Solar Water Pumping A Practical Introduction

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This Solar Slowpump installation helps to start a new vineyard in Mexico.
(Installation by Heliofuerza)

How It Works

Photovoltaic (PV) modules (i.e. solar electric panels) produce electricity from sunlight using silicon cells, with no moving parts. They have been mass-produced since 1979. They are so reliable that most manufacturers give a 20-year warranty, and a life expectancy beyond 30 years. They work well in cold or hot weather.

Solar water pumps are specially designed to utilize DC electric power from photovoltaic modules. The pumps must work during low light conditions, when power is reduced, without stalling or overheating. Low volume pumps use positive displacement (volumetric) mechanisms which seal water in cavities and force it upward. Lift capacity is maintained even while pumping slowly. These mechanisms include diaphragm, vane and piston pumps. These differ from a conventional centrifugal pump that needs to spin fast to work efficiently. Centrifugal pumps are used where higher volumes are required.

A surface pump is one that is mounted at ground level. Surface pumps work well when they draw water through suction less than 10 or 20 feet. A submersible pump is one that is lowered into the water. Most deep wells use submersible pumps.

A pump controller (current booster) is an electronic device used with most solar pumps. It acts like an automatic transmission, helping the pump to start and keeps it from stalling in weak sunlight.

A solar tracker may be used to tilt the PV array as the sun moves across the sky during the day. This can increase daily energy gain by as much as 55%. With more hours of peak sun, a smaller pump and power system may be used, thus reducing overall cost. Tracking works best in clear sunny weather. It is less effective in cloudy climates and on short winter days.

Storage is important. Three to ten days' storage may be required, depending on climate and water usage. Most systems use water storage tanks for simplicity and economy. In other

cases, batteries can be added to the system. Electrical energy from the solar modules is stored in the batteries so that the pump can run at non-sunny times. Add a float switch to the system which can turn the pump off when the water tank fills, to prevent overflow.
Windmills, used to pump water in the "old" days, can still be seen on many horizons. More recently solar pumps have replaced windmills in water pumping applications. A small solar system turns out to be less expensive and much easier to install and maintain. The solar panels also provide a more consistent supply of water; and they can be installed in valleys and wooded areas where wind exposure is poor. A PV array may be placed some distance away from the pump itself; even several hundred feet (100 m) away.
What solar water pumping is used for:
Domestic Water: Solar pumps are used for private homes, villages, medical clinics, etc. A water pump can be powered by its own PV array, or by a main system that powers lights and appliances. An elevated storage tank may be used, or a second pump called a booster pump can provide necessary water pressure. Or the main battery system can provide storage instead of a tank. Collecting rain water can supplement solar pumping when sunshine is scarce. To design a system, it helps to view the whole picture and consider all the resources.
Livestock Watering: Cattle ranchers in the Americas, Australia and Southern Africa are enthusiastic users of solar pumps. Their water sources are scattered over vast rangeland where power lines are few and costs of transport and maintenance are high. Some ranchers use solar pumps to distribute water through several miles (over 5 km) of pipelines. Others use portable systems, and move them from one water source to another.
Irrigation: Solar pumps are used on small farms, orchards, vineyards and gardens. It is most economical to power the pump directly from the PV array (without battery), store water in a tank, and then distribute it by gravity flow. Where pressurizing is required, storage batteries stabilize the voltage for consistent flow and distribution, and may eliminate the need for a storage tank. Batteries also introduce cost, complexity and additional maintenance into the system.

Thinking Small
There are no limits to how large solar pumps can be built. But, they tend to be most competitive in small installations where combustion engines are least economical. The smallest solar pumps run on less than 150 watts of PV, and can lift water from depths exceeding 200 Feet (65 m) at 1.5 gallons (5.7 liters) per minute. You may be surprised by the performance of such a small system. In a 10-hour sunny day it can lift 900 gallons (3400 liters). That's enough to supply several families, or 30 head of cattle, or 40 fruit trees!
Slow solar pumping lets us utilize low-yield water sources. It also reduces the cost of long pipelines, since small-sized pipe may be used. (See How To Size Pipe for Solar Water Pumping for additional pipe sizing information.) The length of piping has little bearing on the energy required to pump, so water can be pushed over great distances as low cost. Small solar pumps may be installed without heavy equipment or special skills.
The most effective way to minimize the cost of solar pumping is to minimize water demand through conservation. Drip irrigation, for example, may reduce consumption to less than half that of traditional methods. In homes, low water toilets can reduce total domestic use by half. Water efficiency is a primary consideration in solar pumping economics.
A Careful Design Approach
When a generator or utility main is present, we use a relatively large pump and turn it on only as needed. With solar pumping, we don't have this luxury. Photovoltaic panels are expensive, so we must size our systems carefully. It is like fitting a suit of clothes; you need all the measurements. For solar water pumps, first identify how much water you need per day and the vertical lift required.

Next, we will determine whether a submersible pump or a surface pump is best. This is based on the nature of the water source. Submersible pumps are suited both to deep well and to surface water sources. Surface pumps can only draw water from about 20 feet (3m) below ground level, but they can push it far uphill. Where a surface pump is feasible, it is less expensive than a submersible, and a greater variety is available.

Now, we need to determine the flow rate required. Here is the equation, in the simplest terms:

Gallons per Hour = Gallons Per Day / Available Peak Sun Hours per Day

Peak Sun Hours refers to the average equivalent hours of full-sun energy received per day. It varies with the location and the season. For example, the arid central-western USA averages 7 peak hours in summer, and dips to 4.5 peak hours in mid-winter. These Sun Hours can be considerably less in northern climates.

Next, refer to the performance charts for the type of pump that is appropriate. They will specify the size and configuration (voltage) of solar array necessary to run the pump. The charts can be found in the specification page or in the Product Documentation tab of the product's specification page.