Make a Solar Fountain!

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Hal Aronson testing various pumps with a group of teachers at a workshop.

Building solar-powered water fountains is the most popular workshop the Solar Schoolhouse program offers. This day-long workshop is one of our efforts to foster energy literacy among teachers and students. We also provide solar energy curricula, solar technology kits for hands-on learning, and professional development workshops for teachers. This article will help you learn how to build your own solar fountain, so you can get in on the fun and education.

Solar-powered fountains are wonderful additions to schools for many reasons. They are an excellent hands-on solar project for teachers, students, and parents. Solar fountains add a beautiful feature to school campuses and demonstrate solar electricity to students and campus visitors. Fountains are relatively inexpensive, and when kept at lower voltages, quite safe. The fact that they are solar powered simplifies the installation because it does not require a connection to the school's electrical wiring.

Students enjoying a fountain/creek system that they helped build at an elementary school.

Solar-powered fountains respond quickly to sunlight. Students and teachers immediately see, hear, and touch the effect of the solar-electric (photovoltaic, PV) panel as it moves the water. If the mount for the panel can swivel, students can experiment. As the panel is aimed more toward the sun, the pump moves the water more vigorously. A student casting a shadow on the panel will slow or stop the water flow. This is perhaps the most effective demonstration of the relationship solar-electric panels have with the sun.

How to Build a Solar-Powered Fountain

Building a solar fountain—from design concept to completed installation—can take less than two days. We'll go through the steps, and you can apply them to your own project.

Step one—design. Pull together a concept of the fountain you want. While the design can unfold during the building process, it is useful to have a starting concept. This will aid in choosing equipment for the installation, especially the pump, solar-electric module, and basin or pond liner material. Do you want a trickling meditation pond, a 6-foot (1.8 m) tall gusher, a cascading creek, a pond aerator, a waterfall, or a bell-shaped spray? All of these features can be created using solar electricity. PV-direct, batteryless systems will only operate when the sun is shining, but batteries can be added to the system if desired.

Step two—choose the pump. Once you have a preliminary concept, you will be able to estimate how much water you want to move (volume) and how high you want to lift the water ("lift" or "head"). Volume, measured in gallons per minute (gpm), and lift, measured in feet, will help you select the water pump.

A meditative trickle can be achieved with a 1 to 2 gpm pump. To create a dynamic fountain, aim for 4 to 6 gpm. To create a cascading stream, 8 to 16 gpm will be needed. But don't design based on our numbers alone—check with your pump supplier and test it out for yourself. Run a garden hose at the flow you want. Place the hose into a gallon container and time how long it takes to fill it. If, for example, it fills in 10 seconds, you will want a pump that moves 6 gallons a minute.

Pump specifications will state the lift (or head) of the pump in feet and the volume of water it will move in gallons per minute or gallons per hour. Lifting water requires energy. With a given pump, the higher you lift the water, the less volume it will move. For example, the Attwood V500 will pump 5.5 gpm at 1 foot (0.3 m) and 2.8 gpm at 5 feet (1.5 m).

Energy is also required to move water horizontally through a pipe: As a rough guide, consider 10 feet (3 m) of horizontal pumping to be equivalent to about 1 foot of lift in 1/2-inch pipe. The specifications in the pump literature typically assume that a 12-volt pump is running at 12 to 13.6 volts. Wired directly to many solar-electric modules, the pump will actually run at 16 to 18 volts most of the day, which means greater pumping power. A linear current booster

Sly Park School's Solar Fountain

At the Solar Schoolhouse Summer Institute for Educators, hosted in June 2004 by the Sly Park Environmental Education School in Pollock Pines, California, we created the fountain in reverse order. We started with a specific solar-electric module and water pump and then designed the fountain with this equipment in mind. The pump was a Rule 360 (60 gpm, 2.1 amps) and the solar-electric module was a Siemens M55 (55 watts, 3 amps). We also brought 1/2-inch copper pipe, wire, and some flexible pond liner material.

We looked on site for reusable materials. Stephen "Hoppy" Hopkins, the director of Sly Park, gave us some well-used gold panning pans, and we scavenged some old 4 by 4 posts. The length of the posts, coupled with the size of the liner we had brought, determined the maximum diameter of the pond. One participant suggested a hexagonal shape. Another laid out the hexagon and the digging began.

Because we had a fairly powerful solar-electric panel, we chose a fountain structure that lifted the water 4.5 feet (1.4 m). Using 1/2-inch copper pipe, teachers soldered together a simple structure that has a 90-degree fitting on the bottom to receive a plastic hose from the pump, and two 90-degree fittings on the top to make a "U" shape to direct the flow of the water downward.

Teachers then put the components together to give the fountain a try. They put the pump in a bucket of water, connected the pump to the copper fountain structure with 5/8-inch ID plastic tubing, wired the solar-electric module to the pump, and aimed the module at the sun. Once we were confident in the design, we solidified the fountain structure and installed and wired the components together.

The fountain was a great learning experience, and a wonderful way to show our appreciation to the Sly Park staff by giving them a cool spot to pause and reflect. It has proven to be an interactive solar demonstration that has already engaged thousands of students.

Participants testing the Sly Park fountain plumbing before installing it in the pond.

(LCB) or controller that optimizes the power to the pump and increases water flow in low-light conditions may be appropriate in some cases—check with your pump supplier.

We strongly recommend choosing a DC (direct current) submersible water pump. Submersible pumps sit in the fountain basin, push the water, and do not need priming. DC pumps can be powered directly by a solar-electric panel. This makes a more effective solar demonstration because students observe the direct relationship between the sunlight, the PV, and the water fountain. There is no mediation (battery and/or inverter) between the PV and the fountain pump. In addition, directly wiring the PV to the pump eliminates the use of a battery, making the system simpler to install, cheaper, safer, and easier to maintain.

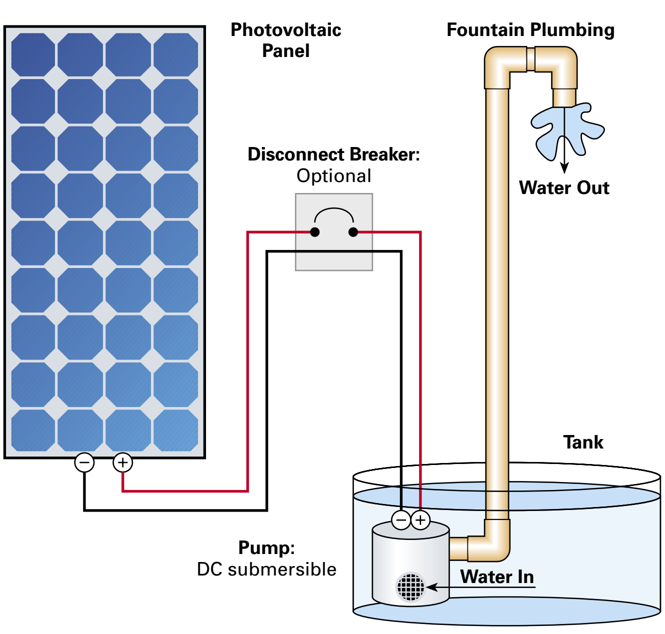
Several readily available pumps provide a range of pumping capacity. For inexpensive pumps, seek out marine bilge pumps (available through catalogs or at marine supply shops). They are designed for a 12-volt DC system and many of them perform well in the 9- to 18-volt DC range. This makes them well suited for solar-electric modules. A bilge pump that moves 6 gpm can be obtained for US$15 to $20. These pumps are quite durable and forgiving.

Step three—choose the solar-electric panel. Your solar-electric panel should be able to provide the voltage and amperage required by the pump. That said, you can intentionally underpower a pump if your goal is a more modest flow and lift of water. For example, for a meditation pond, we have powered a 2-amp Rule pump with a 20-watt (1-amp) PV module.

In some situations, you may benefit from an oversized solar-electric panel. The folks at one school wanted to power a 2-amp pump, but the area is overcast much of the time. We gave them an 80-watt (5-amp) PV module. The fountain performs beautifully, lifting the water 5 feet (1.5 m) even in low-light conditions. An oversized solar-electric panel will also increase the number of hours a day that the pump will be able to move the water.

The liner is laid into the hole dug for the fountain basin and across the fountain curb. Water is added before the liner is tacked to the wooden curb to allow for an unstressed fitting.

Sly Park Solar Fountain



Step four—assemble the components and test. It's a good idea to put together your fountain and test it before making the installation permanent. Test it in a variety of sun conditions, and make sure you're happy with the results.

Step five—dig or build a basin. The key here is to make the basin wide enough to accommodate the splash from the fountain. The basin should be deep enough to hold plenty of water to keep the fountain or stream running for a substantial amount of time without the addition of water. It should also be reasonably watertight, which can be accomplished with rigid or flexible pond lining material, bentonite clay, or concrete. Use your creativity!

Step six—site and mount the solar-electric panel. You need to ensure optimal sun for the solar-electric panel. Use a Solar Pathfinder or other solar siting device to find the sunniest location, year-round.

Once you select an appropriate site, build or buy a sturdy mount for the PV module. A simple design that allows for panel rotation has some educational advantages. Aesthetics may suggest alternative racks made from materials that might not be considered in a home solar-electric system.

Step seven—plumb the pump. The plumbing that brings the water to the fountain can be copper pipe, plastic pipe, or flexible plastic tubing. If it is made from 1/2-inch copper pipe, you will need to make a connection between the pump and the fountain tube. We recommend using thick, clear plastic tubing that has an *inside* diameter of $^5/_8$ inch, with a hose barb and adaptor to the copper pipe. The other end of the plastic tubing will fit over the outlet on the pump. Most of the pumps listed in the table below are designed for a $^3/_4$-inch plastic hose. However, the $^5/_8$-inch plastic tubing will squeeze on if you dip the end in very hot water for a while to soften it up.

If you are snaking flexible plastic hose up the fountain or using a rigid plastic pipe, the connection will depend on the diameter of the hose or pipe you use. We typically use $^5/_8$-inch clear tubing attached to the pump. To make connections, use hose barbs—these connectors will slip on easily but resist sliding off.

Step eight—wire the PV and pump. Mount an outdoor junction box near the pump. The wires from the water pump and the wires from the solar-electric panel meet in this box. The purpose of using the box is two-fold. It provides a weather-resistant enclosure for the electrical connection and makes it easy to replace the pump when it wears out.

The wire from the solar-electric panel to the electrical box can either be rated for the outdoors (sunlight and moisture resistant, and designed for direct burial) or it can be run in conduit. It is important to provide strain relief on the wire by using fittings that make a firm mechanical connection at the solar-electric module frame to prevent damage to the panel, and the possibility of the wires being pulled loose from their connections.

Because PV modules are limited current devices, the *National Electrical Code (NEC)* does not require a DC fuse or breaker in PV-direct pumping systems as long as all the

Putting Fountain Pumps to the Test

Test Conditions: Pumps were tested twice on clear sunny days: from 1 to 3 PM (Daylight Savings Time) on October 29, 2004, and from noon to 2 PM (Standard Time) on November 2, 2004, using one or two, 30-watt, 18-volt solar-electric modules.

The test fountain was built out of lengths of $^1/_2$-inch copper pipe. The various heights were created by screwing on additional lengths of $^1/_2$-inch copper pipe. The pump was connected to the copper pipe using 44-inch (112 cm) lengths of $^5/_8$-inch ID clear plastic tubing.

Amperage was measured with a digital multimeter. The pumps were tested using first one 30-watt module and then two 30-watt modules wired in parallel. You can see how the performance varies depending on the size of solar module you choose. Test data between the two days was fairly consistent. When there were differences, the gpm figure was averaged between the two tests.

A pump is attached to the copper pipe and wired to a solar-electric module.

	Gallons per Minute at Head						
Pump (& # of 30 W modules)	**1 ft.**	**3 ft.**	**4 ft.**	**5 ft.**	**Amps**	**Cost (US$)**	**Pump Type**
Attwood V500 (1 module)	5.5	4.3	3.0	2.8	1.50	$16	Marine bilge
Attwood V500 (2 modules)	8.0	6.5	6.0	5.5	2.50	16	Marine bilge
Rule 360 (1 module)	4.0	2.8	2.2	1.8	1.50	16	Marine bilge
Rule 360 (2 modules)	6.0	5.2	4.5	4.0	2.50	16	Marine bilge
West Marine Gyro 450 (1 module)	4.6	3.0	2.2	1.5	1.40	19	Marine bilge
West Marine Gyro 450 (2 modules)	6.5	5.3	4.8	3.3	2.40	19	Marine bilge
Aquasolar 700 (1 or 2 modules)	2.4	1.2	0.5	—	0.23	180	Solar fountain

Satisfied teachers and leaders of the second Solar Schoolhouse Summer Institute.

wiring is sized to meet *NEC* ampacity requirements. It's still a good idea to include a DC breaker in the system, which can be used to disconnect the PV module from the pump if service is required.

Step nine—use the fountain! People are attracted to fountains. Fountains can be meditative, playful, beautiful, forceful, graceful, expressive, political, or historical. They can be built by skilled artisans or schoolchildren and teachers. They can be built from almost any material that does not dissolve in water—such as driftwood, scrap metal, ceramics, stone, sculptural pieces, or broken dishes.

Moving water brings a place to life. The fact that the fountain is powered by sunlight, a magical and pollution-free energy source, makes it that much more exciting. Fountains create soothing places of calm that are particularly helpful in hectic locations like schools. On a hot day, they can also keep you cool.

Solar fountain projects create infinite opportunities to combine art, solar energy, science, and education. They are also easy to build. Depending on your design, you can build one in an afternoon or a week. It is an opportunity for a collective artistic experience in which you can just put out a pile of materials, some tubing, a pond liner, a pump, wire, and a PV module, and start creating.

Sly Park Fountain Costs

Item	Cost (US$)
Siemens M55 module (used)	$200
Pond liner material	65
Mount materials & hardware	25
Rule pump	16
Copper plumbing, 1/2 in.	12
Wire	10
Total	$328

Access

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