Solar water pumping—a sensible, reliable alternative

By Windy Dankoff

If you are located away from reliable power sources and need to pump water for people, irrigation, or livestock, then solar water pumping may be the solution for you.

More than 20,000 solar pumps are working throughout the world. Most of them are small systems for remote homes and village and livestock drinking water. Some systems cost little more than their fuel-powered equivalents. Their owners enjoy a reliable power system that requires no fuel and very little attention.

Solar pumping is one of the many applications of photovoltaic cell technology, which generates electricity from sunlight. (See related solar cell articles in this and previous issues.)

Photovoltaic technology

Solar water pumps are specially designed to use solar power efficiently. Conventional pumps require the steady AC voltage that utility lines or generators supply. Solar pumps utilize the DC electric power that PV modules produce. They are designed to work effectively during low light conditions, at reduced DC voltage, without stalling or overheating.

Many solar pumping systems use "positive displacement" pumps which seal water in cavities and force it upward, thus maintaining their lift capacity even while pumping at slower rates. This differs from conventional "centrifugal" type pumps, including jet, submersible and turbine pumps, which spin and "blow" the water up, and whose efficiency typically drops off at reduced speeds. Positive displacement pumps include piston and jack pumps, diaphragm, vane, and screw pumps. Centrifugal pumps are more likely to be used for low lift or high volume systems, particularly to meet irrigation requirements.

Some solar pumps are fully submersible. Others use a motor above the ground to drive a submerged pump by means of a rod or shaft. Some are non-submersible, designed to-push water uphill or to supply pressure. All are designed to utilize solar power most efficiently.

A "controller" is included with most solar pumps to prevent stalling in weak sunlight. This electronic device acts like an automatic transmission. It matches the PV array output to the pump motor under varying conditions of sunlight and load. The controller allows the pump to start and run in weak sunlight, however slowly.

Solar trackers

"Solar trackers" tilt the photovoltaic array automatically to face the sun from sunrise through sunset. This extends the usable period of peak sunlight by as much as 55%. With more hours of sun exposure, a lower volume of water flow is required for a given daily yield. Thus, the size and cost of the solar array, pump, wire, and pipe may be reduced. The most common tracking mechanisms are fluid-driven

by solar heat, rather than by electric motors. Trackers are simple, reliable and easy to install, and eliminate the need to build a mounting rack.

Water storage

Storage of water or energy is important to solar pumping. On sunny days the system pumps more than the daily requirement in order to refill the system's water tank. Two to ten days' storage may be required, depending on climate and pattern of water usage. In some systems, storage batteries provide an alternative to water storage by storing energy for pumping during night time and cloudy periods. Batteries are then recharged by the photovoltaic array during daylight hours.

Cost

Solar pumping systems are available in the power range from 1/8 to 3 horsepower. Complete system costs range from under $1000 to tens of thousands, depending on water requirements, lift, and climate. Even some of 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 will lift 600 gallons. That's' enough to supply several families, or 60 head of cattle, or 40 fruit trees!

Advantages

Solar pumps require no fuel. They are quiet, pollution-free, and require little or no maintenance. They produce best during sunny weather when the need for water is greatest.

Low volume solar pumps offer unique benefits. They allow use of slow water seeps and marginal wells, even those producing less than 1/2 gallon per minute (2 lpm). Slow pumping reduces the cost of transferring modest amounts of water through long pipelines since small sized, inexpensive pipe may be used. Solar pumps can push water through miles of pipeline and up hundreds of feet of incline to where it is needed.

Small solar pump systems are compact and light in weight. This minimizes freight and transportation costs. Many small systems are installed by hand. No special equipment or experience is required. They may even be portable, allowing them to be easily moved from one water source to another.

Typical applications

Livestock watering: Cattle ranchers in the western U.S., Canada, Mexico, and Australia are 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 (1000 m or more) 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.

Irrigation

Solar pumps are being used in small farms, orchards, vineyards, and gardens. The most economical approach is 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 are required to stabilize the voltage for consistent flow and distribution, and may 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, which can reduce evaporation losses by 50%.

Domestic water

Photovoltaic systems have been installed in tens of thousands of remote-site homes to power lights, tools, appliances and water pumps. Energy is stored in deep-cycle batteries, for use at night and during cloudy weather. Marine, golf cart, or fork lift batteries are commonly used, storing a 4 to 8-day supply of energy.

The water systems for PV homes may use DC pumps made for solar power, or they may use ordinary AC pumps 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 on demand. Some use !he 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 the situation. A supplier who designs both PV home and pumping systems can help you, determine the optimum system to meet your needs.

Economics of solar pumping

A small solar pumping system, providing a few thousand gallons (10,000 1) per day or less, often costs less initially than a durable engine-powered system. Most larger solar pumps will cost more initially than fuel-powered systems, but tend to be far more economical in the long run.

Determining the life-cycle cost of a fuel-powered pump depends upon a set of assumptions regarding fuel, transportation of fuel and parts, maintenance costs, etc. as well as monetary factors such as inflation, exchange rates, interest rates, etc.

A solar pump minimizes future costs and uncertainties. The fuel is free. Moving parts are reduced to as few as one. A few spare -parts can assure you of many years of reliable water supply at a near-zero operating cost.

If a solar pump costs you "less than twice" the initial cost of a good fuel-powered system, it is probably 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!

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