Name(s) _____ Date _____

Power the Grid

ESSENTIAL QUESTIONS TO KEEP IN MIND:

- Where does the electricity for our school come from?
- Why does it matter where our electricity comes from?

WHAT IS A POWER GRID?

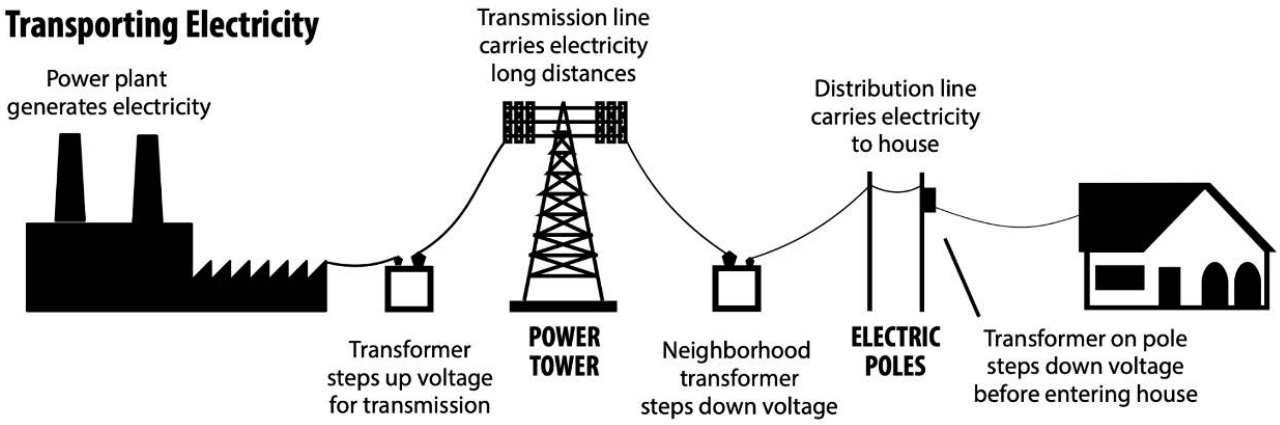


Image from NEED Project: Elementary Energy Infobook- Electricity Travels Through Wires

Power grids get electricity to where it is needed! They include power plants to transform heat, wind, solar, and nuclear energy into electricity. They also include transmission lines that carry lots of electricity at high voltage, and distribution lines that carry smaller amounts of lower-voltage electricity to your home where it will be consumed. Electricity is the movement of charged particles called electrons in a circuit.

In this activity you will build a circuit to model the power grid. Our model will include representations of transmission lines, distribution lines, and consumers. It also includes representations of three kinds of power plants that generate electricity from different kinds of energy: nuclear, solar, and wind energy. Solar and wind energy are *renewable*, but nuclear is *non-renewable*.

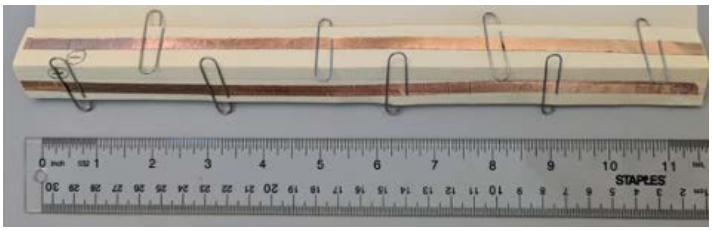
Before beginning the project steps below, review the "Expert Tips for Using Maker Tape" and "Safety" sections at the end of this document.

MATERIALS

- ☐ 10 LEDs (8 red, 2 green)
- ☐ 1 manila folder, cut into pieces
- ☐ Maker Tape (2- to 3-foot strip per student)
- ☐ 2 jumper leads with alligator clips
- ☐ Narrow (1/2-inch) transparent tape
- ☐ 1 hand crank motor with handle
- ☐ 1 solar panel
- ☐ 1 coin cell battery
- ☐ Scissors
- ☐ Ruler and pencil

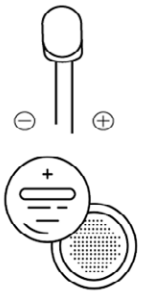
PROJECT STEPS

Build Transmission Lines



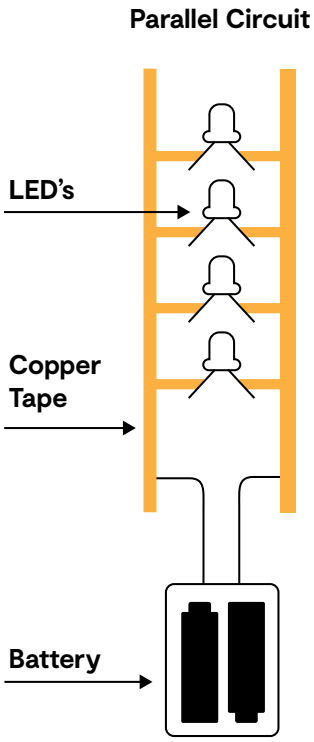
1. If it's not yet done, add an 11-inch strip of Maker Tape to each outside of the folded strip cut from the manila folder.
2. Mark the side closest to the bottom fold (+) and the other (-).
3. Add 2 paper clips, one on each transmission line, to each of the four slits beneath the transmission lines.

IMPORTANT



- The longer leg of an LED is positive (+)The shorter leg is negative (-).
- Coin batteries also have a (+) side marked on them (the back is (-)).
- The solar panel and hand crank each have a red wire which is positive (+) and a black wire that is negative (-).
- Be sure to always match (+) parts to (+) lines and (–) parts to (–) lines.

Create Distribution Areas

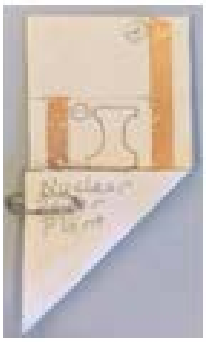


4. Take a 2-inch wide card of manila. Use your ruler to draw a horizontal line one inch from the end of the card. Draw 2 vertical lines one inch apart along the length (long side) of the card. The left line should start at the line one inch from the end of the card. The right line should go from the top to the bottom of the card.
5. Mark the shorter line as negative (-) and the longer line as positive (+).
6. Cover the two drawn lines with Maker Tape so that you have two parallel lines of Maker Tap on the card as shown in the image. Cut one piece of Maker Tape to be the exact length of the left line, then place the tape directly over the line. Do the same for the right line - cut a piece of Maker Tape exactly the length of the right line and place the tape directly over the line.
7. Between the two strips of Maker Tape, draw the "buildings" you want to model, for example, a factory or some houses.
8. Bend the legs of an LED out flat, one leg to each side, so that you can lay it down across your building with the LED in the center. The right leg of the LED should touch the right line of Maker Tape and the left leg of the LED should touch the left line of Maker tap.
9. Use transparent tape to secure the LED leg on each side.
10. Repeat steps #4-9 two more times to make a total of 3 distributions areas (1 per card).

Create the Nuclear Power Plant (Nonrenewable Power Source)

11. Take a 2-inch wide by 4-inch tall manila card.
12. Repeat steps #4-5 on this new card.
13. Draw a fourth line across the middle of the card, dividing the card into an upper half and lower half, and creating a square in the middle.
14. Draw a fifth diagonal line from the bottom left corner of the card up to the right end point of the middle line drawn in step 13.

15. Repeat step #6, adding two strips of Maker Tape to cover the two long parallel lines on the card.
16. Place a coin battery on top of the left (-) strip of Maker Tape, just below the centerline.
17. Secure the coin battery to the card using transparent tape. Do not cover the center of the battery with tape – be sure to leave the center of the battery clear.
    17a. Cut 2 pieces of transparent tape 1.5 inches long.
    17b. Secure the top edge of the coin battery to the card. Take one of the 1.5 inch strip of tape and place it horizontally across the top of the coin battery.
    17c. Secure the bottom edge of the coin battery to the card. Take the second 1.5 inch strips of tape and place it horizontally across the bottom of the coin battery.
18. Fold the bottom right corner of the card up to the left, along the diagonal line, as is shown in the image. This should connect the (+) strip of Maker Tape (the bottom of the right line) to the center of the coin battery, where there is no tape.
19. Secure the folded flap to the manila card using a paperclip.



Test Your Model

20. Slide a model distribution area into one of the slots under the model transmission lines. Adjust the paper clips so the clip on the close (-) **transmission line** touches the short (-) **distribution line** on the card, and the paper clip on the far (+) line touches the long (+) line on the card. *Make sure that that the metal paperclip touches the copper Maker Tape directly and that there is no transparent tape between them. We want the two metal components to connect to create the circuit.*
21. Slide your model nuclear power plant into another slot and adjust the paper clips as in step #17.
22. Ensure that your red LEDs light up (your green LEDs may be dim). Adjust the paper clips to have a solid connection to the copper of the Maker Tape as needed, and tape down the cards and the transmission line fold to make sure everything is secure.
23. Connect the remaining two model distribution areas the same way you did in step 20.
24. Adjust the cards and paper clips to ensure you have solid connections, just like you did in step 22.

Attach the Wind Turbine and Solar Panel (Renewable Sources)

25. Tape the metal tip of the red wire from the hand crank to one end of the positive (+) transmission line where the copper is showing.
26. Similarly, tape the black wire onto the same end of the negative (-) transmission line.
    A hand crank represents wind turbines. The handle will need your energy to light the LED, just like a wind turbine needs blowing wind.
27. Tape the metal tip of the red wire from the solar panel to the other end of the positive (+) transmission line.
28. Similarly, tape the black wire onto the same end of the negative (-) transmission line.
    The solar panel relies on light from the sun. Put your solar panel close to the window or use a flashlight to add solar power to your model power grid.
29. Before you test your hand crank and solar panel, you need to break the connection to the coin battery so that your model power grid is no longer battery-operated. Do this by removing the paper clip and unfolding the triangular card flap on your nuclear power plant model.

MODELING A POWER GRID / ENERGY FORMS AND FLOWS

Draw your model power grid in this space. Label all of the power grid subsystems that are represented in your model. On your drawing of your model, draw arrows to show the flow of energy through the system.

MODELING A POWER GRID / ENERGY FORMS AND FLOWS

In what ways does this model do a good job of representing a power grid system?

In what ways does this model NOT represent a power grid well?

What transformations of energy do you identify?

Form of Energy		*Transforms Into*
	→	
	→	
	→	
	→	
	→	

What are the inputs to the power grid system you modeled?

What are the outputs from the model power grid system?

GETTING ENERGY TO A POWER GRID

As you are running your model with the power sources on, what do you notice about the lights? Are there times when the lights stay on steadily? Are there times when they flicker? What seems to cause those changes?

Were there any times when some of the LEDs failed to light? What happened? Why do you think the LEDs failed to light?

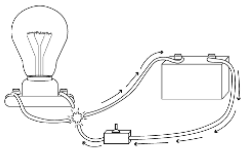
In what ways do the LED lighting problems you see in your model represent problems with real power grids well or poorly?

EXPERT TIPS FOR USING MAKER TAPE

- Fold the maker tape in half the long way. The crease that you create down the middle will help it peel more easily.
- Maker Tape can easily stick to itself. Do not remove all the backing paper at once. Instead, slowly peel the paper backing while you are securing it to the project.
- Avoid cutting the Maker Tape between circuit elements. Instead, fold it to go around corners.

SAFETY

Do not stack coin cell batteries. Do not store them in a way that they could accidentally pile onto each other. Piled coin cell batteries could cause a short circuit.



Short circuits are very dangerous. They happen when electricity flows without passing through a load such as an LED or fan. The battery can become very hot.

Coin cell batteries are amazing, but if eaten by humans or animals can become lethal. Never put any type of battery in your mouth.

VOCABULARY

Carbon Footprint – The total amount of greenhouse gasses generated by a technology when it is used, often measured over a single use or over a year.

Circuit - A closed loop of conductive materials where electricity can flow from the power source along the path to the load and back to the power source.

Distribution – The delivery of electricity from substations to consumers.

Electricity - Electricity is the flow of charged particles, called electrons, through a circuit.

Electrons - Negatively charged subatomic particles that move freely through a conductor.

Generation - The process of transforming a primary energy source (such as heat or kinetic energy) into electrical energy.

Load - Something using electrical power in a circuit: for example, a light bulb, motor, computer, or appliance.

Nonrenewable Electricity - Electricity that is generated from a nonrenewable energy source that will run out, such as coal, oil, natural gas, or nuclear power.

Power Plant – A place where physical energy is converted into electrical energy.

Power Source - The source of electrical energy in a circuit, for example: a battery, solar panel, or wind turbine.

Renewable Electricity - Electricity that is generated from a renewable energy source that will never run out, such as wind, solar, water, or biomass.

Substation- A hub where electricity from power plants or bigger transmission lines is controlled and distributed to different neighborhoods and buildings.

Transmission - The bulk movement of electrical energy from a generating site to electrical substations and community grids for consumer use.

Voltage – The amount of pressure from a power source that pushes electricity through a circuit.