sent back to GPI. The motor had an open lead on the start winding and was replaced under warranty from Franklin Electric.

The system was upgraded from three MS-10s to three MS-12s in the fall of 1995. During this modification the controller failed. Golden Photon went to the site on August 6, 1996 to get the system operational again.

MOR-GRAN-SOU ELECTRIC COOPERATIVE

Site Selection

The site that Mor-Gran-Sou selected for its installation was located on the Dahners ranch near Carson, North Dakota. The well was being used for livestock watering and was previously powered by a windmill. The rancher requested 1440 gallons per day in the spring, summer, and fall.

Mor-Gran-Sou Site Specifications

WATER USE		
Water Demand (gal/day)	End-Use	Storage (gal)
1440/spring-fall	cattle	1,600 gallons

WATER SOURCE				
Description: well				
Static Level (ft)	Draw down (ft)	Discharge Head (ft)	Total Head (ft)	Max. Rate (gal/
25	0	0	25	6

System Selection

Mor-Gran-Sou System Specifications

	Manufacturer	Model	Description	Cost
Water Works Power Supply	Golden Photon	S25-2	480 Watt AC pump power supply	$4,625
Pump	Grundfos	10S0509	1/2HP, 1 Ph, 230 VAC	existing

The system purchased included a 480 Watt array of Golden Photon CT4 modules, an SPC-2000 pump controller, and all above ground hardware and wiring. The pump and all down hole equipment supplied by the customer.

The water output from the purchased system was estimated to produce 2700 gallons per day at 25 feet of head with six sun hours per day.

System Installation

The pumping system was installed on the Dahners ranch on April 27, 1995. The system consisted of three MS-10 structures each holding ten CT-4 modules. The structures were arranged in one row. Fencing was to be provided at a later time by the customer to keep the cattle away from the array. The windmill was left in place as a backup power source. The system installation took approximately three hours to complete.

(See attached photo.)

Mor-Gran-Sou PV-Powered Pumping System

Acceptance Test

Mor-Gran-Sou System Acceptance Test Results

Time	Plane of Array Insolation	PV Voltage	PV Current	DC Power (scaled to 1000 W/m²)	Total Head	Flow Rate
12:00 noon	1000 W/m²	340 volts	2.3 amps	782 Watts	27 feet	12.0 GPM

Monthly Test Reports

Mor-Gran-Sou System Monthly Test Results

Date	Time	POA W/m²	PV Voltage	PV Current	Voc	Isc	Flow Rate	Notes
4/27/95	12:00 noon	1000	340 V	2.3 A	430 V	3.3 A	12.0 GPM	
5/31/95	2:30 pm	1000	330 V	--	402 V	2.5 A	9.7 GPM	
6/14/95	3:00 pm	--	324 V	2.5 A	398 V	2.6 A	9.1 GPM	
7/11/95	1:30 pm	1000	319 V	0.9 A	382 V	3.0 A	7.9 GPM	

Customer Log

The customer was very happy with the system. The system has worked flawlessly and has provided all the water needed at this site.

System Maintenance and Modifications

The only maintenance or modification done to this system was to upgrade from the MS-10s to the MS-12s.

AMERICAN SAMOA POWER AUTHORITY

Site Selection

The site that American Samoa Power Authority (ASPA) selected for its installation was located on the small island of Aunuu. Aunuu is an island just over 1 mile off the coast of the main

island, Tutuila, with just over 1 square mile of land area. The water supply for the island consists of a cistern with a water collection system, an elevated storage tank, a pump system to move water from the cistern to the storage tank, and the associated pipe lines between the tanks and to distribute the water. The cistern is only 400 yards from the coast and the air contains a salty mist most of the time making for a very corrosive environment.

The solar powered pump will run in parallel with two other utility line (generator) powered pumps. This site will serve as a demonstration of the systems capabilities to determine if the system could then be moved to Swains Island, which is a very remote island with access only twice per year, to serve the same community water supply function.

Samoa Site Specifications

WATER USE		
Water Demand (gal/day)	End-Use	Storage (gal)
part of 35,000 GPD	community water supply	65,000 gallons

WATER SOURCE				
Description: well				
Static Level (ft)	Draw down (ft)	Discharge Head (ft)	Total Head (ft)	Max. Rate (gal/
3	0	130	140	25

System Selection

Samoa System Specifications

	Manufacturer	Model	Description	Cost
Water Works Power Supply	Golden Photon	S25-2	480 Watt AC pump power supply	$4,625
Pump	Grundfos	16S0505	1/2HP, 1 Ph, 230 VAC	--

The system purchased included a 480 Watt array of Golden Photon CT4 modules, an SPC-2000 pump controller, and all above ground hardware and wiring. The pump and all piping equipment was provided and installed by ASPA.

The water output from the purchased system was estimated to produce approximately 1,000 gallons per day at 150 feet of head with six sun hours per day.

System Installation

The pumping system was installed on Aunuu on May 11, 1995. The system consisted of three MS-10 structures each holding ten CT-4 modules. The structures were arranged in one row. Fencing was not needed at this site. The system installation took less than three hours to complete once all equipment was on site, however it took until 1:00pm to get the equipment on

site because of the difficult logistics of transporting the system to the site. Transporting the system started with trucking the system to a dock, loading it onto a boat with a large boom truck; and driving the boat to Aunuu. Once at the dock at Aunuu it was determined that the water was too rough to dock, so the system was unpacked in the boat and the pieces were handed across a human chain and into the back of a pickup truck. The truck then made two trips to the installation site to unload the system. Considering the required logistics, all went well. The acceptance test was completed the following day (May 4, 1995) during a return visit to the site.

(See attached photo.)

American Samoa PV-Powered Pumping System

Acceptance Test

Samoa System Acceptance Test Results

Time	Plane of Array Insolation	PV Voltage	PV Current	DC Power (scaled to 1000 W/m²)	Total Head	Flow Rate
11:50 am	840 W/m²	330 volts	1.3 amps	511 Watts	75 feet	5.0 GPM

Monthly Test Reports

Samoa System Monthly Test Results

Date	Time	POA W/m²	PV Voltage	PV Current	Voc	Isc	Flow Rate	Notes
5/11/95	11:50 am	840	330 V	1.3 A	402 V	3.1 A	5.0 GPM	

Limited test reports due to vandalism (see below).

Customer Log

Customer logs were not used for this site since the utility was the customer.

System Maintenance and Modifications

This system was vandalized shortly after installation. Several modules were broken from hits with rocks. The modules were never replaced as it was feared they would be broken again and the system has not been used since.

A report was given on the visible corrosion as of July 1996, just over one year of being in a very corrosive environment. The only component which is failing is the controller enclosure. It is estimated it would only last one more year before being rusted completely through. The junction boxes, wire nuts, and uni-strut are not showing any significant signs of corrosion.

SOUTHWESTERN PUBLIC SERVICE COMPANY

Site Selection

The site that Southwestern Public Service (SPS) selected for its installation was a USDA Agricultural Research Service test facility near Bushland, Texas. SPS wanted to gain experience and collect data on the system before offering it to their customers.

SPS Site Specifications

WATER USE		
Water Demand (gal/day)	End-Use	Storage (gal)
0	test facility	0 gallons

WATER SOURCE				
Description: sump				
Static Level (ft)	Draw down (ft)	Discharge Head (ft)	Total Head (ft)	Max. Rate (gal/
NA	0	NA	150 (adjustable)	NA

System Selection

SPS System Specifications

	Manufacturer	Model	Description	Cost
Water Works Power Supply	Golden Photon	E150S-3	720 Watt AC pump power supply	$7,600
Pump	Grundfos	10S0712	3/4HP, 1 Ph, 230 VAC	existing

The system purchased included a 720 Watt array of Golden Photon CT4 modules, an SPC-2000 pump controller, and all above ground hardware and wiring. The pump and all test equipment was supplied by the USDA.

The water output from the purchased system was estimated to produce 1400 gallons per day at 150 feet of head with six sun hours per day.

System Installation

The pumping system was installed on the USAD test facility on June 13, 1995. The system consisted of five MS-10 structures each holding ten CT-4 modules. The structures were arranged in a single row. No fencing was needed for this installation. The system installation took approximately four hours to complete.

(See attached photo.)

SPS PV-Powered Pumping System

Acceptance Test

SPS System Acceptance Test Results

Time	Plane of Array Insolation	PV Voltage	PV Current	DC Power (scaled to 1000 W/m²)	Total Head	Flow Rate
2:05 pm	1020 W/m²	340 volts	2.5 amps	823 Watts	150 feet	8.0 GPM

Monthly Test Reports

SPS System Monthly Test Results

Date	Time	POA W/m²	PV Voltage	PV Current	Voc	Isc	Flow Rate	Notes
6/13/95	2:05 pm	1020	340 V	2.5 A	--	--	8.0 GPM	150'
6/13/95	--	990	336 V	2.4 A	401 V	6.0 A	--	150'
7/14/95	2:00 pm	1283	320 V	2.1 A	383 V	5.6 A	9.9 GPM	150'
8/9/95	11:00 am	1108	303 V	1.9 A	--	--	6.2 GPM	139'; reduced system output
9/28/95	2:00 pm	1061	306 V	1.6 A	351 V	5.1 A	3.4 GPM	139'
10/25/95	2:30 pm	970	305 V	1.9 A	342 V	4.8 A	1.9 GPM	127'
11/17/95	12:00 noon	900	322 V	2.0 A	428 V	4.7 A	6.0 GPM	upgrade MS-10s to MS-12s
11/30/95	12:00 noon	1060	--	--	--	--	6.5 GPM	
12/8/95	3:00 pm	794	--	--	--	--	5.3 GPM	
12/11/95	1:00 pm	993	358 V	1.7 A	412 V	4.3 A	5.3 GPM	139'; degradation concerns
12/11/95	2:30 pm	859	--	--	--	--	5.8 GPM	
1/3/96	3:20 pm	800	--	--	--	--	5.5 GPM	
1/11/96	12:50 pm	1219	329 V	2.2 A	417 V	5.3 A	7.4 GPM	139'

2/7/96	1:30 pm	1233	349 V	1.8 A	408 V	4.6 A	9.3 GPM	46'
2/28/96	1:30 pm	1100	320 V	1.2 A	405 V	4.3 A	5.5 GPM	139'
3/21/96	10:13 am	881	--	--	--	--	3.0 GPM	139'; see below
3/25/96	11:30 am	888	--	--	--	--	3.2 GPM	139', see below
4/2/96	2:30 pm	975	--	--	--	--	3.1 GPM	139', see below
4/9/96	1:30 pm	1024	317 V	1.9 A	398 V	5.8 A	5.9 GPM	139'; found 1 string not connecte
4/19/96	--	--	--	--	--	--	--	replace a bad module
4/30/96	2:30 pm	1080	317 V	2.2 A	401 V	5.6 A	6.8 GPM	
6/6/96	1:00 pm	924	317 V	1.8 A	401 V	5.0 A	5.3 GPM	
7/17/96	11:05 am	741	302 V	1.7 A	388 V	4.6 A	3.5 GPM	

Customer Log

Customer reports were filled out by the USDA and are included in the monthly test results.

System Maintenance and Modifications

The system performance was fine at the acceptance test however the performance degraded over the first five months of operation. The system was upgraded from five MS-10 structures to five MS-12 structures on November 17, 1995 which brought the system performance back up near that measured during the acceptance test. While the Voc continued to decline some, the system output appears to have stabilized.

NEBRASKA PUBLIC POWER DISTRICT

Site Selection

The site that Nebraska PPD selected for its installation was located on the Liss ranch near Duncan, Nebraska.

Nebraska PPD Site Specifications

WATER USE		
Water Demand (gal/day)	End-Use	Storage (gal)
600/summer	cattle	1,500 gallons

WATER SOURCE				
Description: well				
Static Level (ft)	Draw down (ft)	Discharge Head (ft)	Total Head (ft)	Max. Rate (gal/

4	1	0	5	--

System Selection

Nebraska PPD System Specifications

	Manufacturer	Model	Description	Cost
Water Works Power Supply	Golden Photon	E25S-2	480 Watt AC pump power supply	$4,625
Pump	Grundfos	10S0306	1/3HP, 1 Ph, 230 VAC	--

The system purchased included a 480 Watt array of Golden Photon CT4 modules, an SPC-2000 pump controller, and all above ground hardware and wiring. The pump and all down hole equipment was supplied by the customer.

The water output from the purchased system was estimated to produce 3000 gallons per day at 25 feet of head with six sun hours per day.

System Installation

The pumping system was installed on the Liss ranch on June 21, 1995. As shown in **Error! Reference source not found.**, the PV array was installed inside a cattle loading chute. The intended use is for summer time only, any other seasonal use would require moving some fence structure which would cause shading of the array. The installation went well in general, however, the well used had a very poor recovery rate and could not keep up with the system pumping grate. In addition, the well was full of sand and causing the system to pump very sandy water. Due to this situation, no pump tests could be performed. The following acceptance test form only indicates an unloaded test.

The system consisted of three MS-10 structures each holding ten CT-4 modules. The structures were arranged in two rows. The system installation took approximately four hours to complete.

(See attached photo.)

Nebraska PPD PV-Powered Pumping System

Acceptance Test

Nebraska PPD System Acceptance Test Results

Time	Plane of Array Insolation	PV Voltage	PV Current	DC Power (scaled to 1000 W/m²)	Total Head	Flow Rate
1:45 pm	991 W/m²	--	--	--	--	--

Monthly Test Reports

Nebraska PPD System Monthly Test Results

Date	Time	POA W/m²	PV Voltage	PV Current	Voc	Isc	Flow Rate	Notes
6/21/95	1:45 pm	991	--	--	401 V	3.6 A	--	

Customer Log

The customer was very happy with the system. The system has worked flawlessly and has provided all the water needed at this site.

System Maintenance and Modifications

The system quit working the week after the installation and the problem was traced to a broken wire at the splice near the motor. This was fixed by the pump installer. The system was upgraded from the MS-10s to the MS-12s which was completed on March 7, 1996.

MORGAN COUNTY RURAL ELECTRIC ASSOCIATION

Site Selection

The site that Morgan County selected for its installation was located on the Huey ranch near Brush, Colorado. The well was being used for livestock watering and was previously powered by a windmill. As shown in **Error! Reference source not found.**, the rancher requested 1220 gallons per day in the spring, summer, and fall.

Morgan County Site Specifications

WATER USE		
Water Demand (gal/day)	End-Use	Storage (gal)
1200/spring-fall	cattle	2,390 gallons

WATER SOURCE				
Description: well				
Static Level (ft)	Draw down (ft)	Discharge Head (ft)	Total Head (ft)	Max. Rate (gal/

54	5	3	62	--

System Selection

Morgan County System Specifications

	Manufacturer	Model	Description	Cost
Water Works Power Supply	Golden Photon	E50S-2	480 Watt AC pump power supply	$4,625
Pump	Grundfos	10S0509	1/2HP, 1 Ph, 230 VAC	--

The system purchased included a 480 Watt array of Golden Photon CT4 modules, an SPC-2000 pump controller, and all above ground hardware and wiring. The pump and all down hole equipment supplied by the customer.

The water output from the purchased system was estimated to produce 2200 gallons per day at 53 feet of head with six sun hours per day (the original well data indicated a total head of 53 feet).

System Installation

The pumping system was installed on the Huey ranch on July 12, 1995. The system consisted of three MS-10 structures each holding ten CT-4 modules. The structures were arranged in two rows. Fencing was to be provided at a later time by the customer to keep the cattle away from the array. The system installation took approximately three hours to complete.

(See attached photo.)

Morgan County PV-Powered Pumping System

Acceptance Test

Morgan County System Acceptance Test Results

Time	Plane of Array Insolation	PV Voltage	PV Current	DC Power (scaled to 1000 W/m²)	Total Head	Flow Rate
12:05 pm	996 W/m²	265 volts	2.4 amps	639 Watts	63 feet	10.7 GPM

Monthly Test Reports

Morgan County System Monthly Test Results

Date	Time	POA W/m^2	PV Voltage	PV Current	Voc	Isc	Flow Rate	Notes
7/12/95	12:05 pm	996	265 V	2.4 A	392 V	3.6 A	10.7 GPM	installation
3/7/96								upgrade from MS-10s to MS-12s
8/--/96							10 GPM	

Customer Log

The customer was very happy with the system. The system has worked flawlessly and has provided all the water needed at this site.

System Maintenance and Modifications

The system quit working the week after the installation and the problem was traced to a broken wire at the splice near the motor. This was fixed by the pump installer. The system was upgraded from the MS-10s to the MS-12s which was completed on March 7, 1996.

POWDER RIVER ENERGY

Site Selection

The site that Powder River Energy selected for its installation was located in the Black Hill National Forest north east of Sundance, Wyoming. The Forest Service leases grazing permits in the area and had been using a spring as a water source. However to keep the cattle out of the riparian area and to better utilize some ridge line pastures well above the spring, water was pumped from the spring to supply water to several stock tanks over one mile from the spring.

Powder River Energy Site Specifications

WATER USE		
Water Demand (gal/day)	End-Use	Storage (gal)
3000/summer	cattle	12,000 gallons

WATER SOURCE				
Description: spring				
Static Level (ft)	Draw down (ft)	Discharge Head (ft)	Total Head (ft)	Max. Rate (gal/
3	0	120	125	NA

System Selection

Powder River Energy System Specifications

	Manufacturer	Model	Description	Cost
Water Works Power Supply	Golden Photon	E125S-4	960 Watt AC pump power supply	$7,600
Pump	Grundfos	10S0712	3/4HP, 1 Ph, 230 VAC	-

The system purchased included a 960 Watt array of Golden Photon CT4 modules, an SPC-2000 pump controller, and all above ground hardware and wiring. The pump (single phase), tanks, and all piping was supplied by the Forest Service.

The water output from the purchased system was estimated to produce 3000 gallons per day at 125 feet of head with six sun hours per day.

System Installation

The pumping system was installed in the Black Hill National Forest on August 8, 1995. A 6,000 gallon storage tank was installed below the spring to act as a buffer for the slow (four gallon per minute) spring. As shown in **Error! Reference source not found.**, the PV array was installed on a pad which had been graded for the installation located about 100 feet from the spring storage tank.

The system consisted of five MS-10 structures each holding ten CT-4 modules. The structures were arranged in two rows, two structures in the south row and three structures in the north row. A standard Forest Service type fence was installed during installation around the array.

The customer, being skeptical of the performance of solar pumping, requested a single phase pump motor so they could use a generator for back up power if needed. However, there was some concern about the operation of large single phase motors on the Golden Photon controller based on the experience at KC Electric and Johnson County Electric so Golden Photon provided a three phase motor to use for the system installation. The customer now has confidence in the system, having received all the water they need, and will probably not install the single phase motor. The system installation took approximately four hours to complete.

(See attached photo.)

Powder River Energy PV-Powered Pumping System

Acceptance Test

Powder River Energy System Acceptance Test Results

Time	Plane of Array Insolation	PV Voltage	PV Current	DC Power (scaled to 1000 W/m²)	Total Head	Flow Rate
3:35 pm	964 W/m²	338 volts	3.3 amps	1,160 Watts	100 feet	3 GPM

Monthly Test Reports

Powder River Energy System Monthly Test Results

Date	Time	POA W/m²	PV Voltage	PV Current	Voc	Isc	Flow Rate	Notes
8/8/95	3:35 pm	964	338 V	3.3 A	--	--	3 GPM	

Customer Log

The customer was very happy with the system. The system has worked flawlessly and has provided all the water needed at this site.

System Maintenance and Modifications

The only maintenance or modification done to this system was to upgrade from the MS-10s to the MS-12s.

RIVERTON VALLEY ELECTRIC ASSOCIATION

Site Selection

The site that Riverton Valley Electric selected for its installation was located on the Hudson Grazing Association near Hudson, Wyoming. An artesian well which was previously used to water livestock had slowed to 0.3 GPM and no longer meet the livestock watering needs. Installing a pump in this well would make it usable again.

Riverton Valley Site Specifications

WATER USE		
Water Demand (gal/day)	End-Use	Storage (gal)
1600/summer	cattle	1,000 gallons

WATER SOURCE
Description: spring

Static Level (ft)	Draw down (ft)	Discharge Head (ft)	Total Head (ft)	Max. Rate (gal/
0	70	0	70	7

System Selection

Riverton Valley System Specifications

	Manufacturer	Model	Description	Cost
Water Works Power Supply	Golden Photon	E25S-2	480 Watt AC pump power supply	$4,625
Pump	Jacuzzi	10S05	1/2HP, 1 Ph, 230 VAC	

The system purchased included a 480 Watt array of Golden Photon CT4 modules, an SPC-2000 pump controller, and all above ground hardware and wiring. The pump, tanks, and all piping was supplied by the customer.

The water output from the purchased system was estimated to produce 2500 gallons per day at 30 feet of head with six sun hours per day.

System Installation

The pumping system was installed on the Hudson Grazing Association on May 19, 1995 as part of a two day PV pumping workshop. The workshop was attended by 16 people including local ranchers, Riverton Valley Electric personnel, and Hot Springs REA personnel. As shown in **Error! Reference source not found.**, the PV array was installed on a flat area next to the well. The customer later fenced the array to protect it from cattle. The system consisted of three MS-10 structures each holding ten CT-4 modules. The structures were arranged in one row. The system installation took approximately two hours to complete.

(See attached photo.)

Riverton Valley PV-Powered Pumping System

Acceptance Test

Riverton Valley System Acceptance Test Results

Time	Plane of Array Insolation	PV Voltage	PV Current	DC Power (scaled to 1000 W/m²)	Total Head	Flow Rate
11:50 am	900 W/m²	326 volts	1.6 amps	580 Watts	70 feet	10.7 GPM

Monthly Test Reports

Riverton Valley System Monthly Test Results

Date	Time	POA W/m²	PV Voltage	PV Current	Voc	Isc	Flow Rate	Notes
5/19/95	11:50 am	900	326 V	1.6 A	397 V	3.4 A	10.7 GPM	
6/5/95	2:15 pm	925	344 V	1.4 A	393 V	3.2 A	8.8 GPM	1 cracked module
6/6/95	2:08 pm	1000	332 V	1.6 A	403 V	3.3 A	9.7 GPM	
6/15/95	10:00 am	575	356 V	1.1 A	403 V	2.3 A	8.3 GPM	replaced cracked module
3/20/96								GPI upgrade to MS-12s

Customer Log

No customer reports received from this site.

System Maintenance and Modifications

A cracked module was noticed two weeks after installation and was replaced two weeks later. The crack was blamed on a manufacturing defect (scratch on the edge of the top glass). The only other maintenance or modification done to this system was to upgrade from the MS-10s to the MS-12s which was completed on 3/20/96.

NIOBRARA ELECTRIC ASSOCIATION

Site Selection

Niobrara installed the system initially on a irrigation well near their main office for testing. The well was currently being used with power from the utility line. The system was later moved to a customers well where it was used for livestock watering.

Niobrara Site Specifications

WATER USE		
Water Demand (gal/day)	End-Use	Storage (gal)
--	irrigation/cattle	0 gallons

WATER SOURCE				
Description: well				
Static Level (ft)	Draw down (ft)	Discharge Head (ft)	Total Head (ft)	Max. Rate (gal/
35	5	0	40	+4

System Selection

Niobrara System Specifications

	Manufacturer	Model	Description	Cost
Water Works Power Supply	Golden Photon	S50-2	480 Watt AC pump power supply	$4,625
Pump	Red Jacket	5GPM	3/4HP, 1 Ph, 230 VAC	existing

The system purchased included a 480 Watt array of Golden Photon CT4 modules, an SPC-2000 pump controller, and all above ground hardware and wiring. The pump and all down hole equipment was already installed by the customer.

System Installation

The pumping system was installed near Niobrara's office on September 14, 1995. As shown in Niobrara PV-Powered Pumping System, the PV array was installed on the lawn in front of Niobrara's office. The well was about 150 feet from the array. The system consisted of three MS-10 structures each holding ten CT-4 modules. The structures were arranged in one row. Fencing was not needed at this location.

A connector was installed so the pump could be plugged into the existing line powered controller or it could be plugged into the PV controller. The system installation took approximately two hours to complete.

(See attached photo.)

Niobrara PV-Powered Pumping System

Acceptance Test

Niobrara System Acceptance Test Results

Time	Plane of Array Insolation	PV Voltage	PV Current	DC Power (scaled to 1000 W/m²)	Total Head	Flow Rate
11:15 am	913 W/m²	330 volts	2.0 amps	723 Watts	40 feet	9.3 GPM

Monthly Test Reports

Niobrara System Monthly Test Results

Date	Time	POA W/m²	PV Voltage	PV Current	Voc	Isc	Flow Rate	Notes

9/14/95	10:15 am	700	317 V	1.8 A	432 V	2.6 A	8.3 GPM	
9/22/95	1:30 pm	975						failed pump coupling
12/11/95	2:00 pm	650	--	--	388 V	2.6 A	--	new pump; cloudy
12/14/95	9:30 am	700	305 V	2.1 A	407 V	2.1 A	7.2 GPM	
12/19/95	1:45 pm	700	287 V	1.4 A	421 V	2.5 A	--	

Customer Log

The system worked fine while at the utility office and the new customer is happy with the system.

System Maintenance and Modifications

Shortly after installation the pump coupling stripped out. This was replaced and no other maintenance was done at the Niobrara office site. The system was later moved to a livestock watering site and upgraded from MS-10s to MS-12s. The existing pump was used initially but as expected with that pump the system only delivered 700 gallons per day. A new pump was installed which was better matched to the PV pumping system and then the customers needs were then being meet.

On July16 a severe hail storm broke 23 of the 36 modules in the system. Hail was reported to be greater than 2" with softball size hail in the area. Golden Photon replaced all the broken modules.

WESTPLAINS ENERGY

WestPlains Energy is an investor-owned utility that serves the southeastern region of Colorado. Their primary customer loads are comprised of residential consumers in Pueblo, Colorado; however, they also serve thousands of agricultural customers in eastern Colorado and Kansas. In addition, WestPlains serves portions of Fort Carson Army Base, and Fort Carson has an active wildlife management program. This project was focused on wildlife watering .

Site Selection

WestPlains Site Specifications

WATER USE		
Water Demand (gal/day)	End-Use	Storage (gal)
700/spring-fall	wildlife (deer, elk, etc.)	1,000

WATER SOURCE
Description: spring

Static Level (ft)	Draw down (ft)	Discharge Head (ft)	Total Head (ft)	Max. Rate (gal/
100	0	8	108	NA

System Selection

WestPlains System Specifications

	Manufacturer	Model	Description	Cost
Water Works Power Supply	Golden Photon	E25S-2	480 Watt AC pump power supply	$4,625
Pump	--	--	1/2HP, 3 Ph, 230 VAC	customer

The system purchased included a 480 Watt array of Golden Photon CT4 modules, an SPC-2000 pump controller, and all above ground hardware and wiring. The pump, tanks, and all piping was supplied by Fort Carson.

The water output from the purchased system was estimated to produce 2,000 gallons per day at 108 feet of head with six sun hours per day.

System Installation

The pumping system was installed on the Fort Carson base on June 26, 1995. The system consisted of three MS-10 structures each holding ten CT-4 modules. The system installation took approximately four hours to complete.

(See attached photo.)

WestPlains PV-Powered Pumping System

Acceptance Test

Not available.

Monthly Test Reports

Not available.

Customer Log

Not available.

System Maintenance and Modifications

Not available.

WISCONSIN PUBLIC SERVICE COMPANY

Wisconsin Public Service Company (WPSC) is an investor-owned utility that serves the northeastern region of Wisconsin. Their primary customer loads are comprised of paper mills and the industries that support the mills. However, they also have 10,000 agricultural customers, a third of which are dairy farmers. The terrain in their region of the state consists of gently rolling hills that are forested in the north and covered by farms and wooded areas in the south.

Mr. Jeff DeLaune, Research and Development Consultant at WPSC was project manager for the PV demonstration project, and he was located at WPSC's home office in Green Bay, WI.

Site Selection

The site that WPSC selected for its installation was located on the Vickery ranch near Suamico, Wisconson. Water is being pumped from a river and into a stock tank. Initially a submersible pump was going to be installed in the river, however regulations pertaining to river boating traffic would not allow this type of installation. A surface pump would have to be used for this application. While the Golden Photon system may operate a surface pump, this configuration had not been tested in 1995 and Golden Photon would not support the installation at that time. In early 1996, Golden Photon did offer a three phase surface pump option which would meet the needs of this site at which time the project proceeded.

WPSC Site Specifications

WATER USE		
Water Demand (gal/day)	End-Use	Storage (gal)
700/spring-fall	cattle	--

WATER SOURCE				
Description: spring				
Static Level (ft)	Draw down (ft)	Discharge Head (ft)	Total Head (ft)	Max. Rate (gal/
7	0	8	15	NA

System Selection

WPSC System Specifications

	Manufacturer	Model	Description	Cost
Water Works Power Supply	Golden Photon	E25S-2	480 Watt AC pump power supply	$4,625
Pump	--	--	1/2HP, 3 Ph, 230 VAC	customer

The system purchased included a 480 Watt array of Golden Photon CT4 modules, an SPC-2000 pump controller, and all above ground hardware and wiring. The pump, tanks, and all piping was supplied by the customer.

The water output from the purchased system was estimated to produce 4200 gallons per day at 15 feet of head with six sun hours per day.

System Installation

The pumping system was installed on the Vidkery ranch on May 23, 1995. The system consisted of three MS-10 structures each holding ten CT-4 modules. The system installation took approximately four hours to complete.

(See attached photo.)

WPSC PV-Powered Pumping System

Acceptance Test

Not available.

Monthly Test Reports

Not available.

Customer Log

Not available.

System Maintenance and Modifications

Not available.

Conclusions

The following conclusions were drawn based on the results from these utility system installations during the project's nearly two years of monitoring:

- Every Golden Photon system installed required unanticipated service during the monitoring period, and most installations required such service more than once.
- The unanticipated outages were due to both PV problems and controller problems. The PV problems included manufacturing inconsistencies (e.g., module failures due to desiccant problems, cosmetic blemishes that necessitated module replacements, etc.) and significant damage due to hail storms. As the modules presumably pass the PVUSA hail test, the unprecedented hail damage experienced during this project leads to the conclusion that the PVUSA hail test is not adequate (i.e., especially for module using non-tempered glass

superstrates). The controller problems included high-head nuisance faults (that lead to switching single-phase systems to three-phase systems) and various other software malfunctions that lead to inconsistent operation.

- Only 17 of the 25 Golden Photon systems that were originally proposed for installation were actually installed. The uncertainty caused by system failures was the reason for limiting the installations to 17.
- Despite the technical problems, Golden Photon's quality customer service (i.e., prompt response to problems) kept most utilities and their consumers happy. Additionally, Golden Photon's "packaged system" approach, quality documentation, and attempt to bring a needed product to the market was appreciated by these same customers.
- The benefits of using "off-the-shelf" AC pumps were confirmed. These benefits included: 1) no pump failures occurred during the project; 2) significant interest and support was shown from local well service companies; 3) existing pumps were used in a majority of installations (saving the rancher the cost of purchasing a "PV pump"); and 4) the option for generator back-up (providing both "insurance" and the opportunity to downsize the PV system and associated cost).
- Golden Photon's system cost was as much as 20% higher on a $/gallon basis than comparable PV pumping systems on the market (according to the PSN's PV Systems catalog).
- All total, Golden Photon eliminated one barrier to widespread commercialization (i.e., replacing "specialty" pumps with AC pumps) but introduced their own barriers with insufficient PV and controller reliability as well as higher system cost.
- As of December 1996, Golden Photon has suspended commercial manufacturing of their PV modules, though project participants have been assured that existing system installations will be supported.
- Finally, PV-powered AC pumping continues to be a significant market (and commercialization) opportunity, if a reliable PV power supply can be combined with an AC pump at a competitive price.

Site Data for PV-Powered Pumping

CUSTOMER INFORMATION

Customer Name

Address

State & Zip Code

Telephone Number

WATER USE INFORMATION

Water End Use: (Please circle one)

1. Livestock watering - Number of head _____
   Type of livestock: _____
2. Domestic household use - Number of people _____
3. Other - Please specify: _____

Average Daily Water Requirement:

Summer: _____ Gallons/Day
Fall: _____ Gallons/Day
Winter: _____ Gallons/Day
Spring: _____ Gallons/Day

Water Storage: (Please circle one)

1. Above ground tank - Size: _____Gallons
2. Pressure tank - Size: _____ Pressure: _____ psi
3. Other _____ Size: _____

WATER SOURCE INFORMATION

Water Source: (Please circle one)

1. Drilled Well - Well casing diameter: _____ inches
   Depth of well:_____feet
   Max pumping rate for well: _____ GPM
   Date of most recent well test _____
2. Stream or pond
3. Other - Please specify: _____

Is this water source presently being used?

YES ____ NO ____
If yes, how is it being pumped? _____

If AC pump is used, what is make, model, hp, voltage, rated gpm, # of stages & wires

_____
_____

Static Water Level: (Distance from ground surface to water when not pumping)

_____ Feet

Drawdown Level: (Distance water level drops when pumping at normal rates)

_____ Feet. While pumping at _____ GPM

Discharge Head: (Vertical distance water is pumped uphill to tank or distribution)

_____ Feet

Pressure head: (Tank pressure in psi x 2.31)

_____ Feet

Friction head: (see description in guide book)

_____ Feet

Total Pumping Head: (sum above distances)

_____ Feet

Water Quality:

Very Good ___ Good ___ Fair ___ Poor ___ Very Poor___

Water Contains:

Silt ___ Sand ___ Rust ___

Does the site have unrestricted solar access?

YES ____ NO ____

Installation Preparation Check List

Call #1 (4-5 weeks before installation)

___ Directions to utility or workshop

___ Hotel recommendations

___ Distances & times

Utility to site	_____ miles	_____min.
Airport to utility	_____ miles	_____min.
Site to airport	_____ miles	_____min.

___ Rental car recommendation for site access _____

___ Utility notified of audio/visual equipment requirements

___ Type of structure anchoring _____

___ Preparation items discussed:

- ___ Pump to be purchased & installed in advance by rancher
- ___ Site preparation (grading)
- ___ System to be delivered before workshop to site & away from array area.
- ___ Technician at workshop & site to do wiring on utility/customer side.
- ___ Materials to purchase for generator interconnect & pump to array wiring
  Wire: 12 gauge, 3 wire w/gr; UV resistant & buriable or w/conduit;
  Plug: (1) NEMA config. L14-20p; Connectors: (2) NEMA config. L14-20c
  (For 3 phase L15-20p & L15-20c)
- ___ Shovel (trench), ground rod driver & sledge or jack hammer for installation.
- ___ Does utility have clamp-on DC current meter with resolution to read .1 amp (20A scale)? If not, need to order 10 amp, 100 mv current shunt from R&R Instrumentation; 303-364-8325; PN 871-92UUMTGB

Call #2 (after delivery of system)

___ System received at utility

___ Site graded and prepared

___ Pump purchased and installed in advance by customer

___ Generator interface hardware purchased

___ Materials for wiring pump to array purchased

___ Number of attendees for workshop verified _____

___ System delivered to installation site

Call #3 (on Monday before workshop)

___ Verify weather is acceptable

Installation Trip Check List

Paperwork

___ Trip itinerary

___ Map of region

___ Installation preparation checklist

___ Utility contact name, address and phone

___ Presentation overheads

___ Agendas and presentation handouts

___ Acceptance test form

___ Utility monthly test forms

___ Customer log book

___ Well site data form

___ GPI order form

___ Sun chart for location's latitude

___ Pump curves

___ Insolation data for site

Miscellaneous

___ Calculator

___ Packing tape

___ Sunscreen & sunglasses

___ Camera

___ Film

___ WD-40

Tools, meters and equipment

___ well sounder

___ compass

___ inclinometer

___ multi-meter

___ current meter

___ pyranometer

___ hand tools

___ socket set with 3/8" extension

___ wire brush

___ 50 foot tape measure

___ current shunt

____DAS (not always installed)

...mping System Acceptance Test

General Information

...acy name:	System test date:
Customer name:	System installation date:
Customer phone:	Pumping site location:
Test tech. name	Site latitude & longitude:
Test tech. phone:	Site magnetic declination:

PV Array Information

Module make & model:	
Module peak power:	Nominal array peak power:
Module Vmp:	Nominal array Voc:
Module Imp:	Nominal array Isc:
Module Voc:	Type of array mount:
Module Isc:	Number of array mounts:
Series/parallel configuration:	Method of mount anchoring:
Array tilt & orientation:	Distance from array to pump: ft.

PV Array Test

Weather: (Check all that apply):

___ Bright sun
___ Hazy sun
___ Cloudy
___ Overcast
___ Raining or snowing
___ Snow on ground
___ Temp. below freezing
___ Windy

Ambient air temperature (°F):	Module temperature (back) (°F):

	String 1	String 2	String 3	String 4	String 5	String 6	String 7	String 8
POA Irr. (w/m²):								
String Vmp:								
String Imp:								
Norm. power*:								

Array Voc:	Array Vmp:
Array Isc:	Array Imp:
POA Irr. (w/m²):	Total normalized power*:
	POA Irr. (w/m²):

* Normalized power = V x I x 1000/POA

Please identify string locations.

North ↓

String#	String#	String#	String#
String#	String#	String#	String#

Water Pumping System Acceptance Test (cont.)

Pump/motor Information	
Pump make & model:	
Motor make & model:	
Controller make, model & serial #:	
Number of pump stages:	Rated gallons per minute:
Motor voltage:	Number of phases:
Motor size (watts or hp):	Motor current rating (amps):

Pumping System Tests (15 to 30 minute intervals)	
Total head at installation (before pumping):	
Time of test:	Time of test:
Plane of array irradiance (w/m²):	Plane of array irradiance (w/m²):
Total head at time of test (feet)*:	Total head at time of test (feet)*:
Voltage to load:	Voltage to load:
Current to load:	Current to load:
Normalized power**:	Normalized power**:
Flow rate (GPM):	Flow rate (GPM):
Time of test:	Time of test:
Plane of array irradiance (w/m²):	Plane of array irradiance (w/m²):
Total head at time of test (feet)*:	Total head at time of test (feet)*:
Voltage to load:	Voltage to load:
Current to load:	Current to load:
Normalized power**:	Normalized power**:
Flow rate (GPM):	Flow rate (GPM):

Comments

* Total head = static water level + drawdown + discharge head.

** Normalized power = V x I x 1000/POA

PV Pumping System - Customer Log Book

(Please fill out a log entry whenever you are on site and mail in pages at least once a month)

Date:________________ Time:____________

Weather: (Check all that apply):

___ Bright sun ___ Raining or snowing
___ Hazy sun ___ Snow on ground
___ Cloudy ___ Temp. below freezing
___ Overcast ___ Windy

How full is the water tank? (circle one)
Full 3/4 1/2 1/4 Empty

Is PV system presently pumping water?
___No ___Yes ---> Rate: _______GPM

Is PV system pumping enough water for your needs? ___No ___Yes

What livestock is being watered?
Number: _______ Type:_______________

Does system seem to be working properly? ___No ___Yes

Comments:_______________________________

____

____

Date:________________ Time:____________

Weather: (Check all that apply):

___ Bright sun ___ Raining or snowing
___ Hazy sun ___ Snow on ground
___ Cloudy ___ Temp. below freezing
___ Overcast ___ Windy

How full is the water tank? (circle one)
Full 3/4 1/2 1/4 Empty

Is PV system presently pumping water?
___No ___Yes ---> Rate: _______GPM

Is PV system pumping enough water for your needs? ___No ___Yes

What livestock is being watered?
Number: _______ Type:_______________

Does system seem to be working properly? ___No ___Yes

Comments:_______________________________

____

____

Date:________________ Time:____________

Weather: (Check all that apply):

___ Bright sun ___ Raining or snowing
___ Hazy sun ___ Snow on ground
___ Cloudy ___ Temp. below freezing
___ Overcast ___ Windy

How full is the water tank? (circle one)
Full 3/4 1/2 1/4 Empty

Is PV system presently pumping water?
___No ___Yes ---> Rate: _______GPM

Is PV system pumping enough water for your needs? ___No ___Yes

What livestock is being watered?
Number: _______ Type:_______________

Does system seem to be working properly? ___No ___Yes

Comments:_______________________________

____

____

Date:________________ Time:____________

Weather: (Check all that apply):

___ Bright sun ___ Raining or snowing
___ Hazy sun ___ Snow on ground
___ Cloudy ___ Temp. below freezing
___ Overcast ___ Windy

How full is the water tank? (circle one)
Full 3/4 1/2 1/4 Empty

Is PV system presently pumping water?
___No ___Yes ---> Rate: _______GPM

Is PV system pumping enough water for your needs? ___No ___Yes

What livestock is being watered?
Number: _______ Type:_______________

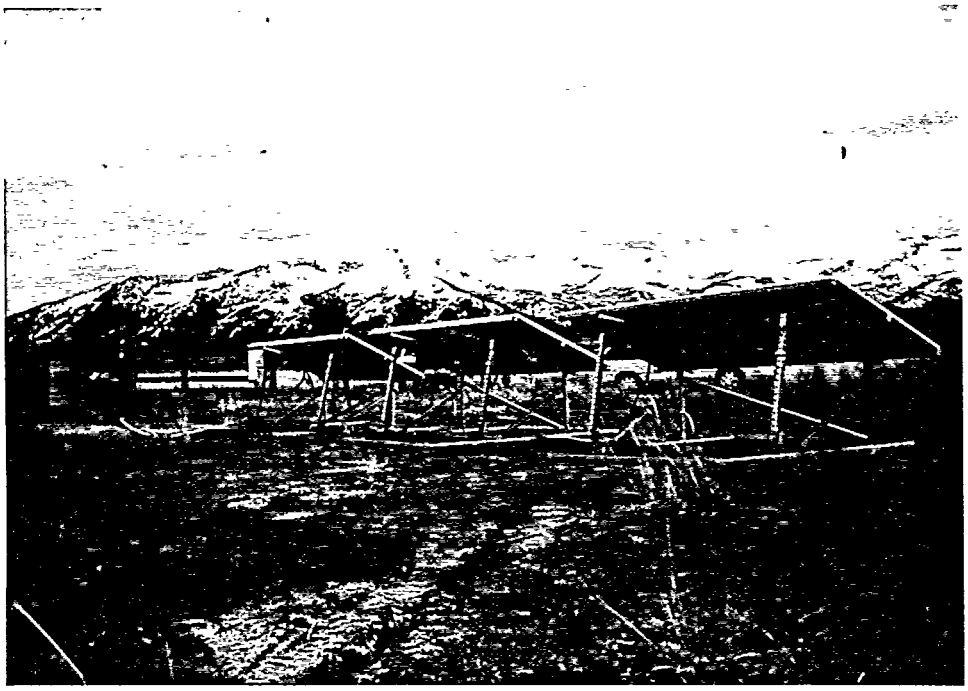
Does system seem to be working properly? ___No ___Yes

Comments:_______________________________

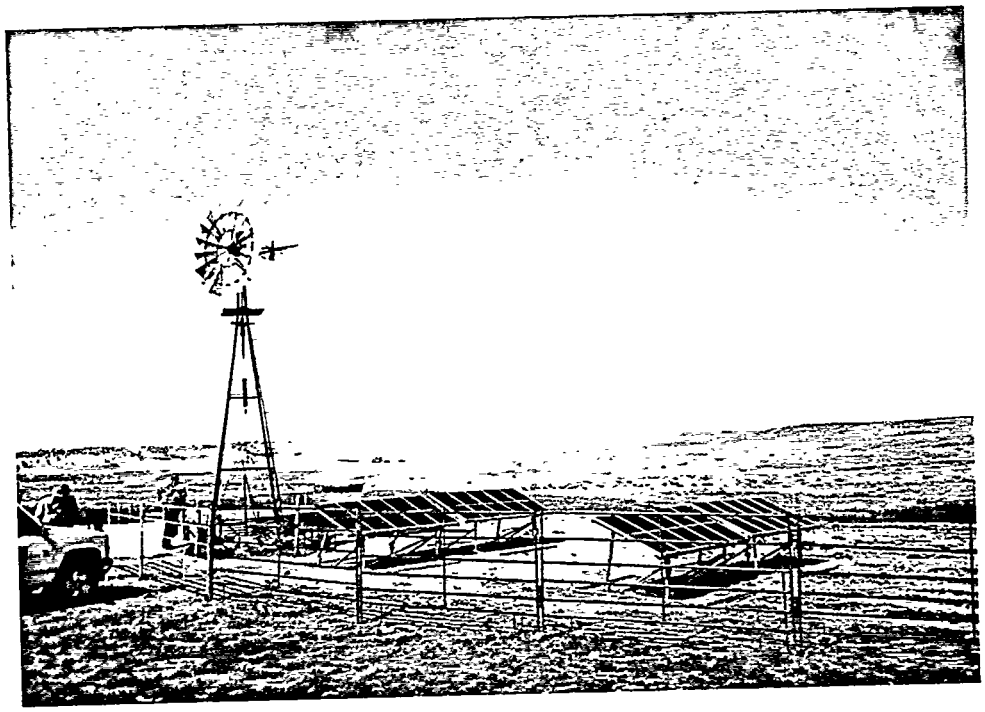
____

____

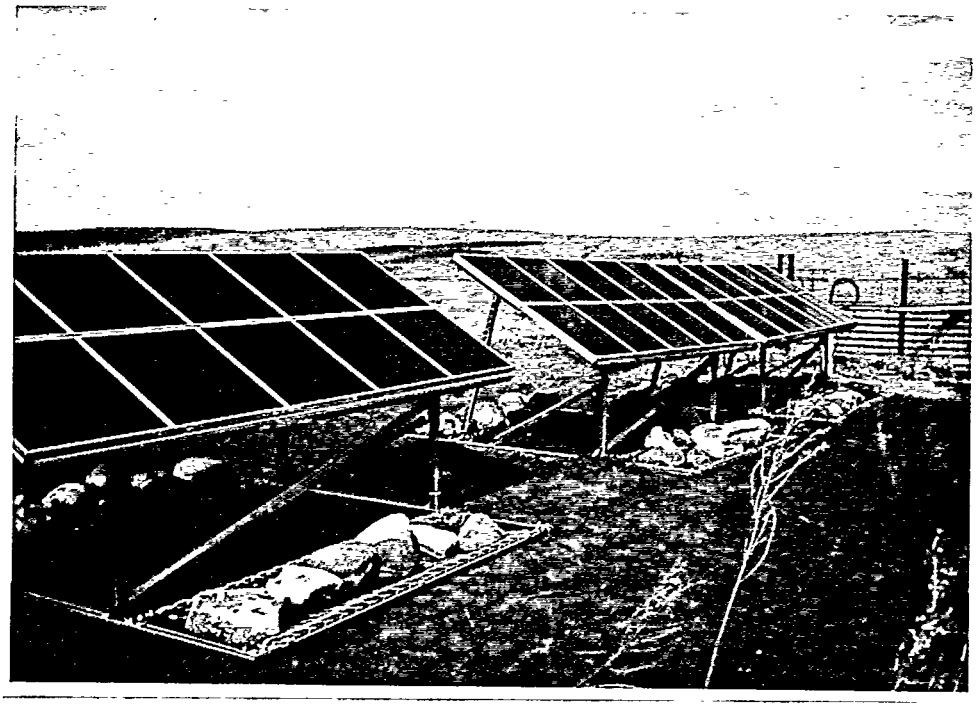
WELLS RURAL ELECTRIC COMPANY



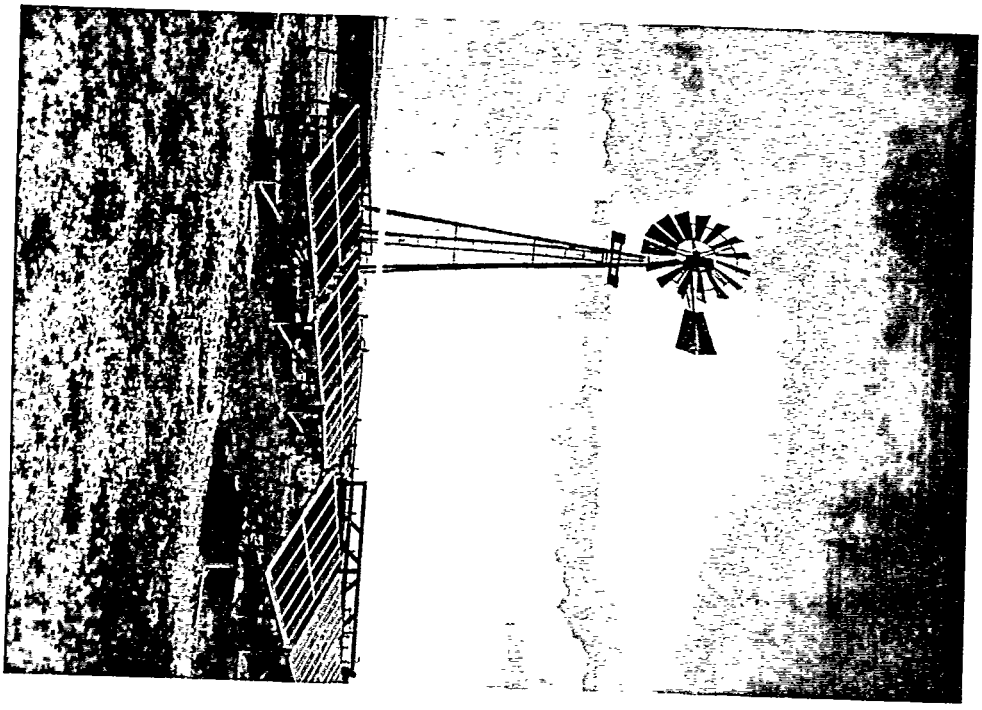
WHEAT BELT PUBLIC POWER DISTRICT



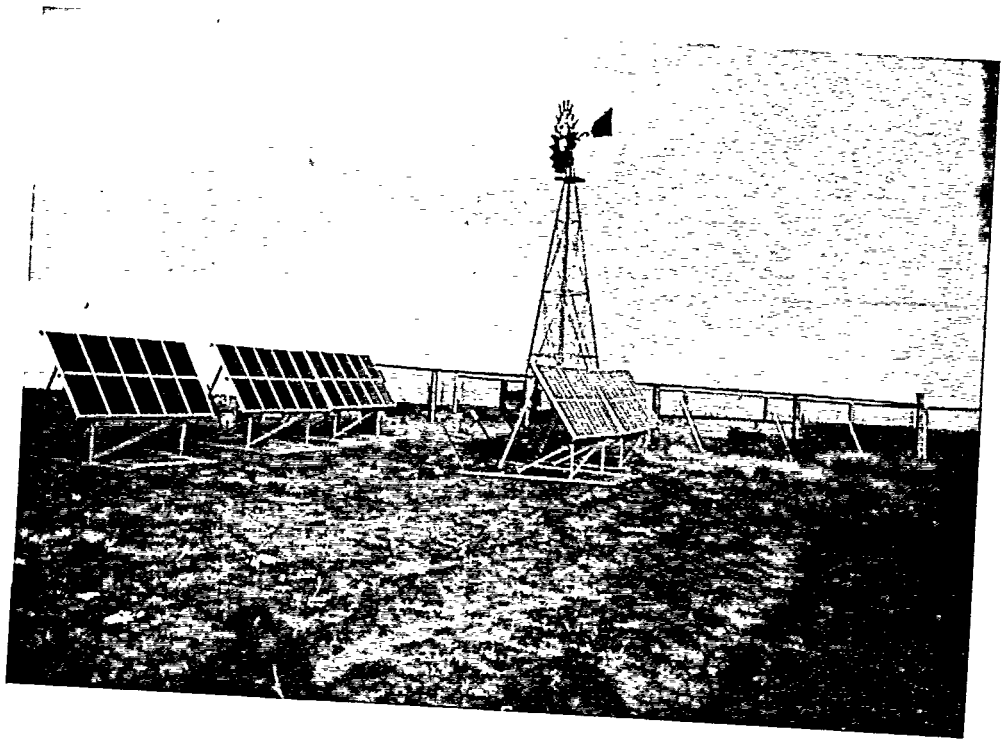
KEM ELECTRIC COOPERATIVE



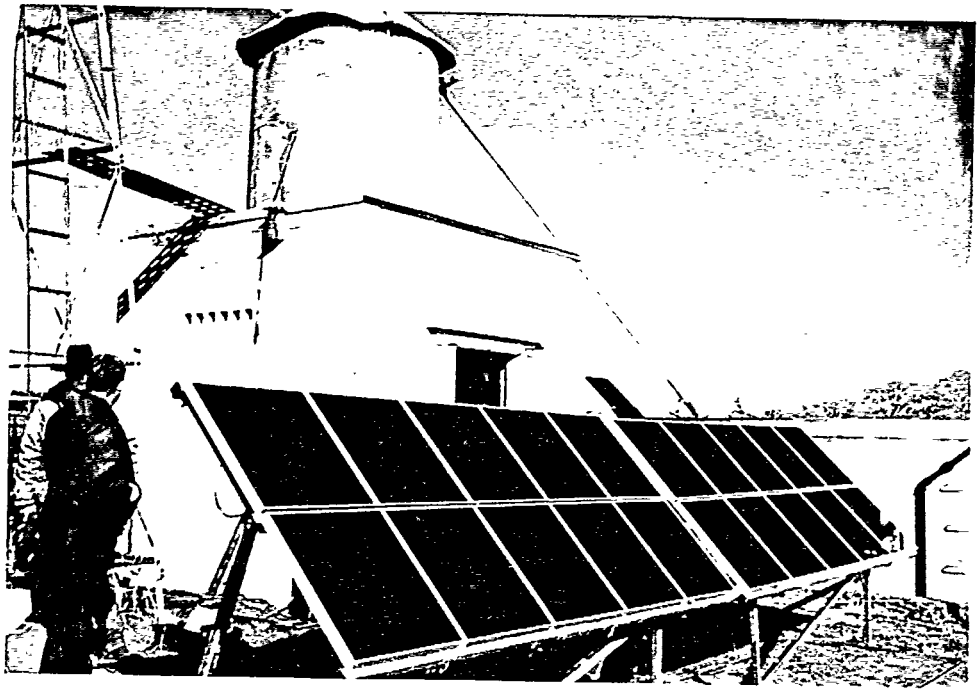
MOR-GRAN-SOU ELECTRIC COOPERATIVE



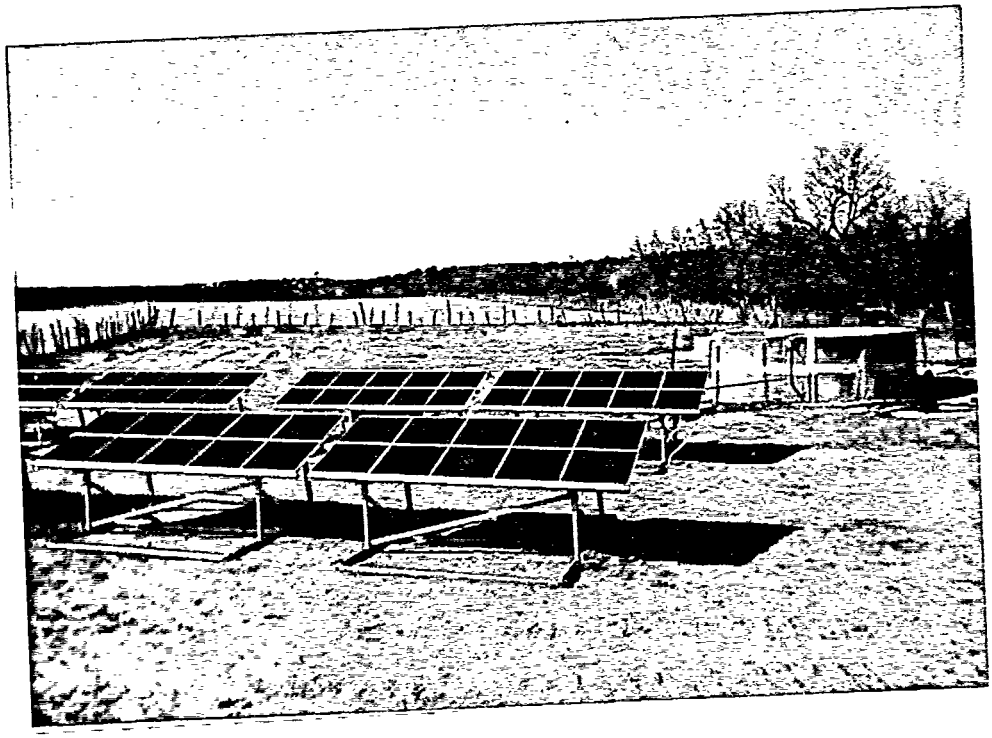
NORTHWEST RURAL PUBLIC POWER DISTRICT



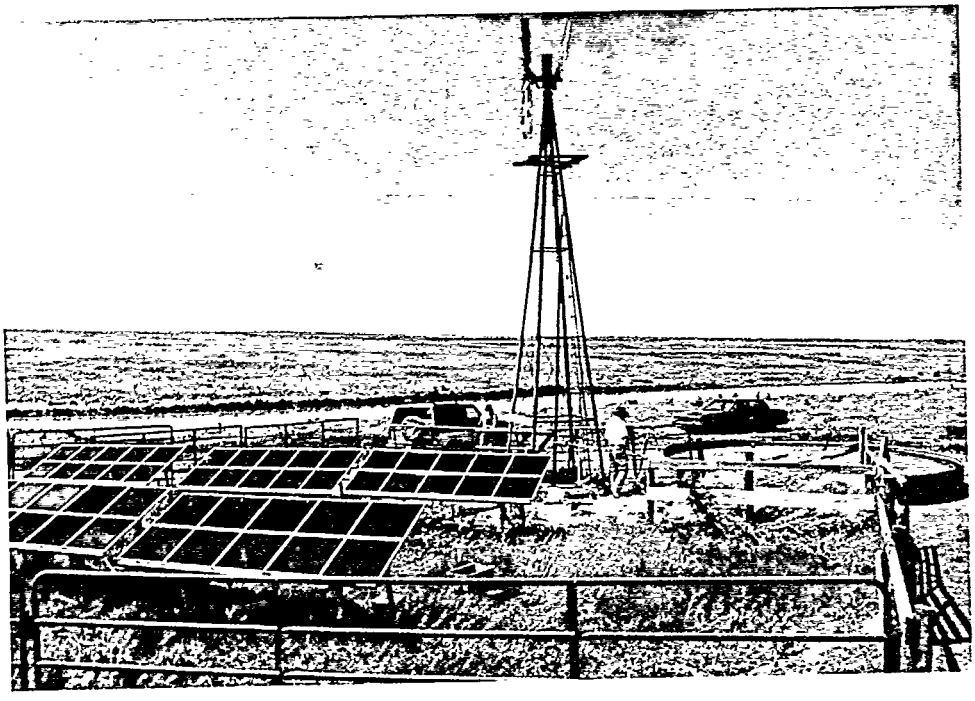
ARIZONA ELECTRIC POWER COOPERATIVE



JOHNSON COUNTY ELECTRIC COOPERATIVE

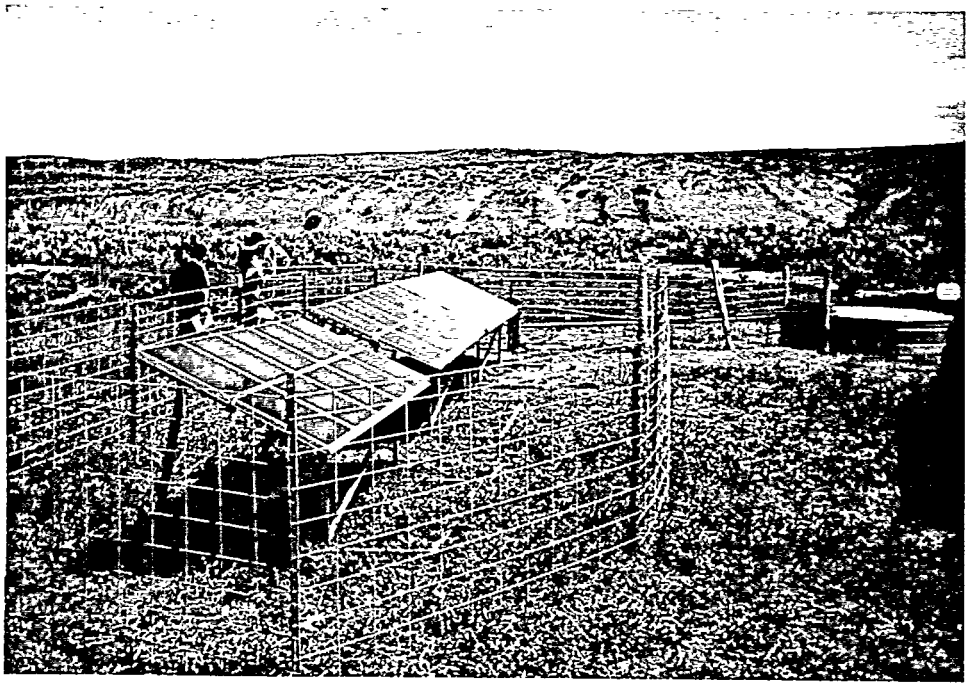


KC ELECTRIC ASSOCIATION

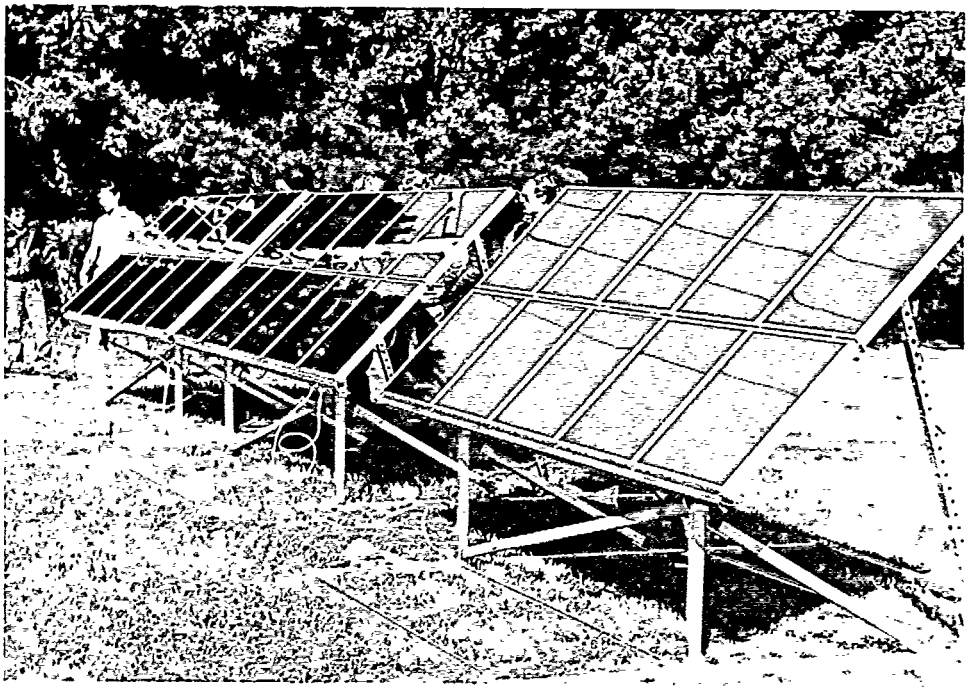


POWDER RIVER ENERGY

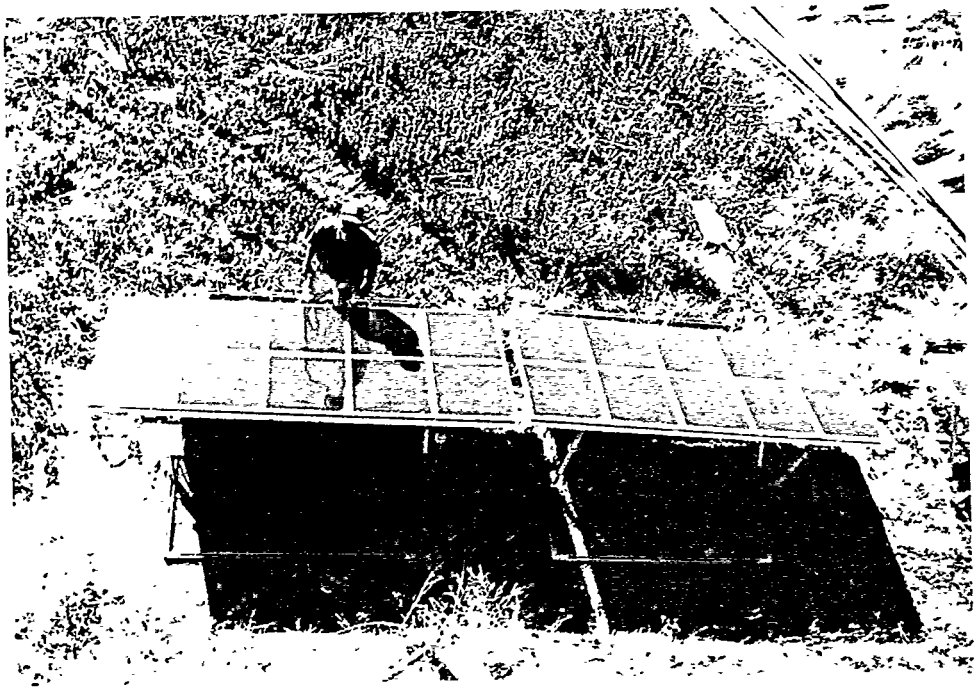
RIVERTON VALLEY ELECTRIC ASSOCIATION



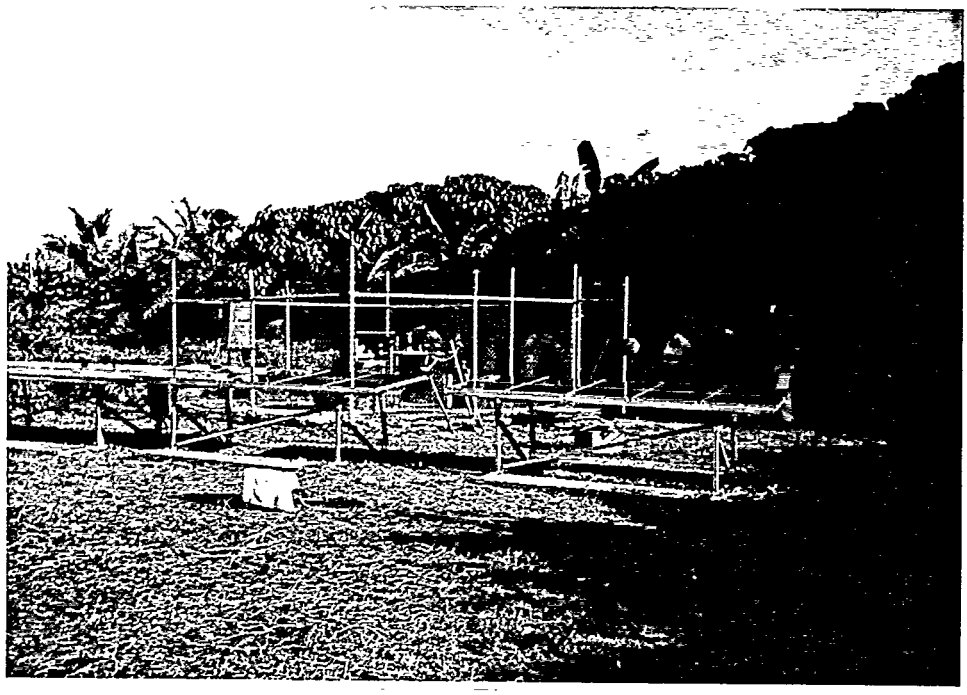
NIOBRARA ELECTRIC ASSOCIATION



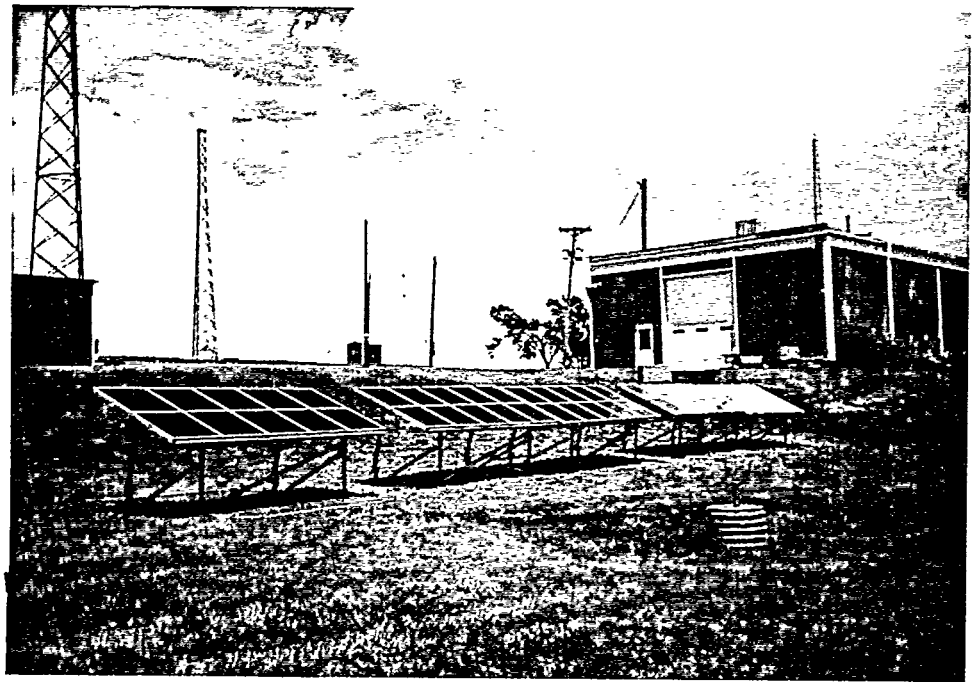
WESTPLAINS ENERGY



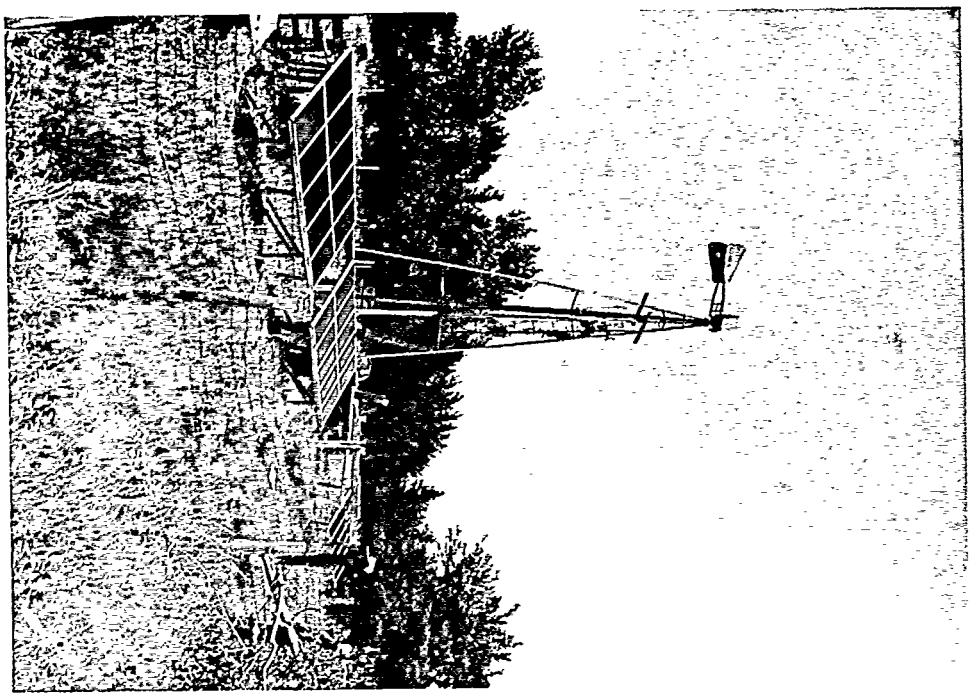
AMERICAN SAMOA POWER AUTHORITY



SOUTHWESTERN PUBLIC SERVICE COMPANY



NEBRASKA PUBLIC POWER DISTRICT



MORGAN COUNTY RURAL ELECTRIC ASSOCIATION