Cost-Effective Solar Power in the Heartland

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COST-EFFECTIVE SOLAR POWER IN THE HEARTLAND

Authors: Dr. Gale Simons
Emeritus Professor
Department of Electrical and Computer Engineering
Kansas State University
Manhattan, KS 66506

Mr. Bill Roush
President
Solar Electric Systems of Kansas City, Inc.
13700 W. 10th Street
Lenexa, KS 66215

Sponsor: Mr. Jim Ploger
Energy Program Manger
Kansas Corporation Commission
1500 SW Arrowhead Road
Topeka, KS 66604-4027

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Copies of this report are available from:
Kansas Corporation Commission
Energy Programs
1500 SW Arrowhead Road
Topeka, KS 66604-4027
Phone: 785-271-3170

COST-EFFECTIVE
SOLAR POWER IN THE HEARTLAND

By

Gale Simons and Bill Roush

ABSTRACT

This report focuses primarily on heightening public awareness about the availability of cost-effective solar electric systems for a five-state region—Iowa, Kansas, Missouri, Nebraska, and Oklahoma. Several cost-effective solar electric technologies deemed important to these Heartland states are discussed in this report. Each technology is addressed separately with respect to its importance for a specific application utilizing photovoltaic (PV) cells to convert energy from the sun directly into electricity. Solar electric technologies continue to grow in importance as they contribute to the reduction of our dependence on domestic and imported fossil fuels—oil, natural gas, and coal—for satisfying the increasing demand for electricity in the United States. Solar electric systems can make an important contribution to the future energy needs of the United States, provided that industry and the public at large are informed about the potential of adopting this renewable energy resource. The United States government and the private solar energy sector are actively pursuing cost-effective methods to generate electric power for our citizens. The goal of this work is to broadcast this information throughout the Heartland in order to assure that solar electric systems will be considered as an alternative source of energy, instead of automatically assuming that utility-generated grid power is always the best choice for powering electrical devices. This report contains information that can be used by homeowners, farmers and ranchers, industry, and state governments in the Heartland to make an informed decision about selecting solar electric systems as the best choice to satisfy their needs for electric power.

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A. INTRODUCTION

Timely development of renewable energy technologies—including solar electric technologies—are essential to satisfy such national needs as reduction in our dependence on imported oil and an overall reduction in use of fossil fuels. Currently, most of the electricity generated in the United States relies on burning fossil fuels. Historically, except for nuclear power, Americans have been complacent about how and where their electricity is generated, as long as the cost is relatively low. The level of concern has fluctuated over the years, depending upon short-term issues. At this time, we hear concern about global warming caused by CO_2 emissions from coal- fired power plants, depletion of natural gas reserves, and the high percentage (greater than 50%) of imported oil. Even though there isn't an energy crisis in the Heartland, concern is growing about escalating energy costs. Thus, the potential exists for renewable energy to be used much more extensively than it is now. Prices of photovoltaic (PV) cells have dropped considerably in the last 20 years, product selection is the best it has ever been, and the quality of many PV-powered products is outstanding.

Off-grid photovoltaic power systems have been routinely used worldwide in areas where electrical energy requirements were relatively small and/or the power was needed in a remote area. These stand-alone PV power units are currently supplying cost-effective power for electric utility companies, municipalities, rural electric cooperatives, industry, governmental agencies, and private citizens. In addition to the cost of the initial installation, PV power offers several other important advantages. Photovoltaic power systems have no moving parts. They provide power entirely with solid-state electronics, which means PV-based products can be expected to provide a high degree of performance and reliability with little or no maintenance requirements. Use of PV-powered products has also been justified on the basis of reducing environmental impacts through the use of a non-polluting technology, elimination of siting problems due to easement restriction on private property, and use of a non-interruptible power supply that can survive outages in emergency situations. We feel that the market for off-grid PV products will continue to grow as this technology matures, and the public becomes more aware of its benefits.

Grid-connected PV arrays are a part of the solution needed to meet worldwide growing energy demands. It is projected that demand for PV arrays connected to the electric grid will grow at a steady rate for many years. Historically, growth has been slow because of the high cost of PV arrays and the low cost of coal-fired generation. It is projected that average electricity prices will not increase drastically in the United States in the next few years. If central power station electricity continues to be produced at or near its current price, then the PV power industry must continue to focus on special market areas and be creative in order to increase its grid-connected market. However, it is interesting to note that the price of solar energy has dropped from $25 per watt in 1980 to $3 - $7 per watt at this time. Thus, as conventional energy prices increase (due to environmental constraints, e.g., global warming) solar prices will continue to decrease. At some point, grid-connected solar energy will be competitive in the domestic market. Solar enthusiasts estimate that this will occur in 2010.

Three key renewable energy technologies of interest to the Heartland of America are wind, biomass, and solar electric. This report highlights the importance of solar electric technologies. The compilation of products reflects current cost-effective solar electric technologies especially important to people living and working in the Heartland. For the purpose of this study, the Heartland is defined as a region containing the following states: Iowa, Kansas, Missouri, Nebraska, and Oklahoma. Obviously, not all of the solar electric products presented in this report are cost-effective for every application in all locations. This report mainly focuses on various off-grid applications since, at this time; most of the cost-effective applications in the Heartland are off-grid. However, world-wide, the markets for solar panels are rapidly shifting from off-grid and consumer products to grid-connected power.

Information is also included on solar electric system design considerations, including the level of solar energy available throughout the Heartland and a list of commercial computer programs written specifically for solar electric system design. In addition, information is provided on local solar dealers, government agencies that receive federal funding for solar energy research, and state energy offices in the Heartland.

B. COST-EFFECTIVE APPLICATIONS

- Small-Battery Charging Applications
- Building-Integrated Photovoltaic Systems
- Cabin Power
- Cellular Call Boxes
- Cathodic Protection
- Fans and Vents
- Fence Chargers
- Gate Openers
- Lighting
    - Area Lighting
    - Marine Beacons
    - Outbuilding Lighting
    - Sign Lighting
    - Yard Lights
- Marine Power
- Original Equipment Manufacturing in Consumer Products
- Recreational Vehicles
- Supervisory Control and Data Acquisition Systems
- Traffic Control
- Transmission and Distribution Sectionalizing Switches
- Utility Grid-Connected Solar Panels
- Water Pumping Systems
    - Low-Volume Water Pumping
    - Medium-Volume Water Pumping (livestock water pumping)
    - High-Volume Water Pumping
- Solar Hot Water with Solar Electric Pump Power

1. Small-Battery Charging Applications

Solar electric panels (see Figure 1.1) are often used to charge batteries. Many "small" batteries are used where frequent recharging can create problems and expenses. Under these circumstances, people are often willing to pay for the convenience of automatic recharging with solar. In some of these applications, the photovoltaic (PV) panel is supplied by the original equipment manufacturer (OEM). Sometimes it is an option; sometimes it is added on as an "aftermarket" item and sometimes it is for a custom, site-built, or homemade project.

Figure 1.1. Small flexible solar panels. (Source: Uni-Solar Corporation)

Examples of small-battery charger applications are—

- OEM applications

  Airport tarmac equipment (see Figure 1.2.)

  Remote fire safety equipment

Figure 1.2. Airport solar battery charging application. (Source: Airport Automation, Inc.)

- Aftermarket applications

  PV to charge laptop and cell phone batteries

  PV for battery maintenance on vehicles, small airplanes, and heavy equipment

- Custom, site-built, and homemade applications

  PV to recharge traffic-counter batteries

  PV for small fountains or lighting in water gardens

  PV for small pumping, such as remote fuel tanks

  PV for running small motors in the field, such as mobile steps at truck stops

Sometimes these applications have a battery on "standby" that has to be fully charged and ready to go at any time, but may be used very rarely. Other applications are for batteries that are used every day.

Solar is great for these small-battery applications for several reasons. For example,

- PV keeps the battery more fully charged, and a fully charged battery lasts much longer.
- PV keeps the equipment ready for use at a moment's notice.
- PV can do the charging job without moving the equipment or stringing wires to remote locations.
- Small PV panels come in many sizes, shapes, and configurations to match the power and mounting requirements of the job.
- Small PV panels are now being "mass produced" so many affordable "off-the-shelf" options are available.

2. Building-Integrated Photovoltaic Systems

Building-integrated photovoltaic (BIPV) refers to the idea of making solar electric power panels an integral part of the building, rather than having them "added on." Basically, there are two choices: make the BIPV a part of the roof or make it a part of the wall. Due to the many kinds of roofs and walls (see Figures 2.1and 2.2), it has been difficult for the solar industry to create the "perfect" product for BIPV. Building-integrated photovoltaic power panels have been designed in many forms, such as metal roof-integrated panels, roof-integrated shingles, glazing material (glass) in "curtain-wall" type installations, and glazing to provide partial shading for greenhouses and canopies.

Figure 2.1. Building-integrated photovoltaic systems installed on buildings in the United States.

The solar industry is attempting to increase its volume of solar panel sales, and BIPV is seen as one of the most promising ways of achieving this goal. BIPV products are still awaiting full acceptance in the marketplace, partially because of cost, but more so because of the lack of technical knowledge within the building community concerning how to integrate a new product into its designs. Unfortunately, very few architects are schooled in this area. Thus, few people involved in the construction industry have thoughts and opinions about incorporating solar power into their building designs. Often

solar is one of the last or lowest priorities behind functionality, site restrictions, overall cost, aesthetics, roof design requirements, etc.

Figure 2.2. Roof-integrated PV panels being installed on a house.

BIPV has historically referred to larger, utility-grid-connected solar electric installations, because that is where the research has been focused to accelerate the rate at which these BIPV panels will be introduced into the commercial marketplace. Most BIPV products are intended to be used for buildings receiving some of their power from solar panels but using the electrical grid as a backup source of electricity. However, as the cost of these products decline, they will be the items of choice for many off-grid applications.

Questions and Answers

Are BIPV installations cost-effective? Cost-effectiveness has been a goal of BIPV from its beginning. The answer to the question depends on many factors, including which solar product is used; size of the installation; what "savings" are allocated to the integration, cost, type of billing, dependability, and quality of utility power at the site; what financial incentives (if any) are available to the solar part of the project; and what value is placed on applicable "side" benefits (backup or uninterruptible power, longer lasting roof, covered parking, educational program, cleaner air, less global warming). BIPV is growing quickly in areas of the U.S. and internationally where the cost of electricity is twice what we pay in the Midwest. These areas also are often locales that

offer financial incentives for solar projects as well. In general, cost-effectiveness for BIPV looks better for larger systems (to spread or remove "specialty" installation costs) located in high utility cost areas with financial incentives, and where all parties (building owner, developer, architect, engineers, local code and planning officials, and potential tenants) want solar as part of the building and place a high value on its benefits.

Are BIPV systems safe? Any electrical system requires that safety precautions be taken. With BIPV, this is even more important than with a "regular" solar electric system because of the size of most BIPV systems. The National Electrical Code has been changed and updated to reflect solar-related issues, but many localities have not adopted the latest versions of this code. Much of the equipment in the BIPV industry has acquired or is in the process of acquiring either UL or ETL safety listings. Inverters that synchronize with the utility grid have to meet rigorous requirements, including automatic grid disconnect if the utility grid is not operating properly.

What kind of maintenance is required? Very little maintenance is required for a BIPV system. The solar panels have long-term warranties, usually for 20 years. They are made to be exposed to the elements, so they are very hardy. Extremely flat placement of solar panels may require periodic cleaning, but panels at a slope should self-clean with rainwater. Systems that are used to provide battery backup power will require maintenance of batteries, as specified by the manufacturer. Systems tied to the utility grid do not require batteries for backup power.

To obtain further information:

Contact your local Heartland solar dealer for a detailed analysis of the benefits and costs of building-integrated photovoltaic systems.

3. Cabin Power

Some homes would be a "cabin" to the well-to-do. Some peoples' "cabin" would be a luxury home to many. So cabin isn't easy to define, but generally we are referring to a home that might be more of a "getaway" place or in other words, might be located remotely and used to escape some of the ties to our hectic everyday lifes. With these thoughts in mind, it is often possible and highly desirable for the cabin to be "off the grid," away from the ties and bill paying associated with utility power.

Part of the joys of cabin life may include the feeling of independence that comes with doing things for yourself. That may include work, not limited to chopping wood, washing dishes, and making repairs. Generating your own electrical energy might also contribute to this feeling of independence. Fortunately, for this aspect, not a huge amount of work is involved after initial installation of equipment.

In cabin systems (see Figure 3.1), PV panels recharge batteries that power limited numbers of lights, water pumps, power tools, ceiling fans, communications equipment (phone/radio/computer), entertainment components (TV/video), and sometimes refrigeration.

Figure 3.1. Solar panels mounted on the roof of a remote cabin. (Source: Kyocera Solar, Inc.)

Things like air conditioning, electric stoves, electric hot water, and electric heaters are out of the question. For the most part, PV panels provide just enough power to operate only four or five essential items for a limited amount of time, versus the energy-intensive appliances found in the average home. After all, cabin owners are trying to "get away from it all."

Questions and Answers

Is solar power for a cabin cheaper than utility power? It can be, especially if the cabin is not located close to a utility power line. The cost of extending a power line can be very expensive—often greater than $15,000 per mile in a remote area. In many cases, if you decide your power needs are somewhat limited, a small PV system is the most cost-effective way to provide power to a remote cabin.

How much solar do I need? It depends on two things—how much power do your limited number of appliances use and how many hours do they use it? A solar electric system with four, 64-watt solar panels might create about one kilowatt hour per average day in the Midwest. That is enough for efficient compact fluorescent lamps, water pumping, a little TV, and some quick power tool work. If you desire more power than this, you will need to install additional solar panels.

What about safety issues? With care, a handy homeowner can install a solar electric cabin system. System components include solar panels, a solar controller, a battery bank, and possibly an inverter (for AC power) all properly fused and grounded. The main danger is working with the batteries. Flooded batteries (like lead acid) need to be handled carefully. However, many deep-cycle batteries minimize this danger. Installing solar panels on the roof involves a certain amount of risk. Many cabin owners choose to mount solar panels on the ground. This allows greater flexibility for locating the power system where trees won't be a problem shading the surface of the panels and makes it easier for the cabin owner to wash the surface of the panels. Several companies

offer training courses for installing cabin power systems. Once the system is installed properly, it needs to be given the safety respect afforded any electrical source.

What maintenance is required? Not much, but with any equipment, it is good to check things out periodically. Check for good, clean wiring connections. Also, use a voltmeter, or better a solar controller, to monitor the state of charge of the batteries. A good solar controller will also display whether the PV array is producing and sending the necessary power to the batteries. It is important to keep the surface of the PV panels clean to maximize their efficiency.

Where can I buy cabin systems? Many Heartland solar dealers sell cabin system components for larger solar energy cabin systems, i.e., more than 100 watts. A few small, "plug-and-play" cabin systems are available from manufacturers such as Sun Wize and En-R-Pak at about 100 watts (see Figure 3.2).

Figure 3.2. Small solar electric power system for a remote cabin. (Source: En-R-Pak)

4. Cellular Call Boxes

In concept, an emergency calling system is one where motorists or pedestrians can be quickly and easily connected to a central call center. A network of solar-powered cellular call boxes is exactly that type of system. Call boxes have been placed on the sides of highways, bike paths, hiking trails, and university campuses for many years. However, most of these hard-wired call boxes have very limited capability. The person using the call box would push one button and, depending on where and why that call box had been installed at that location, that signal would be relayed to some type of emergency personnel (law enforcement, medical, roadside assistance, etc.). Today's cellular technologies allow stand-alone, battery-powered call boxes to be placed anywhere the sun shines (see Figure 4.1). These new systems still only require the push of a single button to contact the emergency number. But they are often equipped with a telephone so the caller can explain his or her specific problem and can be contacted later using the telephone in that call box, i.e., called back. In addition, the cell phone call can easily be monitored by a central computer so that extensive information is automatically recorded; for example, call box number, call box location, call box cellular telephone number, time of call, and date of call. In this way, the correct emergency response personnel can be dispatched to the exact location.

Figure 4.1. Solar panel on a call box in a remote location. (Source: NREL, Photographic Information eXchange)

Several technologies compete with the solar-powered cellular box. Historically, motorists or pedestrians have been able to reach someone for notification about an emergency situation, using stand-alone line-tied telephones. However, many times, these telephones cannot be economically located in remote locations where the need is greatest.

More recently, many people use their own cellular phones to call from almost any location in the United States. This is obviously a very convenient and important way to obtain emergency assistance. Situations where solar-powered cellular boxes are the best choice are addressed in the Questions and Answers section.

Questions and Answers

How many solar-powered call boxes are currently used to make emergency calls? There are over 25,000 call boxes operating in the United States.

What is the major application for solar-powered call boxes? Many call boxes are used by motorists since many are located along highways (see Figure 4.2). An increasing number of call boxes are being placed on bike paths, along jogging paths, in retail store parking lots, in parking garages, on city streets (see Figure 4.3), and on university campuses.

Figure 4.2. A call box emergency telephone call connected by the push of a single button. (Source: ww.paturnpike.com)

Why do we need call boxes when personal cell phones are available? Call boxes offer several advantages over personal cell phones. First, many people don't have a personal cell phone. From a safety standpoint, the call boxes "always" work. You won't find a region where a call box signal is too weak to be of any use, as is possible with a cell phone. The signal from a call box is much stronger than that of a standard personal cell phone, so call boxes are ideal for remote areas. Also, most call box networks communicate with a central computer that records the location of the call, monitors the status of the call box, and immediately identifies a malfunction.

Figure 4.3. A solar-powered call box that provides up to a 40-day charge with one day of sunlight. (Source: www.connectivityinc.com)

What new features are planned for future models of call boxes? Several ideas are being considered, e.g., they can be designed to gather traffic data and weather-related road conditions. They can even have a low-power beacon light to assist people in locating these emergency call boxes at night.

To obtain further information:

Contact your local Heartland solar dealer for a detailed analysis of the benefits and costs of installing a solar-powered cellular call box.

Contact the following manufacturers/installers of solar-powered cellular call boxes for additional information. Products manufactured by other companies may also be available at your local solar energy dealer.

Connectivity, Inc.
240 Comercial Blvd., 2nd Floor
Lauderdale-By-The-Sea, FL 33308
Toll Free: 877-776-9542
World Wide Web: www.connectivityinc.com

Comarco Wireless Technologies, Inc.
2 Cromwell Street
Irvine, CA 92618
Phone: 949-599-7400
Fax: 949-599-1415
Email: callinfo@comarco.com
World Wide Web: www.comarco.com

Schott Applied Power Corporation
4051 Alvis Court
Rocklin, CA 95677
Phone: 916-625-9033
Fax: 916-625-9032
World Wide Web: www.us.schott.com/apc/english

5. Cathodic Protection

To an increasing degree, companies specializing in providing cathodic protection are recognizing that a successful competitive strategy includes effective use of solar power. Many opportunities exist for incorporating solar-generated power into the wide array of cathodic protection (CP) products available commercially. Many CP systems are situated in remote locations that do not have utility power. As the cost of extending utility power lines continues to increase, solar energy has become a cost-effective way of providing the required electricity needed to charge the batteries that provide the low dc voltage (about one volt) required to operate corrosion protection systems 24 hours a day. Solar-powered systems are designed to maintain the current output of the batteries at an effective level even during extended period of cloudy days.

Corrosion is a major problem for structures where metal components are buried or submerged. Corrosion occurs throughout the Heartland in structures containing steel components—gas and oil pipelines, steel storage tanks, well casings, and reinforcing steel in concrete structures, e.g., highway bridge decks, steel in parking garages, docks, and retaining walls. It is widely accepted that CP is the only technique that can prevent corrosion in bridge decks.

Questions and Answers

What is cathodic protection? Cathodic protection is the impressing of a constant current on a metallic structure (the corroding structure or the cathode of the system) that is in contact with the earth or water. As long as this current flows, the structure is maintained at a constant voltage. This significantly reduces the rate at which corrosion (the process of oxidation of a metal due to the interaction of the metal and its environment) occurs on metallic surfaces.

Why is cathodic protection necessary, since most steel components subject to corrosion are coated? Most steel components exposed to a corrosive environment are coated. However, this does not eliminate the need for active CD protection. This coating can be damaged during construction and often contains small voids that act as accelerated corrosion sites.

Why is corrosion a major problem on highway bridge decks? During the winter, bridge decks are treated with deicers containing chlorine. Exposure to the chlorine in the deicer significantly accelerates the rate of corrosion.

To obtain further information:

Contact your local Heartland solar dealer for a detailed analysis of the benefits and costs of installing a solar-powered cathodic protection system.

Contact the following manufacturers/installers of solar-powered cathodic protection systems for additional information. Products manufactured by other companies may also be available at your local Heartland solar energy dealer.

ETA Engineering
2010 E. University Dr.
Suite #20
Tempe, AZ 85281
Phone: 480-966-1380
Toll Free: 1-877-964-4188
Fax: 480-966-1516
Email: energy@engineering.com
World Wide Web: http://etaengineering.com/contact.html

Northern Arizona Wind & Sun, Inc.
2725 E. Lakin Dr., #2
Flagstaff, AZ 86004
Toll Free: 1-800-383-0195
Fax: 928-527-0729
Email: Windsun@Windsun.com
World Wide Web: http://www.windsun.com/

Additional information can be found on the World Wide Web using the key words: cathodic protection.

6. Fans and Vents

A wide range of solar-powered fans and vents are available. The long-range future for this industry is very good. Continuous improvement in DC fan motors and overall product design, combined with the dropping costs of solar cells, have resulted in the development and manufacturing of many cost-effective products. The growing importance of selecting the most convenient and cost-effective way of providing ventilation and space cooling is reflected in the increasing demand for solar-powered fans and vents. Today the decision for a homeowner or business with property located in the Heartland is not drastically affected by cost of electricity. However, almost everyone would like to reduce his or her electric bills. Thus, because of their convenience and low operating cost, photovoltaic-powered devices are becoming the products of choice for a variety of applications such as roof vents, greenhouses, and remote buildings.

Figure 6.1. Solar-powered roof ventilator fan. (Source: suntunnel.com)

To adequately vent an attic or other building spaces requires careful design of the air handling system. Fan and vents are consumer items whose specifications should be carefully reviewed and matched to each specific application before they are purchased. Because of this, it's crucial that you talk to a knowledgeable Heartland dealer about your application to determine your exact cooling requirements before purchasing fans or vents.

Solar fans and vents are available to satisfy a variety of applications, ranging from a small enclosed space such as a small storage shed to large spaces like attics in homes or commercial buildings. Many solar fans and vents are designed for a specific purpose. The fan shown in Figure 6.1 has an air flow rate of 800 CFM (cubic feet per minute) and is used to vent attics. The fan in Figure 6.2 has an air flow rate of 1000 CFM and is designed to be mounted in a wall or ceiling. An example of a lower flow rate (100 CFM) fan is shown in Figure 6.3. This is a popular design because the fan can be easily

mounted onto a 4-inch roof vent pipe of outbuildings. Much lower flow rate fans are also commercially available, e.g., below 10 CFM. Some of these very low flow rate fans have limited application.

Figure 6.2. DC fan and solar panel for daytime ventilation.

Figure 6.3. Small outhouse roof ventilation fan.

Questions and Answers

Where can I obtain technical information about solar fans and vents? The best source of information is from your Heartland dealer. Another option for information about these consumer products is to search the World Wide Web.

Where can I purchase these products? Again, the best approach is to contact your Heartland solar dealer. Obviously, they can be purchased from a World Wide Web site or ordered from a catalog. This can be a mistake. Specifications listed for some solar fan and vent products do not provide adequate information to allow the consumer the opportunity to make an educated decision about performance of the product. Manufacturers may list items such as motor current, housing dimensions, etc. but never mention the most important specification—the air flow rate. Therefore, it is

recommended that for this solar energy application you seek the expert advice available from one of the Heartland solar dealers.

To obtain further information:

Contact your local Heartland solar dealer for a detailed analysis of the benefits and costs of installing solar-powered fans and vents.

7. Fence Chargers

Electric fences have been energized for many years using batteries charged by a single solar module. This is a great example of a solar electric application ideally suited for use throughout the Heartland. These compact units can be used anyplace that an electric fence can be installed, as long as it is placed in a sunny location away from tall plants or other objects that would shade the solar panel. Most solar fence chargers have a long-life weatherproof housing containing the rechargeable battery and electronics. Some units even have a lifetime guarantee on the housing. It is important to purchase only UL-listed chargers.

The solar panel can be mounted directly to its weatherproof housing (as shown in Figure 7.1) or connected to the housing with an electrical cable. Each contains

Figure 7.1. Parmak Model MAG.12 Solar-Pak fence charger with the solar panel mounted directly to the housing. (Source: www.parmakusa.com)

electronic controls and features built-in performance indicators showing the fence condition. They are available in many sizes to satisfy almost any electric fence-charging application — from small to medium areas enclosed by a few miles of fence up to very large units for large enclosures. A typical charger for agricultural use for livestock control (shown in Figure 7.2) or predator control would be one with a several-mile range, capable of operating 24 hours a day for up to three weeks of cloudy days. A wild game preserve might require even larger chargers.

Solar electric fence chargers and replacement batteries can be purchased at local farm supply and hardware stores. If you have trouble finding a solar electric fence charger, you should contact your Heartland solar dealer.

Figure 7.2. Cows grazing in a pasture enclosed with a solar-charged electric fence. (Source: NREL, Photographic Information eXchange)

Questions and Answers

How does a solar fence charger work? The charger contains a rechargeable battery and solid-state circuitry in a weatherproof enclosure. A small solar panel, located outside the enclosure, is connected to the battery's charging electronics. This solar panel will charge the battery even on cloudy days but performs best in direct sunlight. Many solar chargers have a full two-year warranty.

Do these chargers require removal of the battery for recharging? No. The solar charger automatically keeps the battery charged, which eliminates the need to remove the battery to charge it. Thus solar charging uses only the free energy from the sun and eliminates the use of electricity from the power line. These units operate 100% independently of the power line grid and can be located any place the sun shines. The only time you need to touch the battery is to replace it with a new one. Many solar chargers use rechargeable batteries warranted for one year.

Do solar chargers use lead-acid automobile batteries? No. They use deep-cycle batteries designed for long life. Automobile batteries are designed to operate in a nearly full state of charge, while the batteries in solar chargers are optimized for operation in an environment where the battery is cycled from fully charged to a significantly discharged state.

To obtain further information:

Contact your local Heartland solar dealer for a detailed analysis of the benefits and costs of installing a solar-powered electric fence charger.

Contact the following manufacturers of solar-powered electric fence chargers for additional information. Products manufactured by other companies may also be available at your local Heartland solar dealer, e.g., Sureguard manufactured in Australia, Daken Farm Equipment manufactured in Australia, Bramley and Wellesley manufactured in the UK, and Speedrite by Tru-Test manufactured in New Zealand.

Parmak Precision
Parker McCrory Manufacturing Co.
2000 Forest Avenue
Kansas City, MO 64108
Phone: 816-221-2000
Fax: 816-221-9879
Email: info@parmakusa.com
World Wide Web: http://parmakusa.com/

Gallagher Power Fence, Inc.
P.O. Box 708900
San Antonio, TX 78270
Toll Free: 1-800-531-5908
Phone: (210) 494-5211
Fax: 210-494-0364
World Wide Web: http://gallagherusa.com/

FiShock Inc.
5360 National Drive
Knoxville, TN 37914
Toll Free: 1-800-251-9288
Phone: 865-524-7380
Fax: 865-673-4770
World Wide Web: http://www.fishock.com/

RedSnap'r
North Central Plastics, Inc.
906 Fifth Avenue East
Ellendale, MN 56026
Phone: 507-684-3721
Fax: 507-684-3722
Email: ncp@redsnapr.com
World Wide Web: http://www.redsnapr.com

Zareba
P.O. Box 6117
Rochester, MN 55903-6177
Phone: 507-252-3777
Email: farninfo@wtrs.com
World Wide Web: http://www.zarebasystems.com

8. Gate Openers

To an increasing degree, individuals and businesses are recognizing that solar modules are a cost-effective option for charging automatic gate-opener batteries. Many opportunities exit for incorporating solar electricity into gate-opener products. Thus, new solar battery-charger designs have been incorporated into the manufacturing of solar battery-charger products for the automatic gate-opening industry. Solar battery chargers are designed to fit specific gate-opening applications.

Automatic gate-opener applications range from small (about 3.5 feet in width) and lightweight gates for the homeowner, up to long (say 30 feet) and heavy gates for businesses. Gates are available in both single- and dual-swing models, as well as slide gates. Smaller units are often designed to be installed by the customer. As shown in Figure 8.1, battery-powered gate openers make entering and exiting residential property handy and safe. They help protect the privacy of farm and range home entrances, and allow quick and easy access to pastures. Many industrial and commercial applications exit. They can be used to gain access to gated apartment complexes, and to enter secure industrial and government areas. General features listed by manufacturers for battery-operated solar electric gate openers include solid state controls; 12-volt DC motors; entry control options—push button, digital keypad entry control, or radio receiver/transmitter; a solar or AC-powered battery charger; a weatherproof control box; no external power requirements; and a manual gate release. Benefits include dependability, less expensive to install, easy installation for a large

Figure 8.1. Automatic gate opener in operation. (Source: www/gtpomc.com)

variety of applications, operate on safe low voltage, economical for remote locations with solar battery charger, and resistant to lightning static.

Two options exist for charging gate-opener batteries—solar electricity or grid-connected AC voltage. AC systems are supplied with an automatic battery charger powered by utility grid electricity. Solar systems operate independently of the utility grid, since the electricity required to charge the battery is supplied by direct conversion of sunlight to electricity using a solar panel. Many small gate openers operate efficiently on a small, five-watt solar panel. As gate size and, hence, power requirements increase, the wattage of the solar panel is increased.

Questions and Answers

Are solar-powered battery chargers more expensive than AC battery chargers? No, not when you consider life-cycle and installation costs. If one considers only the cost of the gate-opener hardware, the initial cost of a solar-powered system is more than the cost of an equivalent AC system, because the solar module and charge regulator cost more than the AC-powered battery charger. However, installation costs and operational costs are generally lower for a solar-powered system. Providing AC power to the site can be very expensive. Thus, once you factor in the cost of electricity to operate the AC-powered system versus the free energy from the sun for the solar system and installation costs, you will find that solar power is a cost-effective option.

Figure 8.2. A solar-powered gate opener located near a power line. (Source: NREL, Photographic Information eXchange)

As shown in Figure 8.2, the gate owner decided to use a solar electric system, even though an AC power line was available at the site. Otherwise, it would have been

necessary to install a transformer and electrical outlet, and pay monthly electric utility bills.

Which type of system is safer to install? Solar-powered systems are safer, since they operate 100% on low voltage. Manufacturers of solar-powered gate openers even design units that can be installed by the customer, not by professional installers and/or electricians.

How do maintenance costs compare between solar and AC units? These costs should be about the same. The major cost will be replacement of the deep-cycle battery. Since both types use the same type of battery, these costs should be independent of which technology is used to charge the batteries.

To obtain further information:

Contact your local Heartland solar dealer for a detailed analysis of the benefits and costs of installing a solar-powered gate opener.

Contact the following manufacturers of solar-powered gate openers for additional information. Products manufactured by other companies may also be available at your local solar energy dealer.

APOLLO Gate Operators
12902 Delivery Drive
San Antonio, TX 78247
Fax: 210-545-2815
Email: sales@apollogate.com
World Wide Web: http://wwwapollogateoperators.com/

GTO/PRO
Toll Free: 1-800-543-GATE
Phone: 850-575-0176
Fax: 850-575-8912
Email: gtopro@gtoinc.com
Email: mightymule@gtoinc.com
World Wide Web: http://www.gtoinc.com/

U.S. Automatic
118 Hillside
Lewisville, TX 75057
Toll Free: 1-888-204-0174
Phone: 972-221-7000
Fax: 972-436-6636
Email: usauto@dallas.net
World Wide Web: http://www.usautomatic.com/

9. Lighting

Area Lighting

Area lighting in locations remote from utility power (see Figure 9.1) was one of the early solar electric applications. These remote locations are excellent solar power situations for several reasons:

- High costs for extending power lines make for instant "payback".
- Utilities have little incentive to extend lines for "low revenue" use.
- Remote locations with little ambient light make even smaller solar-powered area lights look bright.
- Customers, park patrons, etc. are grateful for light "in the middle of nowhere."
- Lighting efficiency advances (compact fluorescents, low-pressure sodium, and now, light-emitting diodes) outpace even solar advances (see Figure 9.2).
- Solar lighting controllers have improved circuitry for timed on-off lamp control and battery voltage control.
- Reliability is improved with maintenance-free batteries (AGM's and Gel's).

Figure 9.1. An area light at a remote location. (Source: En-R-light)

Figure 9.2. A common configuration for a commercial area light, showing the PV panel and the light mounted at the top of the pole. The storage battery is not shown in the photograph. (Source: Sun Wize)

Marine Beacons

For navigational aids, we begin by stating the obvious—the importance of various attributes that customers consider in making a purchase is strongly dependent on trouble-free performance. Solar-powered navigational aids have been used for many years. Basically, these devices contain a solar panel, light, battery, and control electronics all protected inside a sealed enclosure. Thus, the marine industry has a cost-effective, maintenance-free product that can be easily installed in any sunny location. Recent models include high-intensity white LEDs, in addition to colored LEDs that last the lifetime of the solar beacon (see Figure 9.3).

Figure 9.3. Marine light with low-power LEDs.

Solar-powered flashing beacons are available in many sizes (see Figures 9.4a and 9.4b), and they work especially well on the inland lakes found throughout the Heartland. These lakes do not require the three-mile-plus visibility that can drive up the cost of solar beacons. Smaller beacons work fine, with about a mile of visibility and much lower cost. These units can pay for themselves from the start by avoiding the costs of power line extensions, which may not even be possible on floating structures, for instance. They can also save on maintenance costs due to staff performing the sometimes tricky and time-consuming work of replacing batteries out on the lake.

Figure 9.4a. Compact solar beacons with small solar panels designed to be mounted to a variety of structures, e.g., floating buoys. (Source: Carmanah)

Figure 9.4b. Post-mounted solar beacon designed to use a larger solar panel for charging the beacon's deep-cycle battery. (Source: SES Flexcharge Nightstar)

Outbuilding Lighting

Many outbuildings have no source of electric power for lighting. Solar-powered lighting can solve this problem. Often outbuildings are far enough from utility power that there is significant cost, labor, or hassle to bring in power for what amounts to a very small load. If these costs have to be borne by the user and are not given "free" by the utility, there are strong reasons to go with solar as the power source. Consider—

- Solar is safer than kerosene lanterns.
- Solar is safer and quieter than fueled generators.
- Solar can power many electrical loads, from lighting to power tools.

If the need is only for lighting at the outbuilding location, small pre-wired systems may work well and be affordable (see Figure 9.5).

Figure 9.5. Pre-wired outbuilding solar-powered light with battery storage. (Source: Sun Wize)

If the need is to power things other than lighting, like power tools, a system can be designed with an accessible battery for adding an inverter for AC power tool use. Potential applications include farm/ranch outbuildings and sheds, telephone battery/power/control rooms in remote locations, remote product distribution sub-centers, pipeline outbuildings, and park restrooms.

Outbuilding lighting can be done with either pre-packaged, pre-wired systems or with systems configured from components. Usually, for a one-light situation, a pre-packaged unit would be less expensive and easier to install. If multiple lights are needed, then the choice is either to purchase additional pre-wired products or go with a

configured system. If there is a need for additional battery storage, additional components (such as a fan), or more than about 100 watts of solar power, then a configured system is a good choice.

Sign Lighting

Solar sign lighting seems to be a large and only partially realized solar business opportunity. Currently, there are solar-lit signs of almost every size, from small signs of a few square feet to some of the largest billboards. Almost all of the signs use solar electric power combined with battery storage to power conventional, but usually 12-volt, lighting fixtures. In smaller solar sign applications, designers are beginning to use the new white light-emitting diode (LED) lamps because of their dependability, energy efficiency, and superb cold-weather starting.

Flooding light onto a sign surface (see Figure 9.6) is still more efficient than say, interior sign lighting, so it is by far the leading solar sign application. One problem with a solar sign application is that the size of the solar panel can get to be as big as the sign, if it is in a poor location or if the lighting method uses a lot of energy. Interior lighting of

Figure 9.6. Solar electric panels recharge a battery, and a solar lighting controller/timer turns the light on at dusk. (Source: Solar Electric Systems/KC)

translucent signs uses several times as much energy as “flooding” the sign with light from the exterior. LED changeable message signs are intriguing but require the surface area of the sign to be covered with LEDs that consume power 24 hours a day. Usually solar

technicians are called upon to try to solar power a sign made to be connected to the unlimited power supply of the utility grid. Almost no signs are designed specifically to be solar powered. Further work on methods of conveying a message by sign in energy-efficient ways could lead to large increases in the number of solar-powered signs. An example of a solar-powered informational sign is shown in Figure 9.7.

Figure 9.7. A solar electric panel charges a battery that will power a light built into the informational display. (Source: Carmanah Technologies Corporation)

Yard Lights

A large selection of walkway and garden lights are now available at your local hardware store or garden center. Many low intensity solar light products contain advanced technology white LEDs and rechargeable batteries that can be replaced when they no longer retain an adequate charge. Other popular outdoor light fixtures that produce more light use fluorescent light bulbs. Solar lights are very easy to install since they do not require any electrical wiring (see Figure 9.8). All that is required is that you place them in a sunny location in your yard. Even though solar lights are normally not as bright as AC powered floodlights or low voltage yard lights, they provide adequate light for many applications.

Figure 9.8. A small solar cell mounted on top of this yard light provides all of the power needed to charge the light fixture's battery. (Source: Intermatic Incorporated)

Questions and Answers

Why are solar lights considered to be a cost-effective alternative to using electric lights plugged into a utility grid outlet? Solar light products are great examples of cost-effective solar electric applications. Higher power units like area, outbuilding, and sign lighting, are cost effective if utility power is unavailable or costly. Marine lights are cost-effective because of their remote location and required dependability. Solar yard lights are popular because they can be easily installed anyplace in a sunny location.

Why are solar yard lights so easy to install? First of all, solar lights do not require utility power; therefore, most solar lighting applications do not require an electrician—or even an electrical cable. Basically, solar yard lights are small units that only need to be removed from the packing box and placed directly in the yard or on an outdoor patio table.

To obtain further information:

Contact your local Heartland solar dealer for a detailed analysis of the benefits and costs of installing solar-powered lights.

10. Marine Power

The growing importance of solar electricity for power applications independent of the utility grid is reflected in the increasing use of solar power by boat owners and as navigational aids. (Note: Information on solar beacons is presented in the *Lighting/Marine Beacons s*ection.) Marine power applications are great examples of a cost-effective way to charge batteries using solar power. Today, manufacturers of solar power systems for boats offer a variety of products designed to satisfy the marine industry. Not only has there been an overall increase in product selection, but the more technologically advanced solar marine product companies are offering state-of-the-art battery-charging products. Applications range from trickle-charging batteries to operating a wide variety of on-board appliances installed in larger boats. Solar electric products are available as battery-charging kits that provide cost-effective solar power for the growing boating market. Several manufacturers offer battery-charging kits that require minimal installation. You just connect the solar-charger output cable to your battery. Popular battery-charger kits include a photovoltaic module, a charge controller, mounting hardware, heavy-duty marine-grade wiring, and an installation guide. These chargers are designed to trickle-charge batteries during storage to maintain a full charge on a standard 12-volt battery. Thus, once the solar charger is connected, the battery is always fully charged, eliminating the hassle of using utility power to keep the boat's battery charged. Another common application is providing power to on-board appliances. The range of appliance applications includes powering lights, TVs, radios, and circulation pumps.

Advantages and features quoted by manufacturers include the following:

- quiet battery charging, eliminating the need for on-board generators
- reliable performance because they are rugged, weather-tested, and have no moving parts
- environmentally friendly because they use sunlight instead of fossil fuels
- come with a long-term warranty
- easily expandable and virtually maintenance-free
- no cost to operate

To obtain further information:

Contact your local Heartland solar dealer for a detailed analysis of the benefits and costs of installing solar-powered systems for marine applications.

11. Original Equipment Manufacturing in Consumer Products

OEM solar applications are products with solar power built in. Almost everyone has used a solar calculator, probably the original solar OEM application. Integrating solar into battery-powered products can extend the life of the battery and eliminate the inconvenience of downtime and battery replacement and its associated costs. How many times have the batteries run low, requiring not only the hassle of replacement but also a trip to the store for more? Solar OEM products become especially valuable when the store is miles or maybe hours or days away.

The "right" application for solar OEM has several qualities. First, it must use electrical power, but not too much or too little. If the device uses too little power, then a battery will power it for such an extended time that there is little inconvenience or cost associated with battery replacement. If the battery takes two years to "run down," it is probably time to do a little "look see" maintenance (if it is remote) on the device anyway. If it is not a remote field-type device, then changing a battery every couple of years is often not too much trouble. There has to be a problem before there should be a (solar) solution. If the device is difficult to get to, if power failure would have consequences, if it is a pain to frequently change batteries, then the device is a candidate for solar OEM. On the other side of things, if the device uses "too much" power, then the size of the solar array can become awkwardly large or costly. In this situation, can modifications be made to lower power demand? Often, if a device had used utility "plug-in" power, little consideration was made as to power consumption. If that power use can be lowered into the range that solar OEM could be useful, then often new markets for the product can be opened.

A man once asked if anyone had ever paid $100 a kilowatt hour for electricity (knowing that the going utility rate in the area was about a dime a kilowatt hour). No one spoke up, so he declared, "You <u>all</u> have paid $100 per kilowatt of electricity!" Reaching in his pocket, he pulled out a common battery. Holding it up, he said, "Anyone who has purchased one of these batteries has paid $100 per kilowatt hour for electricity!"

Using $100-per-kilowatt power usually means a lot of thought has gone into lowering power consumption, which is good for a small PV application. The device would have to include a rechargeable battery, although solar PV OEM devices also allow for additional conventional batteries to be used.

Of course the device would have to be exposed to light for the PV panel to recharge the batteries. Solar calculators work well even with indoor lighting. Higher power-drain applications like radios and MP3 players would need exposure to real sunlight to do much recharging. With the price and inconvenience of replacing conventional batteries when they run down, a good PV-powered OEM device can pay for itself quickly in saved dollars and hassle. Three examples are shown in Figures 11.1 - 11.3.

Figure 11.1. Solar-powered MP3 player.

Figure 11.2 Solar-powered stereo headset.

**(Source: Iowa Thin Film, 2337 230th St.
Boone, IA 50036, (515) 292-7606, http://www.iowathinfilm.com)**

Figure 11.3. -AM/FM/SW/TV radio with solar power. (Source: http://www.sun-mate.com)

12. Recreational Vehicles

Recreational vehicles have many electric power-draining items (see Figure 12.1).

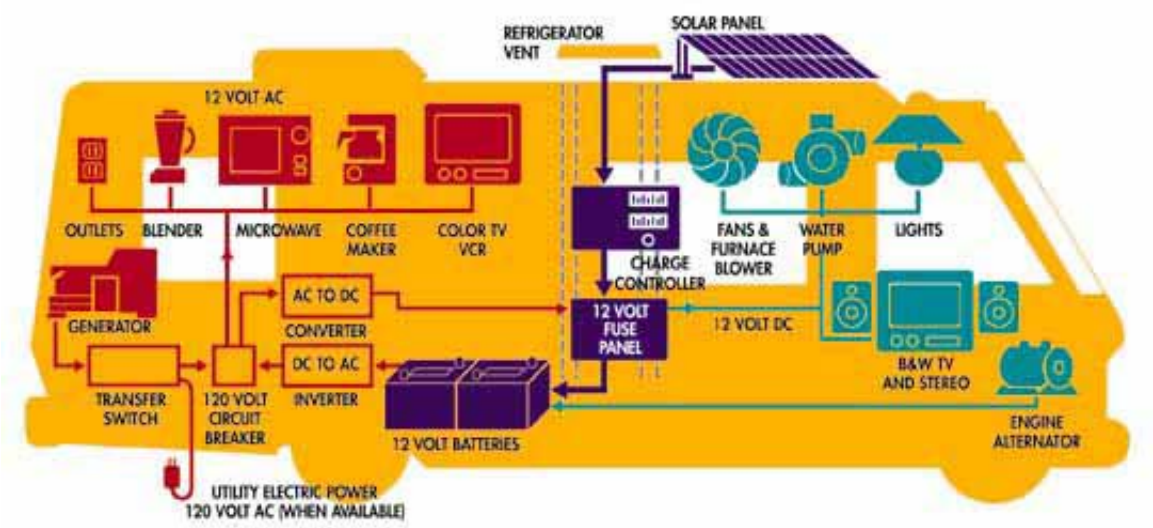

Figure 12.1. Appliances and other DC/AC-operated systems inside a recreational vehicle. (Source: Kyocera Solar)

In the past, when power from the engine alternator was not available, this has required a fossil fuel-powered generator or parking the RV close to a utility power hookup. Now, solar panels add an on-board power supply that is clean and quiet. Whatever the power source, the job is to recharge the batteries that provide power to 12-volt DC appliances and the DC-to-AC inverter that powers the 120-volt AC appliances. This can be done by a generator, but they are noisy, require messy refueling, and emit noxious fumes. Fellow RV campers don't appreciate these generator by-products anymore than the generator owner. Solar is an increasingly popular way to reduce generator run time. Because solar electricity is so clean, quiet, and carefree, it has been welcomed by RV owners as a popular power source.

Questions and Answers

What does it take to install solar on an RV? Solar panels mount to the roof with brackets that are now common in the industry. From there, a positive and negative lead runs to a solar charge controller. The charge controller can have several functions. Its

basic function is to prevent overcharging (and ruining) the batteries by the solar panels. It does this by monitoring the state of charge of the battery and controlling how much power from the solar panels is allowed to pass though to the batteries. The charge controller may also display battery state of charge, solar power output, or even load (power drain) information by using LED lights, or better, by analog (needle) or digital metering. The more information your charge controller can display the better, because it helps users understand how their system is operating.

Is solar for RV applications cost-effective? Satisfied RV solar power users who are recommending solar to fellow RV owners would say yes, although it is more a subjective opinion than a numbers calculation. There would be some savings in fuel and utility hookup charges. Most of the savings is in the aggravation caused by the noise, fumes, and hassle of using a generator. Not being confined to only campsites with utility power hookups also expands opportunities and can lower costs.

To obtain further information:

Contact your local Heartland solar dealer for a detailed analysis of the benefits and costs of installing a solar-powered battery charger on your recreational vehicle.

13. Supervisory Control and Data Acquisition (SCADA)

Microcomputer monitoring devices can record increasing amounts of information. Additionally, efficient methods of delivering that information by radio waves to a central point are becoming commonplace. Often these devices do not only monitor, record, and deliver information, but related devices can also control a process.

As these devices get smaller and more energy efficient, agencies are placing them in more and more locations, often remote from utility power or even easy battery replacement. This is where solar is playing a growing role in SCADA applications. As with other solar applications, the PV is used to maintain the charge in a battery, which powers the SCADA device. Like other solar applications, the power production (on average) has to balance with the power consumption (on average). The battery saves the solar electric power for use by the unit through the night and through low sun periods. These batteries must be deep-cycle batteries, suitable for discharging and recharging.

Questions and Answers

Why is this application cost-effective? Solar-powered SCADA applications have many cost-saving benefits. Directly, solar-powered installation can save significant maintenance costs since personnel costs are reduced, because these systems greatly extend the frequency of battery replacement. Often it can take hours just to get to a remote site. Also, costly data loss associated with battery failure can be virtually eliminated.

How important is this application to industry? It is a very important cost-savings application and allows the user freedom to place the SCADA system in remote locations away from utility power sources. Such remote applications can improve efficiency, lower costs, improve service, and help secure operations.

What are some common applications? Solar-powered SCADA systems are popular in natural gas, oil, and water pipeline situations (see Figure 13.1); weather and lightning monitoring; railroad crossing warning signs; and traffic warning and monitoring.

Figure 13.1. Pipeline SCADA application.

14. Traffic Control

Solar electric power for traffic control has expanded rapidly, both by replacing fueled generators and in new applications. Solar power has often proven to be an improvement over fueled generators for several reasons:

- eliminates refueling and associated labor
- eliminates mess and hazards associated with refueling spillages
- eliminates "downtime" caused by missed refueling times

Photovoltaic cell technology has progressed and improved, but improvements in LEDs or light-emitting diodes have opened the door for solar applications in traffic control (see Figures 14.1 and 14.2). Signaling with LEDs is more energy efficient and more dependable than with incandescent lamps previously used. LEDs improved energy efficiencies have allowed PV cells to do jobs that previously required too much power.

Figure 14.1. Speed indicator. (Source: Kustom Signals)

Examples of solar power for traffic control are growing, for example—

- Replacing fueled generators
  - Arrow and message boards on trailers
- New applications
  - Speed zone flashers
  - Speed zone radar displays
  - Hazard warning flashers
  - Permanent arrows and road markers
  - Traffic counters

Similar "traffic control" applications are now also found in the railroad industry. Solar-powered flashers now mark train cars and power remote intersection flashers. Solar energy now powers many switches in rail yards (it's often very hard to run power lines across multiple train tracks) and in remote areas that once relied on elaborate fueled generators.

To obtain further information:

Contact your local Heartland solar dealer for a detailed analysis of the benefits and costs of purchasing a solar-powered traffic control device.

Contact the following manufacturers of solar-powered traffic control devices for additional information. Products manufactured by other companies may also be available at your local solar energy dealer.

Kustom Signals, Inc.
Steve Hocker, Product Manager
9325 Pflumm
Lenexa, KS 66215
Phone: 913-492-1400
Toll Free: 800-458-7866
FAX: 913-492-1703
Email: Shocker@kustomsignals.com

SUPERIOR SIGNALS, INC.
15785 South Keeler Terrace
Olathe, KS 66062
Phone: 913-780-1440
Toll Free: **800-447-3693**
Fax: 913-780-1427
Email: sssales@smhco.com

Figure 14.2. Traffic manager arrow board. (Source: Superior Signals)

15. Transmission and Distribution Sectionalizing Switches

Sectionalizing switches are an example of a cost-effective application for electric utilities requiring reliable low power in isolated areas. Utilities use these switches to isolate portions of a distribution or transmission line so that they can optimize the distribution of power on their grid or for maintenance purposes. Several options are available for controlling these switches—one manual procedure and three procedures using remote control. Manual control requires that an employee travel to the site and manually close the switch. There are three options for powering switches using remote control: (a) if the automatic power line sectionalizing equipment is located at the substation, then the utility company would install a transformer at that site to provide 110 AC voltage; (b) if the switch is not located at a substation, then the utility company must run a power line extension (this might not be cost-effective, depending on the length of the new transmission line and terrain); or (c) for a remote location, the utility company could install a stand-alone solar electric system to charge the battery that powers the switch (see Figure 15.1).

Market potential is significant for this application in the Heartland. One of the major advantages of using solar energy is the increased reliability that the utility can achieve by providing its customers improved performance with a power source that is independent of the distribution line.

Figure 15.1. Electric utility power lines requiring T&D switches.
(source: NREL, Photographic Information eXchange)

Questions and Answers

Why would a utility company be interested in installing a solar-powered transmission and distribution sectionalizing switch system? Utilities have found that this is a cost-effective option because it eliminates the need to install either a power line extension or the need to install transformers to step down transmission line voltages to power battery chargers.

Is there data to support the statement that this photovoltaic application is cost-effective for electrical utilities? Yes. Data are available that show that utilities can save an average of $4,000 per installation (Cost-Effective Photovoltaic-Powered Transmission and Distribution Sectionalizing Switches, TR-100712, Electric Power Research Institute, 1993).

To obtain further information:

Contact your local Heartland solar dealer for a detailed analysis of the benefits and costs of installing solar-powered transmission and distribution sectionalizing switches.

16. Utility Grid-Connected Solar Panels

Connecting solar electric power to the utility grid is relatively new to the Heartland. We have had one of the lowest consumer cost, highest reliability, and most ever-present electric utility grids on the planet. The usual motivations of high cost electricity, unreliability or total lack of availability have not been factors to stimulate solar sales in the region. Still, there are people and companies who want to produce a portion of their own power using solar energy while still enjoying the benefits of being connected to the grid. As shown in Figure 16.1, that is certainly possible. Patterning after parts of the country where grid interconnection is more popular, e.g., California, some Heartland residents and companies are now generating solar electricity either for their homes or businesses with excess power going into the electric utility grid.

Figure 16.1. A grid-connected home in Kansas with solar panels mounted on the roof.

It is estimated that solar electric power is about four times more expensive than utility power in the Heartland. That is why it is more popular in places where electric utilities charge at least twice what most Midwesterners pay. Or, in places where states pay rebates or tax credits to solar buyers. Or, in places where there have been reliability issues, such as blackouts, brownouts or power shortages. Grid connected power is especially popular in areas with all three factors, high grid-connected costs, state incentives and reliability issues.

Interconnecting electric power to the existing utility grid is serious business and requires the right equipment and installation procedures. The key piece of equipment in the interconnection is the synchronous inverter. Its job is to take the solar generated DC power, invert it to AC for use in the building or by the utility grid. A prime concern is safety of utility line workers. Good PV synchronous inverters are certified to separate from the utility grid if the grid is "down." This protects utility personnel who expect the line to be dead, not energized.

More than 30 states have passed legislation making it easier and safer to connect PV equipment to the existing utility grid. Kansas has improved solar-utility interconnection laws in recent years. Missouri in 2002 passed the most restrictive solar-utility interconnection requirements in the country. Iowa has a 'net-metering' law that has been in place the longest in the region.

17. Water Pumping Systems

The price of solar electric water pumping systems has been decreasing at a steady rate due to increasing demand for solar pumps and the drop in price of solar cells. At this time, livestock water pumping is considered to have a great potential for growth.

An effective procedure for increasing the energy production from a PV water pumping system is to assemble the solar modules on solar tracking mounts. This is consistent with the prevailing desire to always extract the maximum power from all PV array configurations. Trackers allow the modules to capture maximum energy from the sun's rays from the first twinkle of morning light until sunset. Integration of tracking mounts in the design of pumping systems requires application of advanced design considerations. Tracking innovations allow the design engineer to take advantage of the dynamic nature of solar energy to guarantee that the surface of each PV module is positioned close to a 90° angle to the sun as the sun travels across the sky. This procedure provides assurance that the length of time that the water pump operates at its greatest potential is maximized. An important determinant of cost-effectiveness is the added maintenance associated with solar trackers.

Computer software is available for designing PV water pumping systems. Heartland solar dealers and companies that manufacture solar pumps can assist in characterizing the performance of different systems and their ability to supply the needed amount of water.

In the following discussion, water pumping systems are broken down into three categories:

- low volume—residential
- medium volume—livestock water pumping
- high volume—surface watering, such as large ponds and crop irrigation

Low-Volume Water Pumping

Many applications in residential areas require a flow rate of only a few gallons per minute. This includes fountains, swimming pool solar thermal heating systems, and home solar hot water systems.

Medium-Volume Water Pumping

Livestock water pumping is a major example of a medium-volume solar energy off-grid application (see Figure 17.1). This application has significant potential for widespread use in the Heartland. Currently, over 10% of all PV module sales go to livestock water pumping and the PV market, for this application, is projected to grow as more information becomes available. Solar electric power is often the best choice, since it provides the farmer and rancher with a very reliable power source that can be installed at the exact location where the water is needed, regardless of where the utility power line is located. And, in most cases, these off-grid installations do not require battery power backup since storage is provided by a stock tank or a small pond (see Figure 17.2).

Figure 17.1. Livestock tank being filled using power supplied by the solar array. (Source: Grundfos Pumps)

Figure 17.2. Livestock tank serves as storage for the water to account for cloudy days and nighttime when the solar array is not producing sufficient power to operate the pump. (Source: Grundfos Pumps)

A large number of electric utilities throughout the United States have installed solar electric water pumping systems. The two driving forces behind these installations are the aging of windmills and the cost of line extensions for new wells in remote regions. The utilities are now recognizing that solar electric pumping systems offer them an alternative to provide a reliable and cost-effective service to their customers. Life-cycle costs of solar electric livestock water pumping systems are particularly attractive.

High-Volume Water Pumping

Moving high volumes of liquids from place to place is a large worldwide industry encompassing many applications. For high-rate pumping applications, the pumping industry uses high-efficiency three-phase AC motors as pump drivers. Diesel or gasoline engines may by used as emergency energy sources or as primary energy sources where electric power is not available. However, the high cost of continuous operation and the loss of efficiency when not operated at full power preclude the use of diesel or gasoline energy sources for many water pumping applications. A notable application of efficient use of diesel and L.P. gas is farmland irrigation in the Heartland.

The solar water pumping industry has been unable to capture a meaningful share of the market for high-volume water pumping in the Heartland. There may be future examples of solar electric irrigation systems installed that provides water for small plots of land. But these will be exceptional cases where grid-connected electric motors or diesel engines are not practical. This all relates back to the relationship between the power required and the type of energy source selected. Historically, off-grid PV power was considered cost-effective only for low and medium power applications. This power-level limit continues to climb as the efficiency of PV cells improves and the relative cost per kW drops. Another factor is the improved system efficiency resulting from better control electronics and motor-pump assemblies. The solar water pumping industry strives to make its industry more competitive for higher volume applications by providing new products and services. This statement points to the long-term goal of sustainable development of renewable energy sources, and technology's role in future advances in motors and pumps that can provide cost-effective high-volume water

pumping.

To obtain further information:

Contact your local Heartland solar dealer for a detailed analysis of the benefits and costs of installing a solar-powered water pumping system.

Contact the following manufacturers/installers of solar-powered water pumping systems for additional information. Products manufactured by other companies may also be available at your local solar energy dealer.

Grundfos Pumps
17100 W. 118th Terrace
Olathe, KS 66061
Phone: 913-27-3400
Fax: 913-227-3500
Email: pyaple@us.grundfos.com
World Wide Web: http://www.grundfos.com

Dankoff Solar Products
2810 Industrial Road
Santa Fe, NM 87505-3120
Phone: 050-473-3800
Toll Free: 888-396-6611
Email:
pumps@dankoffsolar.com

SHURflo Pump Manufacturing Company
5900 Katella Avenue
Cypress, CA 90630
Phone: 562-795-5200
Toll Free: 800-854-3218
Fax: 562-795-7564
Email: customer_service@surflo.com
or literature@surflo.com

SunPumps
325 E. Main Street
Safford, AZ 85546
Phone: 928-348-9652
Toll Free: 800-370-8115
Fax: 928-348-9653
World Wide Web:
http://www.sunpumps.com

SolarJack (a division of Kyocera)
Use Kyocera's Web page:
http://www.Kyocerasolar.com

Ivan Labs, Inc.
305 Circle W.
Jupiter, FL 33458
Phone: 561-747-5354
Fax: 561-747-9973
Email: ivandelsol@aol.com
Note: These pumps are low volume 12 Vdc units primarily intended to circulate water through a solar hot water system (see the next section on Solar Hot Water with Solar Electric Pump Power).

18. Solar Hot Water with Solar Electric Pump Power

Solar electric power is also used in the solar hot water industry, but not to heat water. It is used to move water or fluid to the solar thermal (heating) panel. This can make the solar domestic hot water (SDHW) system independent of utility power. As shown in Figures 18.1 and 18.2, there are two basic types of hot water systems—direct PV system and indirect PV system. For the direct system, the PV-powered water pump transfers hot water from the thermal panels directly to the hot water tank. The indirect system contains a heat exchanger inside the hot water tank so that the water from the thermal panels is circulated in a closed loop and does not mix with the water in the tank.

Questions and Answers

What are the advantages of using photovoltaic (PV) power for solar hot water systems? First, there is a nice "match-up" or synergy between solar thermal and solar electric parts of the system. When there is enough sunlight to heat the water (or fluid), there is enough sunlight to power the pump. In some systems, the speed of the pump will vary with the amount of sunlight. When there is strong, direct sun, the pump will move the water more quickly though the solar panels. When there is less direct sunlight, the pump will move the water more slowly, giving it more time to warm up. PV can also be looked at as another aspect of freeze protection, eliminating times when a utility-powered pump could send water up to a cold thermal panel. A system installed in a remote area is shown in Figure 18.3.

What are the cost advantages of using PV? The time and expense of bringing electrical service to the pump can be eliminated. Often, this might include the cost of bringing in an electrician for this small job. Using PV means there is no waiting for a power line to be made available to the pump. SDHW installers can do the whole job and when they are done, the system is ready to work, no waiting or coordinating with another contractor or technician.

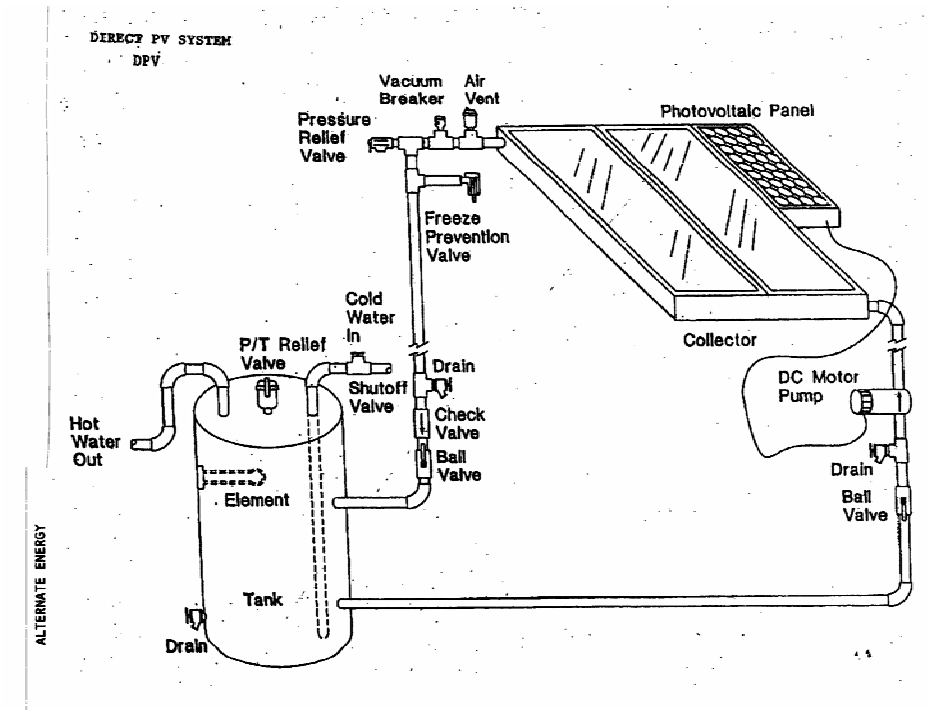

Figure 18.1. Schematic of a direct PV hot water pumping system. (Drawing courtesy AET Solar)

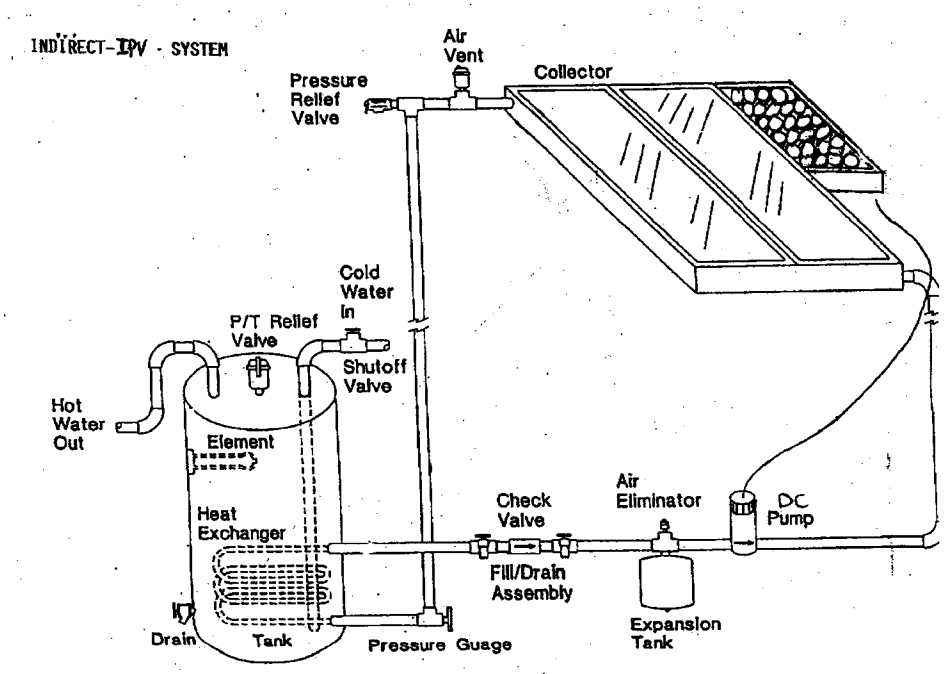

Figure 18.2. Schematic of an indirect PV hot water pumping system. (Drawing courtesy of AET Solar)

Figure 18.3. Solar electric hot water system showing the thermal collectors and PV panel.

(Photograph courtesy of Heliotrope Thermal)

To obtain further information:

Contact your local Heartland solar dealer for a detailed analysis of the benefits and costs of installing a solar domestic hot water system with photovoltaic pump power.

Contact the following manufacturers of solar domestic hot water systems with photovoltaic pump power for additional information. Products manufactured by other companies may also be available at your local Heartland solar dealer.

Heliotrope Thermal

4910 Seaport Ave.

Richmond, CA USA 94804

Phone: 510-237-9614

Fax: 510-237-7018

World Wide Web: http://www.heliodyne.com

American Energy Technologies, Inc.

1057 N. Ellis Road, Suite 4

Jacksonville, FL USA 32254

Phone: 904 781-7000

Fax: 904 781-1911

World Wide Web: http://www.aetsolar.com

C. FUTURE COST-EFFECTIVE SOLAR PRODUCTS

Future Cost-Effective Solar Products

Development of a strong solar industry is a world-wide endeavor. In an environment of intensifying global demand for electricity—either for small off-grid applications or large grid-connected systems—deployment of new technologies is becoming the strategic arena of the international solar energy marketplace. Research institutions, universities, and businesses are working hard to find ways of deploying renewable energy technologies. Moreover, discovery, development, and deployment of new products are being expanded nation by nation in order to create a world-wide solar energy market. Only one of many examples of this is the action recently taken by the European PV community. This action will lead to "an increase of vitality and competitiveness of the European PV industry through the formation of a comprehensive strategy for research, marketing, products, human resources, and development by formulating a viable strategy for directing the future of European photovoltaics" (*Development of a Roadmap for European PV R&D*, World Renewable Energy Congress VII, Cologne, Germany, June 29 – July 5, 2002).

Historically, expensive solar panels have limited the growth of the solar market. Fortunately, the cost of solar panels continues to drop since significant research and development funding has been directed toward manufacturing lower-cost photovoltaic cells. World-wide production of PV cells is at an all time high and the cost is at an all time low. Increased demand and production shows no sign of slowing down—the PV industry has grown more that 35% in the last two years, and about 25% per year for the last five years (Lawrence L. Kazmerski, *Photovoltaic Myths—The Seven Deadly Sins,* Solar Today, pp. 40 – 43, July/August 2002) . This growth trend is reflected in the increased capital investments that major companies are making in the PV industry. For example, Sharp, one of the world's largest solar cell manufacturer plans to double output capacity in 2002. Likewise, Kyocera plans to increase production by 20% and Sanyo Electric by 40%. Sharp reported that it expects the market for solar panels to rise at an annual rate of over 40% per year over the next several years. In June of 2002, United Solar dedicated the world's largest solar-cell manufacturing plant in the United States. This new plant will increase the company's production capacity by a factor of six from its

current output. Thus, as the cost of solar cells decline, numerous new solar electric products will be introduced into the marketplace.

In the long run, the key to future solar energy competitive success involves designing new products that take full advantage of the feature offered by solar electricity. This includes incorporating the latest technology and developing new components for solar products. This has already occurred in the water-pumping industry since most solar water-pumping systems include only components specifically designed to be powered by a solar panel. Recently, lighting has seen major changes because of the availability of compact fluorescent lights and high intensity light emitting diodes (LEDs). Improved rechargeable battery technology continues to contribute more and more to improved solar products. Thus, the synergy between solar power and the discovery of new low power components offers the solar industry an opportunity to expand at a steady rate for the foreseeable future.

D. SOLAR ELECTRIC SYSTEM DESIGN

- Design Software
- Solar Insolation in the Heartland

1. Design Software

Solar system software is a valuable tool for designing new solar electric systems. Several computer codes are available. The codes listed below were selected to offer the reader examples of codes whose capabilities span a wide range of applications. Each code listed below has its own unique features, ranging from designing a specific system with design data for each PV system component to just estimating the life-cycle cost of a generic system located at a specific location. If you are interested in buying any of the commercial computer software, you should contact the companies to obtain current information on the technical capability, cost, and licensing restrictions.

Program name: **Solar Design Studio 5.0**
Category: On-grid, off-grid, and PV water pumping systems
Application: This is a stand-alone solar electric system design and analysis software package developed by the Maui Solar Energy Software Corporation (MSESC) in partnership with the Sandia National Laboratories Photovoltaic Systems Department.
Cost: $149.00 plus shipping and handling
Availability: MSESC
World Wide Web: www.mauisolarsoftware.com
Comments: This software package provides professional designers and nonprofessionals the tools necessary to design PV systems. It is also a good learning tool for anyone interested in learning more about solar electric systems.

Program name: **WinCAPS**
Category: Solar water pumping
Application: This product contains information on commercially available solar water pumps and associated products, and SQFlex water pumping system-sizing software.
Cost: Free
Availability: Your local Grundfos Pumps Corporation office or from its World Wide Web site
World Wide Web: www.grundfos.com
Comments: This is a software package developed by the Grundfos Corporation to assist its customers in optimizing their solar-powered water pumping systems.

Program name: **Multiple Software Programs**
Category: Off-grid
Application: Solar electric power system design for water pumping, residential, security and health, communications, and hybrid systems
Cost: Free
Availability: Sandia National Laboratories

World Wide Web: www.sandia.gov/pv (To access the PV system design information, first select PV Systems, next select Design and Installation, and finally select System Applications and Design Considerations.)
Comments: This site allows the user to choose from several solar electric power applications and contains a variety of design examples.

Program name: **PVWATTS**
Category: Grid-connected
Application: PVWATTS calculates the amount of electrical energy produced by a grid-connected solar electric system. Since it uses the cost of electricity generated locally, it provides an estimate of monthly and annual cost savings achieved by installing a grid-connected PV system.
Cost: Free
Availability: National Renewable Energy Laboratory
World Wide Web: http://rredc.nrel.gov/solar/codes_algs/PVWATTS/
World Wide Web key word: pvwatts
Comments: This site contains valuable information on solar insolation for the United States.

Program name: **PV F-Chart**
Category: Grid-connected and stand-alone with or without battery storage
Application: PV F-Chart is a program useful for analysis, design, and economic analysis of PV systems.
Cost: $400.00
Availability: F-Chart Software
World Wide Web: www.fchart.com
Comments: This code is non-application specific; it calculates the energy available for a particular hour of each month and compares this to the user-supplied hourly load profile.

To obtain further information:

Contact your local Heartland solar dealer.

2. Solar Insolation in the Heartland

Deciding if a solar electrical system is the right choice often involves performing some type of design calculation. This can range from reviewing the specifications of a simple system like a solar yard light that just needs to be placed in a sunny location, to specifying the components and installation procedures for a solar electric system for a remote home. Design procedures involve knowing the solar energy available at the particular site where the solar electric system would be installed. In addition, it is often necessary to know the solar energy available at a specific fixed angle or how the energy varies as a function of time of day and time of year. Thus, accurate knowledge of the solar energy available at a specific site requires measuring the solar energy at various locations. Once experimental data exists at multiple points within a region, i.e., the U.S.A., then mathematical models can be used to estimate the solar energy at many more locations within that region. To achieve this task, the National Renewable Energy Laboratory completed version 1.1 of the National Solar Radiation Data Base (NSRDB) in 1994 for 239 locations in the U.S., plus sites in Guam and Puerto Rico. The NSRDB contains hourly values of data measured at 56 sites and modeled values at an additional 183 sites. Experimental values were averages based upon the 30- year period from 1961 – 1990. The 56 sites where the data were measured are called primary sites. For the remaining 183 sites, called secondary sites, solar energy data were modeled based upon values at the 56 primary sites, and meteorological data such as cloud cover and temperature.

To effectively use published solar energy data, it is often necessary to know how a few technical terms relate to solar resources. The first term is solar irradiance.

- **Solar irradiance** is the amount of power striking a given area. It is a measure of the intensity of the sunshine reaching the solar panel and is expressed in units of watts (or kilowatts) per square meter W/m^2.

Another important term is solar insolation.

- **Solar insolation** is derived from the phrase **IN**coming **SOL**ar radi**ATION**. It refers to the amount of solar energy received on a given area measured in kilowatt-hours per square meter (kWh/m^2). If this energy

is averaged over a time period of one day, then the units would be ($kWh/m^2/day$).

Another way solar data are presented is as peak sun hours. The insolation data are most often presented as an average daily value for each day of the month. Of course, on any given day the solar radiation varies continuously from sunup to sundown. The term peak sun hours is defined as:

- **Peak sun hours** are the equivalent number of hours per day when the solar irradiance equal 1,000 W/m^2.

Six peak sun hours, are then, the energy received had the sun shone for six hours with an irradiance of 1,000 W/m^2. Therefore, peak sun hours correspond directly to average daily insolation. That is, the conversion factor from peak sun hours at 1,000 W/m^2 is unity. Hence, 3.4 kWh/m^2 is the same as 3.4 peak sun hours.

Table 1 lists solar insolation data for one city in Kansas, Iowa, Missouri, Nebraska, and Oklahoma. If a primary site existed in one of these states, then solar data for that city was used. Otherwise, the state capital was selected.

Table 1. Average daily solar insolation (kWh/m^2/day) on flat-plate solar panels[a].

Dodge City, Kansas Latitude: 37.77° N Station type: Primary												
Tilt (°)	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Zero	2.7	3.6	4.7	5.9	6.5	7.2	7.2	6.3	5.1	4.0	2.8	2.4
Latitude	4.6	5.3	5.8	6.2	6.1	6.4	6.5	6.4	6.0	5.6	4.6	4.2
Des Moines, Iowa Latitude:41.53° N Station type: Secondary												
Tilt (°)	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Zero	2.0	2.8	3.8	4.9	5.8	6.5	6.5	5.7	4.4	3.2	2.1	1.7
Latitude	3.6	4.3	4.7	5.2	5.5	5.8	6.0	5.8	5.3	4.7	3.4	3.0
Columbia, Missouri Latitude: 38.82° N Station type: Primary												
Tilt (°)	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Zero	2.2	3.0	4.0	5.2	6.0	6.6	6.6	5.9	4.6	3.5	2.3	1.9
Latitude	3.8	4.4	4.9	5.5	5.6	5.9	6.1	5.9	5.4	4.9	3.6	3.2
Omaha, Nebraska Latitude: 41.37° N Station type: Primary												
Tilt (°)	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Zero	2.1	2.9	3.9	5.0	5.9	6.7	6.6	5.7	4.5	3.3	2.1	1.7
Latitude	3.8	4.4	4.9	5.3	5.6	6.0	6.0	5.8	5.3	4.7	3.5	3.2
Oklahoma City, Oklahoma Latitude: 35.40° N Station type: Secondary												
Tilt (°)	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Zero	2.8	3.5	4.6	5.7	6.2	6.8	6.9	6.2	5.0	4.0	2.9	2.4
Latitude	4.4	4.9	5.5	5.9	5.8	6.0	6.3	6.3	5.7	5.4	4.4	4.1

[a] Reference: *Solar Radiation Data Manual for Flat-Plate and Concentrating Collectors*, National Renewable Energy Laboratory, 1617 Cole Boulevard, Golden, CO 80401 (1994).

For more information about solar energy data at other sites, contact the National Renewable Energy Laboratory at www.nrel.gov.

E. COST-EFFECTIVE CONSIDERATIONS

- PV Cost-Effective Decision Maker
- Federal Government Renewable Energy Incentives
- State Government Renewable Energy Incentives

1. PV Cost-Effective Decision Maker

There are many factors that go into deciding if an application is cost-effective for PV. Many times the weighting of these factors is a judgment call by the person charged with making the decision. With the PV Decision Maker worksheet shown in Figure 2, we have tried to highlight certain key cost factors that people should consider if they are looking at PV cost effectiveness. In addition to the cost factors included in Table 2, there may be other cost factors, e.g., Federal and State incentives and initiatives, that would significantly reduce the cost of a PV system. Some of the incentives currently available are discussed in the *Federal Government Renewable Energy Incentives* and the *State Government Renewable Energy Incentives* sections. Of course, non-cost factors may also influence the decision, like environmental impact, but they are not a part of this worksheet.

Table 2. PV Cost-Effective Decision Maker Worksheet.

Negative is bad for solar, positive is good

INITIAL COST PV may have a higher capital cost. Is the total cost, including installation much higher than the competing product (neg.) or about the same (pos.)?	-3	-2	-1	0	1	2	3
INTEREST RATES If there is a higher initial cost, and if this cost can be financed over time, are available interest rates for the project high (neg.) or low (pos.)?	-3	-2	-1	0	1	2	3
ROUTINE FUEL COSTS PV has no fuel cost. Is the competing fuel cost low (neg.) or high (pos.)?	-3	-2	-1	0	1	2	3
OTHER FUEL EXPENSES Is it easy (neg.) to acquire and deliver batteries or fuel if the unit is not PV powered or troublesome (pos.)?	-3	-2	-1	0	1	2	3
MAINTENANCE COSTS Does solar require more (neg.) or less (pos.) maintenance on the equipment to keep it running?	-3	-2	-1	0	1	2	3
INSPECTION COSTS Is the unit easy (neg.) or hard (pos.) to get to for regularly scheduled physical inspections? If it is hard to get to, or if you have to wait for others (like utility companies or electricians) to repair downed lines, etc., that is usually a benefit for self-fueling owner repairable PV systems.	-3	-2	-1	0	1	2	3

Total columns and add together in end box. A positive score likely means a cost-effective PV project.								

2. Federal Government Renewable Energy Incentives

Nuclear power and renewable energy electricity technologies have received over $150 billion in federal subsidies since 1947. Nuclear power received over 95% of these funds, while solar electric was the second highest funded technology receiving only 2%. Other technologies, including solar thermal electric, wind, and biomass, received about 3%. Nuclear subsidies started to decline in the 1970's, and subsidies for renewable energy slowly began to increase. It is interesting to note that between 1980 and 1995, the price of photovoltaic power dropped 84%. Additional cost data and current news about the renewable energy industry can be found on the Renewable Energy Policy Project World Wide Web page www.repp.org.

Federal Government Renewable Energy Incentives for Commercial Property Owners

Solar energy property incentives for commercial entities in the United States include an investment tax credit and an accelerated depreciation schedule.

Federal Government Solar Energy Business Tax Credit

The tax credit incentive, known as the Business Energy Tax Credit, has been permanently incorporated as part of the federal tax code (see U.S. Code Citation: 26 USC Sec. 48). Any qualified commercial entity is allowed up to 10% tax credit on the investment cost or purchase and installation cost of equipment. Energy property is defined as equipment that uses solar energy to generate electricity (photovoltaic cells and solar thermal electric) to heat or cool (or provide hot water for use in) a structure, or to provide solar process heat. This includes equipment that is used to provide hot water for use in a structure. Several examples are not included in the definition of solar energy property, such as passive solar systems designed to use conductive, convective, or radiant heat transfer; equipment used for most swimming pools; and equipment used by industry to generate steam. The tax form needed is the Investment Credit Form No. 3468 and perhaps the General Business Credit Form No. 3800. More information can be obtained by visiting the Internal Revenue Service (IRS) Web site at http://www.irs.gov and

entering 3468 in the *Search Forms and Publications for* search box, and clicking on GO to view the desired forms and information. From this IRS Web site, you can download the Investment Credit Form and the Instructions for Form 3468 document. This 10% tax credit is limited to $25,000 per year, plus 25% of the total tax remaining after the tax is taken. Consult a tax advisor to find out more about how your company can utilize this very important solar energy incentive.

Federal Government Solar Energy Accelerated Depreciation

Another federal incentive for commercial property owners is the five-year accelerated depreciation for solar energy property. The federal government offers a five-year accelerated depreciation for specific solar equipment, see U.S. Code Citation: 26 USC Sec. 168. This incentive is also only available to commercial entities investing in or purchasing qualified solar energy property. The definition of solar property is the same as for the 10% tax credit incentive. The Modified Accelerated Cost Recovery System (MACRS) five-year depreciation schedule is shown in Table 3.

Table 3. MACRS five-year depreciation schedule for solar energy property.

Year	Percent (%)
1	20.00
2	32.00
3	19.20
4	11.52
5	11.52
6	5.76

Federal Government Million Solar Roofs Initiative for Businesses and Communities

This program, which started in 1997, focuses on aiding businesses and communities to install solar energy systems on one million rooftops across the United States by 2010. Its purpose is to encourage deployment of solar technologies in communities throughout the United States in order to reduce the energy demands of buildings. The U.S. Department of Energy (DOE) coordinates this initiative by working with state/local governments and the private sector. The U.S. DOE has formed over 57 state and local partnerships. This effort has brought together business, government, and

community organizations that have committed to installing solar energy systems in their communities.

This program provides assistance in many areas that have posed problems in the past. This includes design support in order to obtain the optimum system for a particular application and region of the country, selection of hardware components, installation training for the hardware, and operation training. Financial support is provided by several sources, such as the state, community partners, and awards from the DOE.

Currently, this program has been responsible for more that 900,000 solar energy systems. Iowa is the only state in the Heartland (IA, KS, OK, NE, and MO) that has formed a partnership with the DOE. For more information about the Iowa Million Solar Roofs Program, contact:

Million Solar Roofs Program Planner
Iowa Department of Natural Resources
Wallace State Office Building
502 E. 9th Street
Des Moines, IA 50319
Phone: 515-281-8518
Fax: 515-281-6794

Additional general information about this program is available at the DOE's Energy Efficiency and Renewable Energy Network (EREN) Web site at http://www.eren.doe.gov/millionroofs/millionroofs.html. The Million Solar Roofs Program is coordinated through the six DOE Regional Offices. Two of the offices especially important to the Heartland are the Chicago and the Denver Regional Offices. The states in their regions and their Web site addresses are as follows:

- Chicago Regional Office (Region: IL, IN, IA, MI, MN, OH, and WI) http://www.eren.doe.gov/cro.

- Denver Regional Office (Region: CO, KS, LA, MT, NE, NM, ND, OK, SK, TX, UT, and WY) http://www.eren.doe.gov/dro.

2002 Farm Bill Title IX—ENERGY

A wide variety of programs are proposed for assisting farmers, ranchers, and rural small businesses to purchase and install renewable energy systems and make energy efficiency improvements. The new Energy Title in this bill contains $405 million in mandatory appropriations over six years. Renewable energy is defined as energy derived from a wind, solar, biomass, or geothermal source and hydrogen derived from biomass or water using a renewable energy source. This program has been authorized but funding is subject to appropriations. Additional information on this and other renewable energy initiatives is available at http://www.midwestenvironment.org/energy and http://www.newuses.org/.

Other Federal Government Renewable Energy Incentives

There are several other federal programs designed to encourage state and local governments, electric cooperatives, and homeowners to invest in solar technologies. For example, the U.S. DOE's Office of Power Technologies has oversight on funds provided for the Renewable Energy Production Incentives program. This program promotes increasing generation and utilization of electricity from renewable energy sources, and furthering advances in renewable energy technologies. Qualifying facilities must use solar, wind, geothermal, or biomass generation technologies. Further information is available on the World Wide Web site http://www.eren.doe.gov/power/repi.html.

3. State Government Renewable Energy Incentives

The U.S. government's National Renewable Energy Laboratory maintains a Web site containing information on renewable energy technologies and policies applicable for each state. It is a general-purpose renewable energy site containing information on all types of renewable energy technologies, including solar for all 50 states (http://www.nrel.gov/stateandlocal/). This comprehensive renewable energy Web site links to the State Energy Alternatives Web site that shows extensive information on technologies and policies for all renewable energy technologies. The Data Base of State Incentives for Renewable Energy (DSIRE) site (http://www.dsireusa.org/) focuses on providing information on state, local, utility, and selected federal incentives that promote renewable energy. The DSIRE site's home page shows a map of all 50 states. Simply click on the state of interest to access information for your state. For example, specific financial incentive information for the state of Kansas includes property tax exemptions, state grant programs, and solar access law/guidelines on solar easements (described under the Rules, Regulations & Policies category). Information on other state incentives can be obtained by contacting your State Energy Office.

Incentives for Renewable Energy in Kansas

Kansas Alternative Vehicle Incentives

In 1999, Governor Bill Graves signed into law Senate Bill 45. Section 5 of Senate Bill 45 amended K.S.A. 79-32,201 to allow a tax credit for qualified alternative-fueled motor vehicles and alternative-fuel fueling stations. Alternative fuels are defined under Title 42 of the United States Code Section 13211 to include electricity (including electricity from solar energy).

For qualified alternative-fueled motor vehicles placed into service between January 1, 1996 and December 31, 2004, the credit is 50% of the conversion or incremental cost, up to a maximum for the vehicle's gross weight (see Table 4). For qualified alternative-fueled motor vehicles placed in service on or after January 1, 2005, the credit will be 40% of the conversion or incremental cost, up to the maximum for the gross vehicle weight shown in Table 4.

Table 4. Maximum credit for qualified alternative-fueled motor vehicles.

Gross Vehicle Weight (pounds)	Maximum Available Credit	
	1996 - 2004	On or after 2005
Less than 10,000	$ 3,000	$ 2,400
10,000 – 26,000	$ 5,000	$ 4,000
Over 26,000	$ 50,000	$ 40,000

In addition to a tax credit for alternative-fueled motor vehicles, Kansas tax credit is also available for any qualified alternative-fuel fueling station. This includes electricity, including electricity from solar energy. The credit is 50% for the period from January 1, 1996 to December 31, 2004, up to a maximum of $200,000 for each fueling station. After January 1, 2005, the credit is 40% of the total amount expended up to a maximum of $160,000 for each fueling station. The Kansas Alternative-Fuel Tax Credit tax schedule (Schedule K-62) and instructions for completing schedule K-42 are available from the Web page http://www.ink.org/public/kdor. For assistance with the technical aspects, contact the Kansas Corporation Commission's State Energy Office at http://www.kcc.state.ks.us/energy/energy.htm.

Renewable Energy Grant Program

This program is administered by the Kansas Corporation Commission's State Energy Program. All renewable energy technologies are eligible, but projects with commercial applications are favored.

Other Kansas Solar Incentives

Additional information on other Kansas incentives is available from the Kansas Corporation's State Energy Office.

F. NATIONAL AND STATE GOVERNMENT RESOURCES

- United States Government and National Laboratories
- State Agencies

1. United States Government and National Laboratories

U.S. Department of Energy
Office of Solar Energy Technologies
1000 Independence Ave. SW
Washington, DC 20585
Phone: 202-586-7867
Fax: 202-586-8148
World Wide Web: www.eere.energy.gov/solar.html

National Renewable Energy Laboratory
National Center for Photovoltaics
1617 Cole Boulevard
Golden, CO 80401-3393
Phone: 303-384-6600
Fax: 303-384-6481
World Wide Web: www.nrel.gov/

Sandia National Laboratories
Photovoltaics Program
P.O. Box 5800
Albuquerque, NM 87185-0753
Phone: 505-844-8195
Fax: 505-844-6541
World Wide Web: www.sandia.gov/pv

2. State Agencies

Iowa Department of Natural Resources
Energy Bureau
Energy and Geological Resources Division
Wallace State Office Building
Des Moines, IA 50319
Phone: 515-281.8681
Fax: 515-281-6794
World Wide Web: http://www.state.ia.us/dnr/energy

Kansas Corporation Commission
Energy Programs
1500 SW Arrowhead Road
Topeka, KS 66604-4027
Phone: 785-271-3170
Fax: 785-271-3268
World Wide Web: http://www.kcc.state.ks.us./energy/energy.htm

Missouri Department of Natural Resources
Energy Center
P.O. Box 176
Jefferson City, MO 65102
Toll Free: 1-800-361-4827
Phone: 573-751-3443
Email: energy@mail.dnr.state.mo.us
World Wide Web: http://www.dnr.state.mo.us/de/homede.htm

Nebraska Energy Office
P.O. Box 95085
Lincoln, NE 68509-5085
Phone: 402-471-2867
Fax: 402-471-3064
World Wide Web: http://www.nol.org/home/NEO/
In addition, several renewable energy companies operating in Nebraska are listed on the Nebraska Cooperative Extension Web site:
http://www.ianr.unl.edu/pubs/consumered/nf88.htm

Oklahoma Department of Commerce
900 N. Stiles/P.O. Box 26980
Oklahoma City, OK 73126-0980
Toll Free: 1-800-879-6552
Phone: 405-815-6552
http://www.odoc.state.ok.us/

G. HEARTLAND SOLAR DEALERS

Information on the Heartland solar dealers that responded to our *Heartland Solar Electric Business Survey* are listed in the following tables.

Heartland Solar Electric Business Survey

	Equipment sales	Installation	Service	Financing	Are you including photos of your work in this area?	Are you a member of a local, regional or national solar trade or business group? If so, please list the group(s) below.
Water Pumping	x			x		Heartland Solar Energy Industries Association
Gate openers	x			x		Heartland Renewable Energy Society
Fence charging	x			x		American Solar Energy Society
Building integrated	x	x	x	x		
Utility Grid Intertie	x	x	x	x		
Outbuilding lighting	x		x	x		
Area Lighting	x		x	x		
Sign Lighting	x	x	x	x		
Traffic signs	x		x	x		
Call Boxes	x			x		
Marine Beacons	x			x		
Cabin power	x			x		
Electric vehicle charging station	x	x	x	x		
RV power	x			x		
Small battery chargers	x			x		
Marine Power	x			x		
Fans & Vents	x			x		
Cathodic Protection						
Utility T&D switches						
Solar Raycing	x			x		
SCADA	x			x		
Solar hot water						
OEM	x					
Other, please describe						

: Mr. Bill Roush
Solar Electric Systems of KC
13700 W 108th St
Lenexa, KS 66215-2026
(913) 338-1939
solarbeacon@email.msn.com
http://www.solarguide.com

Heartland Solar Electric Business Survey

	Equipment sales	Installation	Service	Financing	Are you including photos of your work in this area?	Are you a member of a local, regional or national solar trade or business group? If so, please list the group(s) below.
Water Pumping	x					Heartland Solar Energy Industries Association
Gate openers						
Fence charging	x					
Building integrated	x					
Utility Grid Intertie	x					
Outbuilding lighting	x					
Area Lighting						
Sign Lighting	x					
Traffic signs						
Call Boxes						
Marine Beacons						
Cabin power	x					
Electric vehicle charging station						
RV power	x					
Small battery chargers	x					
Marine Power	x					
Fans & Vents	x					
Cathodic Protection	x					
Utility T&D switches						
Solar Raycing	x					
SCADA						
Solar hot water	x					
OEM						
Other, please describe						

: Mr. Bob McBroom
Kansas Wind Power
13569 214th Rd
Holton, KS 66436-8138
(785) 364-4407
sales@kansaswindpower.net
http://www.kansaswindpower.net

Heartland Solar Electric Business Survey

	Equipment sales	Installation	Service	Financing	Are you including photos of your work in this area?	Are you a member of a local, regional or national solar trade or business group? If so, please list the group(s) below.
Water Pumping						Heartland Solar Energy Industries Association
Gate openers						
Fence charging						
Building integrated		x	x			
Utility Grid Intertie		x	x			
Outbuilding lighting						
Area Lighting						
Sign Lighting						
Traffic signs						
Call Boxes						
Marine Beacons						
Cabin power		x	x			
Electric vehicle charging station		x	x			
RV power						
Small battery chargers						
Marine Power						
Fans & Vents						
Cathodic Protection						
Utility T&D switches						
Solar Raycing		x	x			Kansas Electro Rally
SCADA						
Solar hot water						
OEM						
Other, please describe						

: Mr. Jeff Simpson
Sunlectric
20735 Pebble Lane
Lenexa, KS 66220
(913) 422-3567
jsgoev@thirdwave.net

Heartland Solar Electric Business Survey

	Equipment sales	Installation	Service	Financing	Are you including photos of your work in this area?	Are you a member of a local, regional or national solar trade or business group? If so, please list the group(s) below.
Water Pumping						
Gate openers						
Fence charging						
Building integrated						
Utility Grid Intertie						
Outbuilding lighting	x	x	x			
Area Lighting	x	x	x			
Sign Lighting	x	x	x			
Traffic signs						
Call Boxes						
Marine Beacons						
Cabin power	x	x	x			
Electric vehicle charging station						
RV power	x	x	x			
Small battery chargers	x	x	x			
Marine Power						
Fans & Vents						
Cathodic Protection						
Utility T&D switches						
Solar Raycing						
SCADA						
Solar hot water						
OEM						
Other, please describe						

: Mr. Jim Mixan
Solar Light and Power
7209 S. 39th St.
Omaha, NE 68147
(402) 733-7279
http://www.SolarLightandPower.com

Heartland Solar Electric Business Survey

	Equipment sales	Installation	Service	Financing	Are you including photos of your work in this area?	Are you a member of a local, regional or national solar trade or business group? If so, please list the group(s) below.
Water Pumping	x		x			
Gate openers						
Fence charging	x					
Building integrated						
Utility Grid Intertie						
Outbuilding lighting						
Area Lighting						
Sign Lighting						
Traffic signs						
Call Boxes						
Marine Beacons						
Cabin power						
Electric vehicle charging station						
RV power						
Small battery chargers	x					
Marine Power	x					
Fans & Vents						
Cathodic Protection						
Utility T&D switches						
Solar Raycing						
SCADA						
Solar hot water						
OEM						
Other, please describe						

: Mr. Christopher Chedzoy
Solar Water Technologies
426-B Elm Ave.
Portsmouth, VA 23704
(757) 398-0098, 800-952-7221
swt@solarwater.com
http://www.solarwater.com

Several dealers in the region. Pumps have been manufactured in Oklahoma.

Heartland Solar Electric Business Survey

	Equipment sales	Installation	Service	Financing	Are you including photos of your work in this area?	Are you a member of a local, regional or national solar trade or business group? If so, please list the group(s) below.
Water Pumping	x	x	x			
Gate openers						
Fence charging						
Building integrated						
Utility Grid Intertie	x	x	x			
Outbuilding lighting	x	x	x			
Area Lighting						
Sign Lighting						
Traffic signs						
Call Boxes						
Marine Beacons						
Cabin power	x	x	x			
Electric vehicle charging station						
RV power						
Small battery chargers						
Marine Power						
Fans & Vents	x	x	x			
Cathodic Protection						
Utility T&D switches	x	x	x			
Solar Raycing						
SCADA						
Solar hot water	x	x	x			
OEM						
Other, please describe						

: Pat and Mac Obourn
AeroSun Electric
Route 1
Box 122A
Eureaka, KS 67045
(620) 853-2260, 877-634-6295
arrow@sktc.net
http://www.4solar.biz

Heartland Solar Electric Business Survey

	Equipment sales	Installation	Service	Financing	Are you including photos of your work in this area?	Are you a member of a local, regional or national solar trade or business group? If so, please list the group(s) below.
Water Pumping	x	x	x			Iowa Renewable Energy Associaition-IRENEW
Gate openers						Midwestern Renewable Energy Association
Fence charging						
Building integrated						
Utility Grid Intertie	x	x	x			
Outbuilding lighting						
Area Lighting						
Sign Lighting						
Traffic signs						
Call Boxes						
Marine Beacons						
Cabin power	x	x	x			
Electric vehicle charging station						
RV power	x	x	x			
Small battery chargers	x	x	x			
Marine Power						
Fans & Vents	x	x	x			
Cathodic Protection						
Utility T&D switches	x	x	x			
Solar Raycing						
SCADA						
Solar hot water	x	x	x			
OEM						
Other, please describe						

: Dennis Pottratz
Go Solar
718 Mechanic Street
Decorah, IA 52101
(563) 382-3242, 563-380-6265cell
gosolar@oneota.net

Heartland Solar Electric Business Survey

	Equipment sales	Installation	Service	Financing	Are you including photos of your work in this area?	Are you a member of a local, regional or national solar trade or business group? If so, please list the group(s) below.
Water Pumping						Iowa Renewable Energy Association-IRENEW
Gate openers						
Fence charging						
Building integrated						
Utility Grid Intertie						
Outbuilding lighting						
Area Lighting						
Sign Lighting						
Traffic signs						
Call Boxes						
Marine Beacons						
Cabin power						
Electric vehicle charging station						
RV power						
Small battery chargers						
Marine Power						
Fans & Vents						
Cathodic Protection						
Utility T&D switches						
Solar Raycing						
SCADA						
Solar hot water						
OEM	x					
Other, please describe						

: Andy Ruff
Iowa Thin Film Tech Inc
2337 230th St.
Boone, IA 50036
(515) 292-7606
ruff@iowathinfilm.com
http://www.iowathinfilm.com

Heartland Solar Electric Business Survey

	Equipment sales	Installation	Service	Financing	Are you including photos of your work in this area?	Are you a member of a local, regional or national solar trade or business group? If so, please list the group(s) below.
Water Pumping	x	x	x	x		
Gate openers	x	x	x	x		
Fence charging	x	x	x	x		
Building integrated	x	x	x	x		
Utility Grid Intertie	x	x	x	x		
Outbuilding lighting	x	x	x	x		
Area Lighting	x	x	x	x		
Sign Lighting	x	x	x	x		
Traffic signs	x	x	x	x		
Call Boxes	x	x	x	x		
Marine Beacons	x	x	x	x		
Cabin power	x	x	x	x		
Electric vehicle charging station	x	x	x	x		
RV power	x	x	x	x		
Small battery chargers	x	x	x	x		
Marine Power	x	x	x	x		
Fans & Vents	x	x	x	x		
Cathodic Protection						
Utility T&D switches						
Solar Raycing						
SCADA						
Solar hot water	x	x	x			
OEM						
Other, please describe						

: Lew Monteil
Solair Solutions
511 S. Johnson Dr.
Odessa, MO 64076-1285
(816) 230-1625
lewmon@msn.com

Heartland Solar Electric Business Survey

	Equipment sales	Installation	Service	Financing	Are you including photos of your work in this area?	Are you a member of a local, regional or national solar trade or business group? If so, please list the group(s) below.
Water Pumping	x	x	x			
Gate openers						
Fence charging	x		x			
Building integrated						
Utility Grid Intertie						
Outbuilding lighting	x	x	x			
Area Lighting	x	x	x			
Sign Lighting						
Traffic signs						
Call Boxes						
Marine Beacons						
Cabin power						
Electric vehicle charging station						
RV power						
Small battery chargers	x	x	x			
Marine Power						
Fans & Vents	x	x	x			
Cathodic Protection						
Utility T&D switches						
Solar Raycing						
SCADA	x	x	x			
Solar hot water						
OEM	x	x	x			
Other, please describe						

: Dennis Austin
Solar Power & Pump
216 N. Oklahoma Ave.
Elk City, OK 73644-4446
(580) 225-1704
daustin@cableone.net
http://www.2gosolar.com

Heartland Solar Electric Business Survey

	Equipment sales	Installation	Service	Financing	Are you including photos of your work in this area?	Are you a member of a local, regional or national solar trade or business group? If so, please list the group(s) below.
Water Pumping						
Gate openers						
Fence charging						
Building integrated						
Utility Grid Intertie						
Outbuilding lighting						
Area Lighting						
Sign Lighting						
Traffic signs						
Call Boxes						
Marine Beacons						
Cabin power						
Electric vehicle charging station						
RV power						
Small battery chargers						
Marine Power						
Fans & Vents						
Cathodic Protection						
Utility T&D switches						
Solar Raycing						
SCADA						
Solar hot water	x	x	x			
OEM						
Other, please describe						

: Kenneth King
King's Solar
6003 E. Eales Road
Hutchinson, KS 67501
(316) 265-8568
ken@jakoinc.com

Heartland Solar Electric Business Survey

	Equipment sales	Installation	Service	Financing	Are you including photos of your work in this area?	Are you a member of a local, regional or national solar trade or business group? If so, please list the group(s) below.
Water Pumping	x	x	x			Heartland Renewable Energy Society
Gate openers						
Fence charging	x	x	x			
Building integrated	x	x	x			
Utility Grid Intertie						
Outbuilding lighting	x	x	x			
Area Lighting	x	x	x			
Sign Lighting						
Traffic signs						
Call Boxes						
Marine Beacons						
Cabin power	x	x	x			
Electric vehicle charging station						
RV power						
Small battery chargers						
Marine Power						
Fans & Vents	x	x	x			
Cathodic Protection						
Utility T&D switches						
Solar Raycing						
SCADA						
Solar hot water	x	x	x			
OEM						
Other, please describe	x	x	x			Off grid residential

: Paul Krumm
Gyld Wynd's
1313 23rd Road
Kanapolis, KS 67454
pkrumm@grapevine.net

Heartland Solar Electric Business Survey

	Equipment sales	Installation	Service	Financing	Are you including photos of your work in this area?	Are you a member of a local, regional or national solar trade or business group? If so, please list the group(s) below.
Water Pumping	x					Heartland Solar Energy Industries Association
Gate openers						
Fence charging						
Building integrated						
Utility Grid Intertie						
Outbuilding lighting						
Area Lighting						
Sign Lighting						
Traffic signs						
Call Boxes						
Marine Beacons						
Cabin power						
Electric vehicle charging station						
RV power						
Small battery chargers						
Marine Power						
Fans & Vents						
Cathodic Protection						
Utility T&D switches						
Solar Raycing						
SCADA						
Solar hot water	x					
OEM						
Other, please describe						

: Paul Yaple
Grundfos Pumps Corp.
17100 W. 118th Terr.
Olathe, KS 66061
(913) 227-3461
pyaple@us.grundfos.com