SOLAR WATER PUMPING BASICS

By Windy Dankoff

There are major reasons to consider the use of solar-powered pumps. Solar pumps require no fuel. They are quiet, pollution-free, and require very little maintenance. They produce best during dry sunny weather when the need for water is greatest.

How it works

Solar water pumps are specially designed to use photovoltaic-generated power efficiently. Photovoltaic, or PV, cells are solar cells that convert the sun's energy directly into a DC current at a DC voltage. DC is direct current, like the power one gets from a battery. PV cells are grouped together into modules that provide a convenient voltage, i.e., 12Vdc. PV modules are tough, all-weather panels that will withstand extreme temperatures (cold or hot), precipitation (including hail), and unattended operation.

PV modules are available in a variety of shapes, sizes, and wattages. They are modular in nature, meaning each PV module may be grouped with other PV modules in racks to build arrays that may be wired in series or parallel to any desired voltage, current, or overall power requirement. This characteristic makes it very easy to increase the capacity of a system. Just add more.

Conventional pumps require the steady AC voltage that utility lines or generators supply. Solar pumps utilize DC electric power from the sun directly. The intensity of the sunshine may vary daily (dawn to dusk), seasonally (summer to winter), and intermittently (clouds and fog). Nevertheless, PV-powered pumping systems work effectively during low light conditions at reduced voltage without stalling or overheating the pump.

The hardware

Many solar pumping systems use a **positive-displacement pump**. It seals water in cavities and forces it upward. This type of pump will maintain its lift capacity even while pumping at a slow rate. This differs from a conventional **centrifugal pump** that needs to spin fast to work efficiently. Positive-displacement pumps include diaphragm, vane, piston, and jack pump types. Centrifugal pumps are used where higher volume is required.

A **surface pump** is one that is mounted at ground level. A submersible pump is one that is lowered into the water. Most deep wells require submersible pumps. The development of solar submersibles is an ongoing process.

A **controller** or **current booster** is an electronic device used with most solar pumps. It acts like an automatic transmission, helping the pump to start and not stall in weak sunlight.

A **solar tracker** tilts the PV array automatically to face the sun as it moves through the sky. This increases daily energy gain by as much as 55% over the same number of modules used in a fixed, south-facing array. With more hours of peak sun available, a smaller pump and power system will prove effective, thus reducing overall cost. Two types of trackers are available: passive (fluid-driven) and active (electric). Tracking works best in clear sunny weather. It is less economical to use in cloudy climates.

The well under this dead windmill has been brought back to life by a solar submersible pump powered by a 120-watt array.

(Photo by Zuni Conservation Project)

Storage of water or energy is important to solar pumping. Three to ten days' **water storage** may be required, depending on climate and pattern of water usage. On sunny days, the system pumps more than the daily requirement in order to fill the system's water tank. **Storage batteries** may be used to store energy for pumping during night time and cloudy periods. However, for simplicity's sake, most systems use water storage rather than batteries.

The cost of solar pump systems ranges from under $1000 to tens of thousands, depending on water requirements, vertical lift, and climate. Even the smallest systems can lift water from depths exceeding 200 feet at low volumes. You may be surprised by the performance of a 1-gallon-per-minute pump. In one sunny day (10 hours), it can lift 600 gallons. That's enough water to supply several families, or 30 head of cattle, or 40 fruit trees.

Compared with windmills, solar pumps are less expensive and much easier and safer to install and maintain. They provide a more consistent supply of water, especially in critically dry times when there is plenty of sun but little wind. As well, solar pumps can be installed in valleys, canyons, and wooded areas where wind exposure is poor.

A photovoltaic array need not be placed close to the water source. To gain full exposure to sunlight, it may be placed some distance away from the pump itself, even hundreds of feet providing the electrical wire is sized properly.

Solar pumps can operate automatically. Level sensors are available to turn the pump off when the water tank fills, thus stopping wasteful overflow. Similar controls may be used to turn the pump off if the water source is drawn down too far.

Solar pumps are expandable. A pump may be installed with a half-sized PV array, and it will deliver half-volume. Later, when more money is available or water requirements increase, the system may be expanded to full capacity.

In an emergency, some solar pumps may be back-up powered by an engine, a generator, or batteries. Small solar pumps may even be powered by the battery in a vehicle.

Small solar pumps are compact, thus minimizing freight and transportation costs. They may even be portable, allowing them to be moved from one water source to another. Small, lightweight systems reduce the need for special equipment and skills at the site.

Low volume solar pumps offer unique benefits. They allow use of slow water seeps and marginal wells, even those producing less than ½ gallon per minute. Slow pumping reduces the cost of long pipelines, since small, inexpensive pipe may be used.

Pump applications

Livestock watering: Cattle ranchers in North America, Mexico and Australia are among the most enthusiastic solar pump users. Their water sources are scattered over many miles of rangeland where power lines are few and refueling and maintenance costs are high.

Ranchers make use of marginal land by using solar pumps to lift from wells hundreds of feet deep and to push water through pipelines that may be several miles long. Ranchers who rotate pastures to protect their rangeland may move their pumps from one well to another quickly and easily.

A 300-watt solar array powers a piston-type solar submersible pump located 550 feet deep in a nearby well.

Irrigation: Solar pumps are used in small farms, orchards, vineyards, and gardens. It is most economical to pump solar-direct (without battery), store water in a tank, and distribute it by gravity flow. If water is to be pressurized by a solar pump, storage batteries stabilize the voltage for consistent flow and distribution, and many eliminate the need for a storage tank. Solar pumping is most economical when combined with water conservation techniques, such as drip irrigation and night-time distribution, to reduce evaporation losses.

Domestic water: PV systems have been installed in tens of thousands of remote-site homes to power lights, tools, and appliances. Energy is stored in deep-cycle batteries for use at night and during cloudy weather. A water pump may be part of a home power system, like any other appliance.

A PV-powered home may use a DC pump made for solar power, or a conventional AC pump powered by the home's DC-to-AC inverter. Some systems use an elevated storage tank and some use a second pump called a booster pump to pressurize the water. Some use the home's battery system for storage instead of storing water in a tank. A variety of factors are considered in determining the optimum approach for each situation. A designer of PV home systems can help you determine the best way to meet your needs.

The easiest way to minimize the cost of solar pumping is by conservation of water. By using one-gallon flush toilets, a home's total water consumption may be reduced by half. Energy may be further conserved by installing household plumbing using pipe one size larger than minimum, so that lower water pressure may be used without loss of flow.

Landscaping and gardens should be designed to minimize water use.

Economics

A small solar pumping system providing a few thousand gallons per day or less, often costs less initially than an engine-powered system. Most larger solar pumps will cost more initially than fuel-powered systems, but they tend to be far more economical in the long run.

Determining the life-cycle cost of a fuel-powered pump requires predicting the future costs of fuel, transportation, maintenance costs, etc. as well as monetary factors of inflation, exchange rates, etc. A solar pump minimizes future costs and uncertainties. The fuel is free. Moving parts are as few as one. With a few spare parts, you can depend on years of reliable water supply with complete autonomy.

If a solar pump costs you less than twice the initial cost of a good fuel-powered system, it is certain to be the economical choice. If the pumping location is very remote, or if fuel delivery, quality of maintenance, and availability of parts and funds are uncertain, then a solar pump may be economical even at five times the initial cost of engine power.

Many of the materials being developed for PV panels do not have the proven durability of today's crystalline silicon technology. Also, some technologies are less efficient, thus requiring greater surface area to catch the sun.

The best PV panels are costly, but have proven themselves for decades. Since 1980, price reductions have been substantial, but gradual. It does not pay to wait. So, if supplying water is costly now, it is time to consider solar pumping.

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HOW TO CHOOSE A SOLAR PUMP SYSTEM

Choosing a pumping system is like ordering a suit of clothes. When talking with a supplier, know the following:

- Well depth or description of water source
- Depth to water surface: Does level vary? If so, how much?
- Yield of well estimated in gallons (or liters) per minute
- Total vertical lift from water surface to storage tank or pipe outlet
- Size of well casing (inside diameter)
- Water requirements in gallons per day according to season
- Will other sources of water be available?
- Application for water: Home? Livestock? Irrigation?
- Describe any existing system at the site
- Quality of water: Is it clear, silty or mineralized?
- Is pressure required for home or for sprinkler irrigation?
- Can a storage tank be easily located higher than the point of use?
- Will the pump be located near a home/battery system? Distance?
- Elevation above sea level (to determine suction limitations)
- Geographical location of system, plus any solar data available
- Solar access: Is unobstructed sunlight available near water source? If not, how far away, or how many hours of clear sun are available?
- Complex terrain? Include a map or diagram.