Solar Water Pumping: *Building a Solar Fountain*

Solar-powered fountains are excellent projects for teachers, students, and parents. They are also great science projects, and can add a beautiful feature to schools to demonstrate solar electricity to students and visitors. They are relatively inexpensive, and when kept at lower voltages, quite safe. Being solar powered simplifies installation because it does not require a connection to the school's electrical wiring.

Solar fountains are excellent student science projects.

Solar-powered fountains respond quickly to sunlight. Students and teachers immediately see, hear, and can even touch the effect of the solar-electric panel as it moves the water. If the mount for the panel can swivel, students may see first hand how orientation affects the pump's performance.

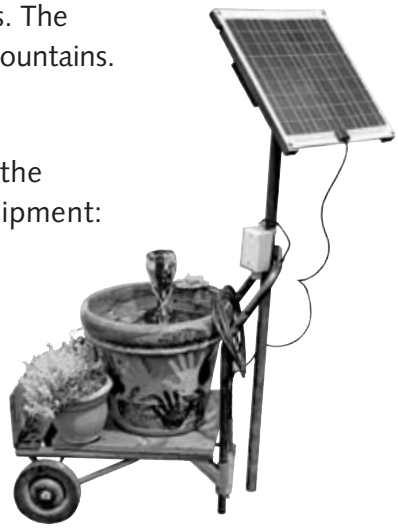
How to Build a Solar Fountain

Building a solar powered fountain, from design concept to completed installation, can take only a few hours for basic models, or many days or more for complex designs. The following steps apply to all fountains.

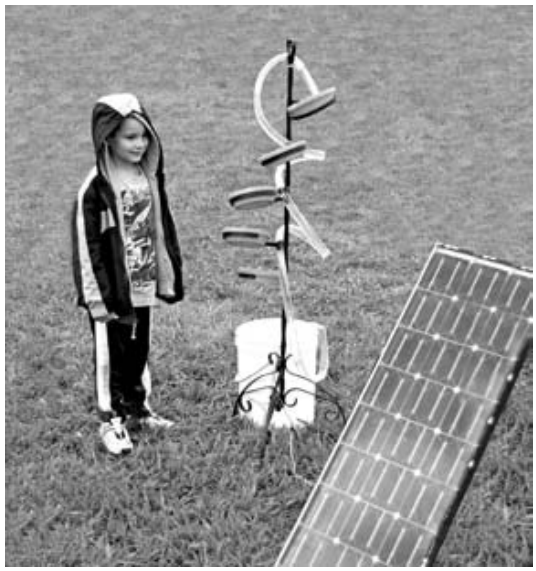
Step One: Design.

Pull together a concept of the fountain. Then choose equipment: the pump, solar-electric module, and basin or pond liner material.

There are many types of solar fountains, from simple, moveable tub or bucket designs, to complex permanent installations.



Movable solar panels help students understand the effect of orientation



☑ Materials List

- ☐ Solar Module(s)
- ☐ DC water pump (submersible recommended)
- ☐ Tubing: copper &/or plastic
- ☐ Pond liner, plastic basin or tub
- ☐ Electrical junction box (optional)
- ☐ Wire
- ☐ Fountain infrastructure
- ☐ Fountain nozzle
- ☐ Hose barbs
- ☐ PV mounting structure/hardware
- ☐ linear current booster (optional)

A moveable tub design with a soldered copper fountain.

Water cascades down tiered flower pot bases in this design.

Attwood T500 Pump
6-8 gpm, Lift: up to 6 ft.
1 to 1.5 amps @ 12 volts,
Inexpensive (~$25)
Best efficiency

Step Two: Choose the pump.
Next, estimate how much water will flow (volume), and how high it will rise (lift or head). Volume, measured in gallons per minute, and lift, measured in feet, will help you select the water pump. As a rough estimate, a meditative trickle uses about a 1 to 2 gpm pump. A more dynamic fountain uses 4 to 6 gpm. 8 to 16 gpm gives a cascading stream.

A high school welding class made this aluminum solar fountain.

Pump specifications 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 the lift, the less volume it moves. For example, the Attwood T500 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, 10 feet (3 m) of horizontal pumping equals about 1 foot of lift (in ½-inch pipe).

DC (direct current) submersible water pumps are good choices for solar fountains. They sit in the fountain basin, need no priming, and can be powered directly by a solar-electric panel.

For inexpensive pumps, use 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$20 to $25. These pumps are also quite durable and forgiving.

Step Three: Choose the solar-electric panel.
The solar electric panel should be able to provide the voltage and amperage required by the pump. Sometimes, however, a pump will be intentionally underpowered to produce a smaller flow and lift of water. For example, for a meditation pond, a 2-amp Rule pump can be powered with a 20-watt (1-amp) PV module.

In other situations, an oversized solar-electric panel is used. One school wanted to power a 2-amp pump, but the area is overcast much of the time. An 80-watt (5-amp) PV module performs beautifully, lifting the water 5 feet (1.5 m) even in low-light conditions. An oversized solar-electric panel also increases the number of hours a day that the pump operates.

Rule 360 Bilge Pump
Up to 6 gpm, Lift: up to 6 ft.
1 to 2.5 amps @ 12 volts,
Inexpensive (~$20)

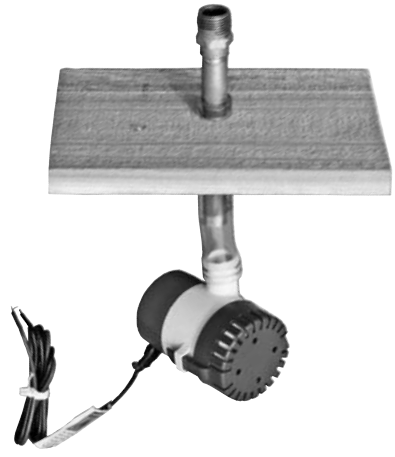
Step Four: Build the fountain infrastructure.
The fountain structure can be made with a variety of materials. A simple method uses a short piece of 1/2" copper pipe, some 5/8" (inside diameter) vinyl tubing, and a small wooden board (see illustration at bottom right). A hole is drilled to fit the pipe and tubing. A threaded male adapter is attached to the top of the pipe with copper epoxy putty, silicon caulking or waterproof tape. If desired, plastic fountain nozzles (available from many hardware stores and garden suppliers) can then be connected to the adapter for a variety of spray effects.

Simple fountain nozzles made with 1/2" copper tees and elbows can be epoxied or taped to the main pipe. Smaller diameter tubing is then epoxied or caulked into the larger pipe to produce various spray patterns.

OASE Aquasolar Pump
1-3 gpm, Lift: up to 1-4 ft.
0.6 to 1 amp @ 12-24 volts,
Expensive (~$140)
Good for low sun & low wattage modules

When powered by a small (20-60 watt) solar module, these portable fountains are good for demonstrating the relationship of photovoltaics effect. They work well in a 5 gallon bucket, especially when stabilized with two other short wooden boards. The bucket, solar panel and fountain can be easily stored in a relatively small space.

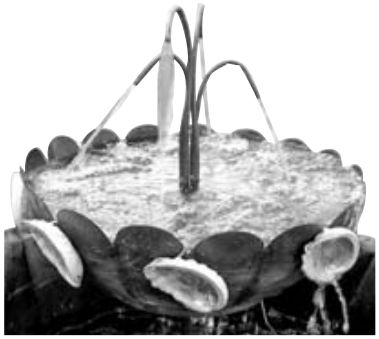
More rugged fountain structures can be made by sweat soldering copper components. This process is surprisingly simple, but does require certain tools, including a pipe cutter and a propane torch. Many books and articles on home plumbing describe copper soldering in detail. The Solar Schoolhouse also teaches workshops on solar fountain construction using soldered copper.



A simple fountain structure made of copper pipe & a piece of wood.

Step Five: Assemble the components and test.
When making a permanent installation it's a good idea to put together the fountain and test it in a variety of sun conditions to be sure you're happy with the results.

Step Six: Dig, build or select a basin.
Portable fountains can be made with a washtub or large flower pot. Permanent installations are often dug into the ground. Make the basin wide enough to catch the splash from the fountain, and deep enough to hold plenty of water to keep the fountain running. Some fountains use a float valve to maintain the water at an optimum level. The basin can



Make sure the fountain water is caught by the basin or tub.

Bell nozzles make a wide spray.

Module & meters mounted on 1/2" board. (Design available at www.solarschoolhouse.org)

be made reasonably watertight with rigid or flexible pond lining material, bentonite clay, or concrete. Many hardware stores and garden suppliers have books on building fountains and ponds.

Step Seven: Site & mount the solar panel. For permanent fountains it's important to put the solar panel in a location with year-round sun. Once you select a site, build or buy a sturdy mount for the PV module. A simple design that allows for panel rotation has some educational advantages.

For portable systems, module racks that can be readily disassembled make it easy to store solar panels indoors. A basic version can be made with wood and plumbing parts. The module is screwed onto a simple wooden frame. The frame is attached to a long copper pipe with a pipe flange and a copper elbow. These parts can be soldered, or drilled and bolted together. A hole is dug, and a second, smaller diameter steel pipe is fixed into the hole with concrete.

The copper pipe mounted to the module can be slid onto the steel pipe, and swiveled to face the sun. This design allows easy student interaction, and can be broken down quickly for storage.

Another easy, portable module rack can be built from two 1/2" boards hinged together to make a single leg. This design can lie flat for storage,

Soldered copper structure with a plastic bell nozzle.

A simple washtub fountain stabilized by two boards.

Durable fountain structures made of soldered copper tubing.

and volt and amp meters can be easily attached. This design is available at *www.solarschoolhouse.org.*

Build or buy a sturdy mount for the solar module.

A long copper pipe connected to a wooden frame with a pipe flange.

Step Eight: Plumb the pump.
A seen in the portable fountains above, thick, clear plastic tubing with an inside diameter of 5/8 inch is an easy way to connect the pump outlet to fountain structures made with 1/2" copper pipe.

Several pumps are listed in a table on the next page. Most are designed for a 3/4-inch plastic hose, but 5/8-inch inside diameter hose will squeeze on if the end is dipped in very hot water for a short while to soften it up. To make more permanent connections, attach the plastic tubing to the copper pipe with a hose clamp.

To reduce clogging and increase pump life, wrap the pump inlet with aquarium filter material or nylon pantyhose.

To allow rotation, the outer pipe & flange slip over a permanently mounted inner pipe.

Step Nine: Wire the PV and pump.
For permanent installations, 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.

To prevent damage to the panel, provide strain relief on the wire using fittings that make a firm mechanical connection at the solar-electric module frame. Because PV modules are current limited devices, the National Electrical Code (NEC) does not require a DC fuse or breaker in PV-direct pumping systems as long as all the 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.

Outdoor junction box for the pump-to-module connection.

Permanent fountain made with a flexible pond liner.

Step Ten: Enjoy the fountain!

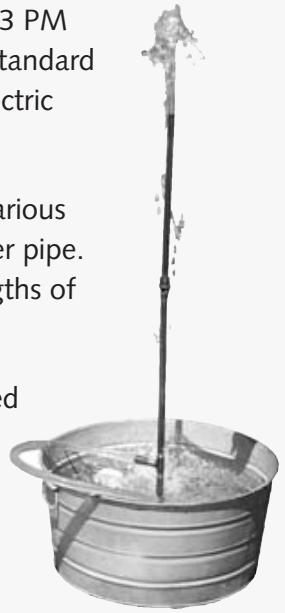
People are attracted to fountains. Fountains can be meditative, playful, beautiful, forceful, graceful, expressive, political, or historical. They can be built by school children and teachers, using almost any material that does not dissolve in water. The fact that the fountain is powered by sunlight makes it that much more exciting.

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 basin or pond liner, a pump, some wire, and a photovoltaic module, and start creating.

Fountain Pump Tests

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.

	Gallons per Minute at Head						
Pump (& # of 30 watt 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

Note: Attwood has replaced their V500 pump with the new T500 Tsunami pump.