

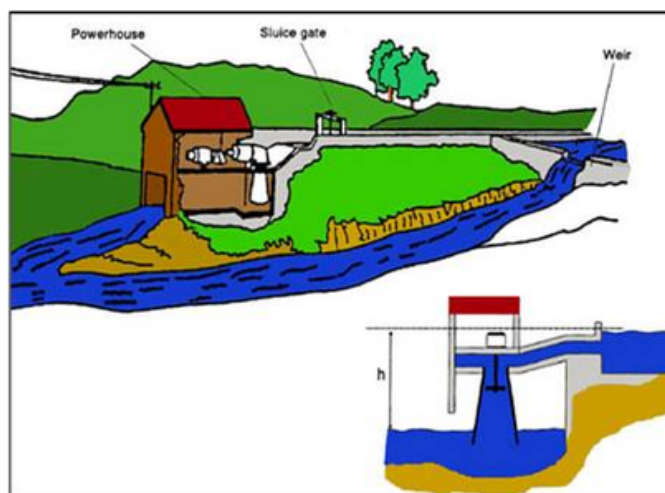
Build Your Own Hydroelectric Generator

Background

Micro-hydro Basics

Most machines that make electricity need some form of mechanical energy to get things started. Mechanical energy spins the generator to make the electricity. In the case of hydroelectricity, the mechanical energy comes from large volumes of falling water. For more than 100 years, the simplest way to produce the volumes of falling water needed to make electricity has been to build a dam. A dam stops the natural flow of a river, building up a deep reservoir behind it. However, large dams and reservoirs are not always appropriate, especially in the more ecologically sensitive areas of the planet.

For making small amounts of electricity without building a dam, the small-scale hydroelectric generator is often the best solution, especially where fast-flowing streams on steep slopes are close by. A small-scale hydro system usually consists of an enclosed water wheel or turbine, which is made to spin by jets of high-velocity water. The water is taken from the stream and moved down slope to the turbine through a long pipe called a penstock. Water flowing through the penstock picks up speed and is directed at the blades of the turbine by nozzles. The turbine spins continuously if there is water to drive it. The turbine is connected to an electrical generator, and the electricity is then available for running appliances or charging batteries. The spent water is returned to the stream. This kind of system is called a “micro-hydro” system, “run-of-stream hydro” or “low-impact hydro.”



Micro-hydro systems can provide clean, environmentally friendly electricity in rural communities.



Example of a micro hydro system that can be used in rural communities.

For this activity:

You will use plastic spoons to build a model of a simple micro-hydro system. It generates surprising amounts of electricity, provided you have a supply of pressurized water, such as from a lab sink. This model closely resembles real micro-hydro designs and can produce enough electricity to light a small light bulb.

Making Electricity

Most appliances use electricity to do work. But what is electricity? Electricity is a flow of electrons in a metal wire, or some other conductor. Electrons are tiny particles found inside atoms, one of the basic building blocks of all matter. We call the flow of electrons through any conductor a “current of electricity.”

Each electron carries a tiny negative charge. When electrons move through a conductor, they produce an invisible magnetic field, like to that around a magnet. The strength of this field depends on how many electrons are in motion. A stronger field is created by concentrating it through a tight coil with many turns, which increases electron flow. Placing a piece of iron in the middle of the coil turns the iron into a powerful magnet due to the electromagnetic field.

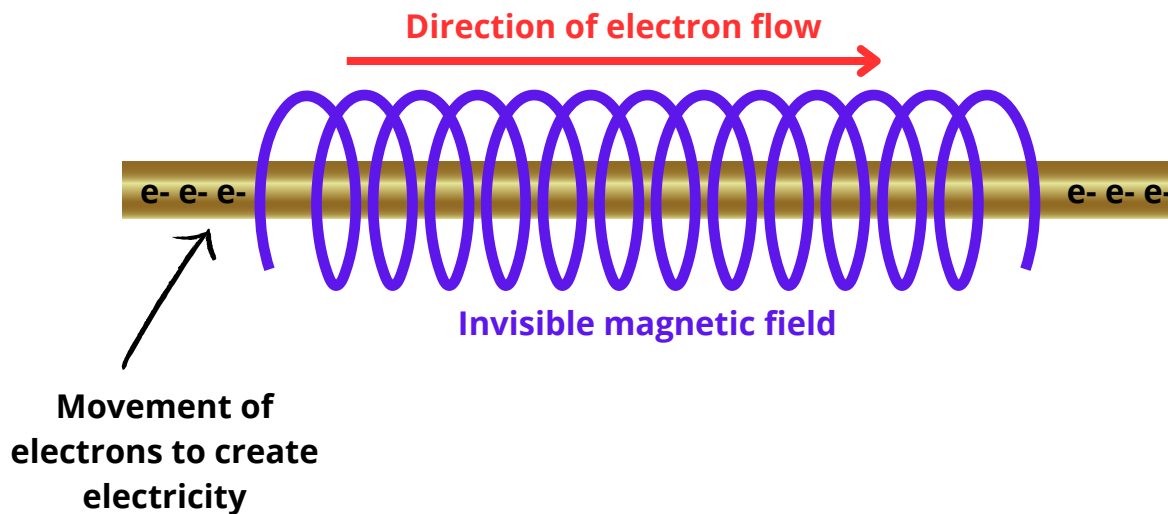


Figure 1. How electricity is conducted as an electron moves through the coil.

While it is true that electrons moving through a conductor produce a magnetic field, the reverse is also true. You can make electrons move in a wire by "pushing" them with a moving magnet, which is how an electrical generator works. Electrical generators usually contain powerful magnets that rotate very close to dense coils of insulated wire. These coils develop a flow of electrons that becomes an electrical current when the generator is connected to an electric circuit.

You will be building an electrical generator as part of this project. It uses moving magnets to create a current of electricity in coils of wire. This generator is technically called an alternator because the electrons move back and forth in the wire, rather than flowing in just one direction as they do from a battery. A meter connected to the wire would show that the charge of the wire switches or alternates between positive and negative as the electrons change directions. Such an electrical current is called alternating current or AC. Household electrical current is alternating current (AC). Appliances must be specially designed to use it. The other type of current is called direct current because the electrons move in one direction only. Most battery-powered appliances such as calculators and portable CD players use direct current.

Construction Plan: Build It!

Safety Precautions

- Electric drills can cause serious eye and hand injuries. Eye protection is required, and leather gloves are recommended when drilling small parts such as corks. A cork borer can be used as a substitute, but it also has risks for injury.
- Hot glue guns can cause superficial burns. Be sure glue guns are warmed up only when needed and unplugged immediately after. Hot glue can stick to skin and clothing.
- Utility knives can be hazardous. Expose only as much blade as you need to cut the material, and fully retract the blade when not it's not in use.



Materials Required

- Paper Templates: Please download the following templates separately and print according to the printing instructions.
- Micro-hydro template (74K)
- Important: Printing Instructions
- 4L plastic jug (rectangular style, from vinegar, windshield washer fluid, or similar- see illustration)
- 10 plastic spoons
- 1 large cork (3.5 to 5 cm)
- Enameled magnet wire, 24 gage (approx. 100 m)
- Foam core or heavyweight corrugated cardboard (approximately 22 cm by 30 cm)
- 6 mm (1/4 inch) wooden dowel (20 cm long)
- 4 ceramic or rare earth magnets (18mm or larger)
- Clear vinyl tubing (6 cm long, 1/4" inside diameter)
- 4 brass paper fasteners

Tools

Gather together the following tools:

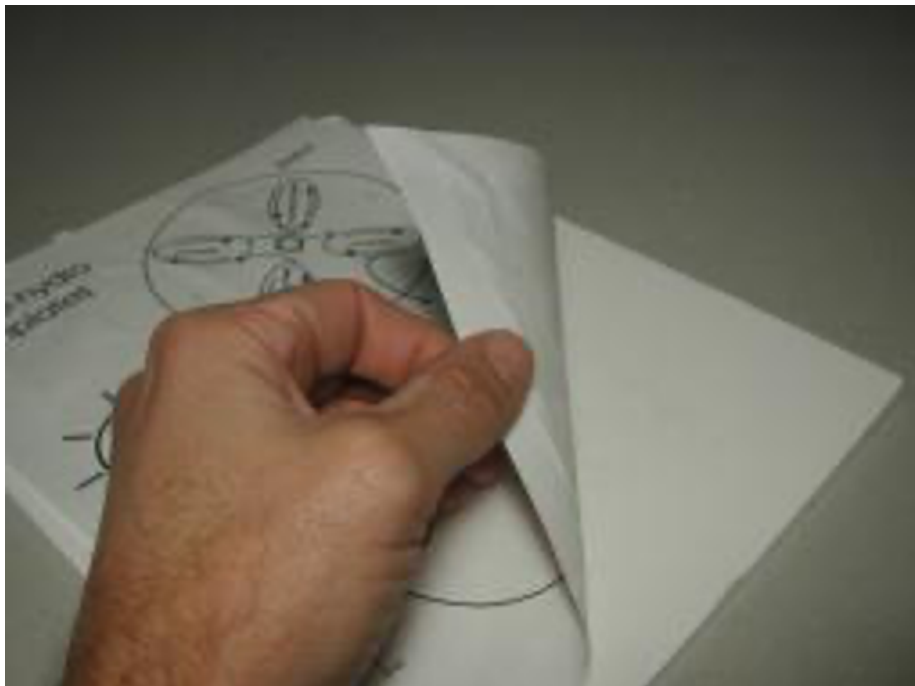
- Electric drill, with ¼" drill bit
- Scissor
- Electrical tape
- Ruler
- 10 cm (3.5 inch) nail or awl
- Hot glue gun, with 3 glue sticks
- White glue
- Utility knife
- Pencil sharpener
- Permanent felt tip marker
- Magnetic compass
- Wire cutters
- Gloves
- Safety glasses



Part A: Prepare the Discs

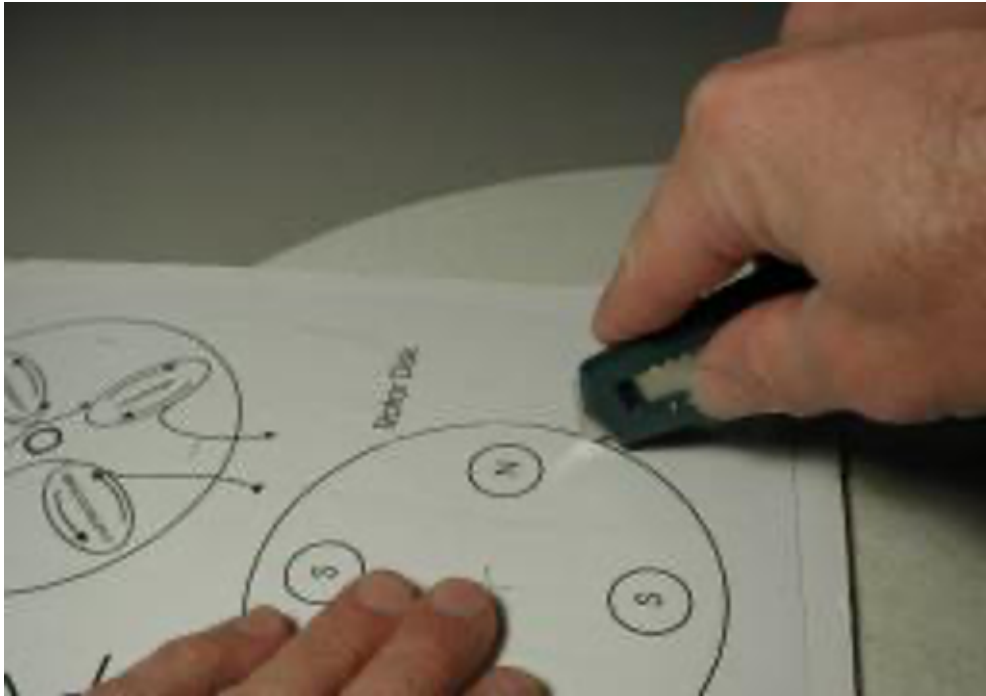
The generator we are building has two basic parts—the rotor and the stator. The stator is the part that remains stationary and has coils of wire to collect electricity. The rotor is the part that moves. It is equipped with powerful magnets that will induce current of electricity in the coils.

1. Glue the template sheet to the cardboard with white glue. Be sure to spread a thin layer of glue evenly over the entire back of the template.



2. When the glue has dried, use the utility knife to cut the rotor and stator disks from the cardboard sheet. Carefully trim the edges. Also, be careful not to damage the tabletop with the utility knife. Work on a piece of scrap wood or a cutting board.

3. Using an awl or sharp nail, punch a small hole through the rotor disc at its exact centre, as shown. Using the utility knife, make a larger (1 cm) hole at the center of the stator disc.



Part B: The Stator

1. Prepare a jig for winding your coils by cutting a 3 cm by 16cm piece of cardboard, folding it in half and securing with a small piece of electrical tape.
2. Cut 8 short (4cm) strips of electrical tape and set these aside.
3. Leaving a lead of about 10cm, start winding the first coil on the jig. Wrap the wire neatly onto the jig, forming a tight coil. Use 200 wraps or turns.



4. Carefully slip the coil off the jig and secure it using two pieces of the electrical tape you set aside in step 2 above.



5. Using a small patch of emery cloth or sandpaper, remove the enamel insulation from the ends of each lead, exposing about 1 cm of bare wire. Be sure the wire is completely bare!
6. Repeat steps 1 through 5 to make three more coils.
7. Lay the coils loosely on the disk in the position shown by the template. Arrange the coils so their windings alternate between clockwise and counter-clockwise, as shown on the template. **THIS IS VERY IMPORTANT!** Arrange and connect the coils so that an electron would follow the path shown by the arrows, starting with the counter-clockwise coil on the left-hand side.
8. When you are sure you have them arranged correctly, connect the coils by twisting the bared ends together, covering the connections with small pieces of electrical tape.
9. Check your connections: Set your multimeter for measuring electrical resistance (ohms). If your connections are good, there should be little resistance to the movement of electrons, and the meter should produce a reading of about 10 ohms or less. To check this, touch or connect the probes to the two free ends of the wires from the coils. If the coils are not properly connected, the reading will be a very large number, or infinity.



Check to make sure you have good connections between the coils.

10. Once you are confident the coils are properly positioned and connected, glue them to the stator disk. Lift each coil up a little and apply a large blob of glue to the template where the coil touches. Let the glue solidify before gluing the next coil.

11. With the utility knife, cut 4 slits through the cardboard between the magnets as shown on the template. These slits will be used to fasten the stator to the plastic container later.

Part C: The Rotor.

1. Obtain 4 magnets. Using the magnetic compass, determine the polarity of each face, and mark the south pole of the two magnets and the north pole of the remaining two using a felt pen.



Checking the polarity of one face of a magnet using a compass

2. Warm up your hot glue gun, and prepare to attach the magnets to the rotor disc. The magnets must be arranged so that their polarity alternates (i.e., N-S-N-S). Their position and polarity are indicated on the template.

3. Squeeze a small (1cm) blob of hot glue on the spot where the first magnet will go. Quickly press a magnet with its washer onto the blob, as shown below. Allow the glue to solidify before moving onto the next magnet.



4. Repeat this for the remaining 3 magnets, making sure to alternate north and south poles as you go.

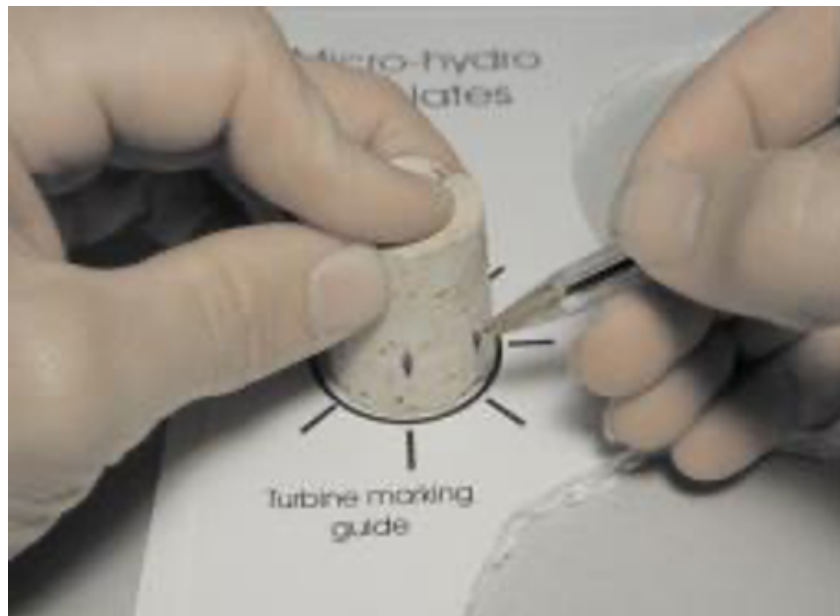
Part D: The Shaft

1. Cut the dowel down to 20cm in length

2. Using a pencil sharpener put a point on each end of the wooden dowel (it is not necessary to make a sharp point - blunt will do).

Part E: The Turbine

1. Drill a ¼" (6mm) hole through the CENTER of the large cork or use a cork borer to make the hole.



2. Using a pencil sharpener put a point on each end of the wooden dowel (it is not necessary to make a sharp point - blunt will do).

3. Place the cork wide end down on a cutting board. Use the utility knife to cut the shallow slits into the cork where the spoons will be inserted. USE CAUTION.

4. Obtain 8 plastic spoons. Using the wire cutters, cut the spoon handles leaving a 1cm stem on the bowl of the spoon.

5. Be sure the glue gun is warmed up and that you have a glue stick or two handy.

6. Insert the first spoon into the cork, using the turbine template as a guide. Push the stem of the spoon into the cork to a depth of about 1cm.



7. Repeat step 6 with the remaining 7 spoons. Adjust the angle and depth of the spoons so they are evenly spaced and all project from the cork at the same angle.

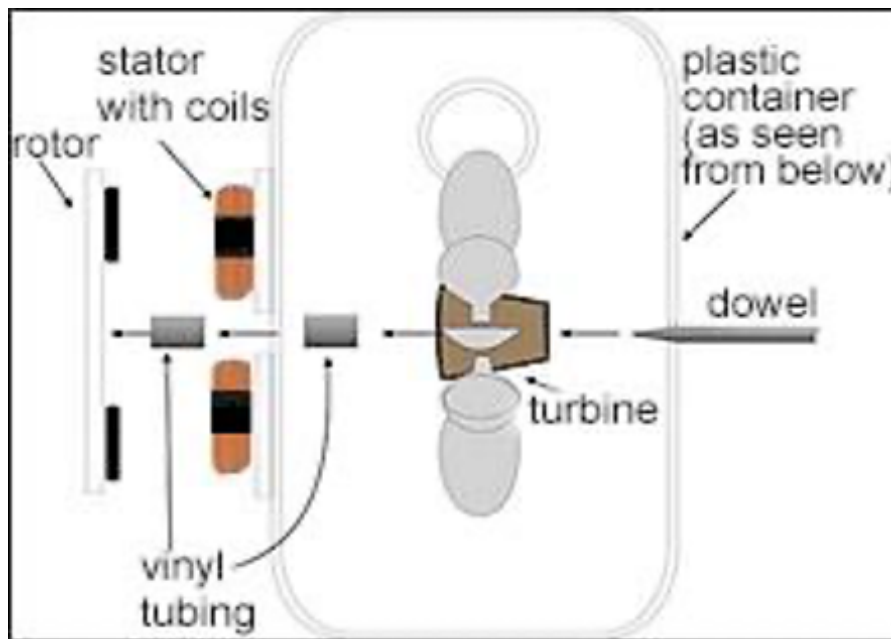
8. When you are satisfied with your turbine, add some hot glue to each spoon to secure it on the cork.

Part F: The Housing

1. Obtain the plastic container and tear off any labels that might be attached to the sides. Using scissors or a utility knife, cut part of the bottom off, as shown in the photo below.



- Using a ruler, find the center of the side as accurately as you can. Mark this point with the permanent marker. Repeat for the other side.
- At the mark on each side of the container, drill a $\frac{1}{4}$ " (6mm) hole through the plastic.
- Lay the stator with its attached coils on the side of the container so that its center hole is over the hole in the container. Push the nail (or awl) through each slit on the stator disc to mark the locations of these slits on the side of the plastic container.
- Using the utility knife, make 4 small slits on the side of the container, corresponding with those on the stator disc.
- Using the brass fold-over tabs, securely mount the stator disc to the side of the plastic container. Bend the tabs flat on the inside of the container, as shown.



Part G: The Final Assembly

- With scissors, cut the vinyl tubing into two small lengths, each 1 cm long.
- Slide the shaft into the plastic container through the hole in the stator. Inside the container, slide one piece of tubing onto the shaft.

3. Position the turbine inside the container so the spoons face the neck of the bottle.



4 Push the shaft through the turbine's cork. Work the cork and the tubing down the shaft so the shaft comes out the other side of the container and projects by about 4cm.

5. Adjust the position of the turbine so the spoons line up with the neck of the container.

6. Adjust the position of the tubing to that it comes close to but does not touch the inside of the container.

7. Slide the second section of tubing over the end of the shaft as shown. The two pieces of tubing will help to keep all parts of the turbine positioned correctly when it spins. Spin the shaft to be sure it turns without binding, and that the turbine does not strike the inside of the container as it spins. **The magnets should be close to, but not touching the coils as they turn.**



8. Slide the rotor disc onto the shaft. Position it so that the magnets come to within 2 or 3 millimetres of the coils. Spin the shaft to be sure the magnets do not strike the coils.

9. Check the rotor disk to see that it spins true. Turn the shaft slowly and note any wobble. Adjust the angle of the disk on the shaft as necessary.

10. When the rotor disk spins without wobbling, fix it in position with hot glue applied to the point where the shaft passes through the reinforcing discs.

Position the turbine inside the container so the spoons face the neck of the bottle.



Reinforce the rotor disk with hot glue.

Part H: Test It!

If all has gone well with your construction, this turbine should be able to produce significant amounts of electricity, depending on the speed of the water striking the spoons.

1. Place the neck of the plastic container under a faucet and turn on the water. The rotor should spin quickly!
2. Connect your micro-hydro turbine to a multi-meter and set the dial to read volts of alternating current. Measure the voltage generated by the operating turbine.



Questions

1. What variables in a micro-hydro system could you change to get more electricity from it?
2. In what locations in Canada or other parts of the world would micro hydro be a good choice for clean energy?
3. What practical problems would you encounter in setting up and running a micro-hydro system in a rural area?
4. Why are micro-hydro systems seen as better for the environment compared with large-scale dams?
5. Use the Internet to locate distributors and manufacturers of micro-hydroelectric components. Use the search terms "micro-hydro", "Pelton wheel", and "run of stream."