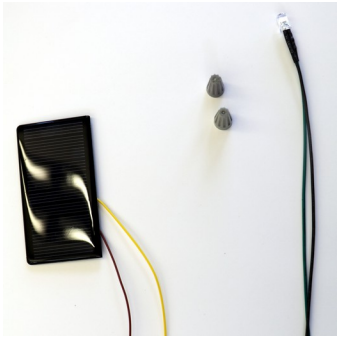
This kit allows you to design and build your own mini microgrid.

A microgrid is a local electrical grid. It can work with the larger grid or on its own.

You will use a solar panel to give power to a whole community! As you work, you will learn about city planning, solar power, and electrical circuits.

Build Your First Circuit: Explore

To build an electrical grid, you will need to know about circuits. Let's build a simple circuit. We'll use one light and one power source.



Connect the wires from your solar panel to the wires from one LED. To light up your LED, you will need to have the correct pairs of wires connected. Do not connect more than two wires to each other for now.

You can hold wires together or twist them together using a wire nut. (To learn how to use a wire nut, see page 3.)

Did you get your LED to light up? If not, you may need to swap your LED wires. Energy can only flow one direction through LEDs.

If you are still having trouble, make sure your solar panel is getting enough light. You may want to point it toward a light source. Sunlight is best, but ceiling lights or a flashlight can work as well.

Build Your First Circuit: Explain

1. Sketch what your successful circuit looks like.

2. What do you need to make the LED light up?

3. You might have noticed the LED's brightness can change. What will happen to your LED if you shine a bright flashlight on your solar panel?

4. Solar energy is light energy from the sun. This light is valuable to us, but we must convert it if we want it to power our homes. What part of our kit converts energy?

5. What type of energy does light energy turn into?

6. What shows us that energy has been converted?

7. We have converted energy twice. Light energy → electrical energy → light energy. Every time we change the energy's form, we lose some of it. How is energy lost in our system?

Build Your First Model: Explore

LEDs will soon light up our community! Let's make our first building. Choose which you'd like to make first. There are several sample models in your kit. For example, you might want to make a house, retail store, or apartment building.

Cut the patterns on the solid lines. Do not cut the dashed lines. See the image on page 1 to see what the buildings may look like.

Fold in along the dashed lines. All the lines should be pointed inside the building. You don't want to see any lines from the outside. Make sure everything fits together and that no tabs were lost.

If you want to decorate your building, unfold the parts and lay them flat again. Before you start decorating, think about where you will put the LED light(s). Do you want them to be porch lights? Window lights? Something else? You can use crayons, colored pencils, or markers to add color and detail.

If you want, you can install your first light by carefully making a hole in your building. Do not glue or tape it yet. Can you light up the LED using your solar panel?

When you are done decorating, tape or glue the building along its white tabs. Hold the building together, but don't tape or glue any tabs to your cardboard base. We will do that later!

Build Your First Model: Explain

1. How did you decide which building to start with? Think about what it might take to plan a city. Which type(s) of buildings do you think a city planner would start with? Why?

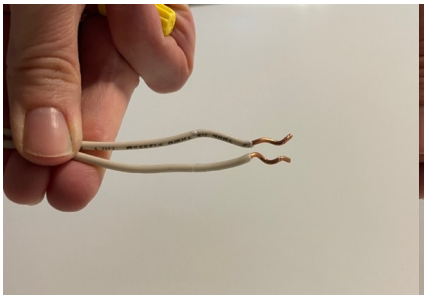
2. How is your model similar to or different from a building in the real world?

Add Multiple Lights: Explore

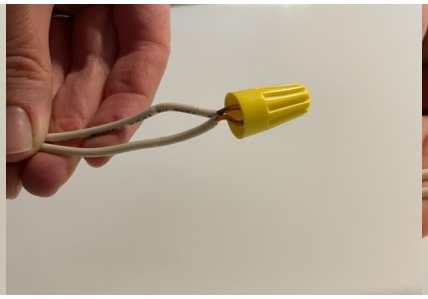
Great job making your first building! Let's add another LED to our circuit. It is easier to explore how multiple LEDs work before we add them to buildings.

Find a way to connect 2 LEDs to your solar panel so they both light up. You should be working with 6 wires: 2 wires from your solar panel and 4 wires from 2 LEDs.

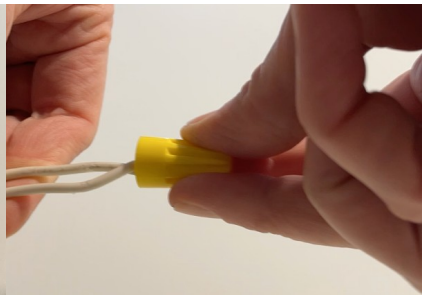
When you have all the wires you need to join in one place, use a wire nut to join them.



Line up two parallel ends of exposed wire.



Place the wire nut on top of parallel wires.



Twist the wire nut counter clockwise.

Add Multiple Lights: Explain

1. Sketch what your successful second circuit looks like below.

2. What do you notice about all your black wires? Where do they go?

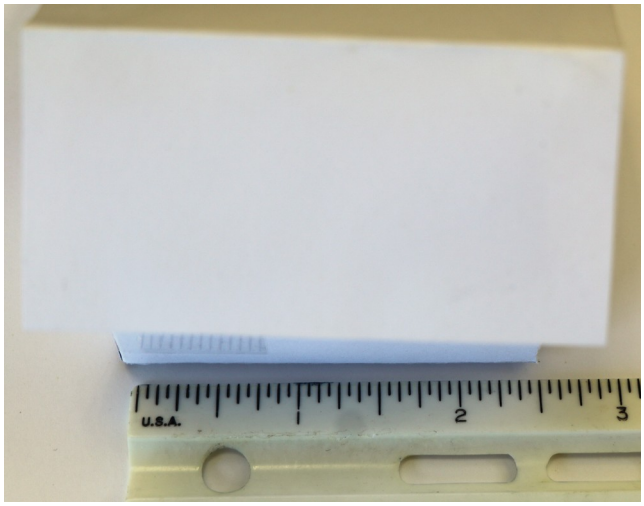
3. You have built a parallel circuit. Why do you think it is called a parallel circuit?

4. How will more and more LEDs connect to your circuit?

Create a Second Model: Explore

Engineers and architects often build models before building anything full-size. To be useful, the model must be built to scale. The building you made earlier is scaled down from a real building. Our solar panel has also been scaled down.

1. How big is the model of the house included in your kit? Use a ruler to measure the length of the two bottom sides of the model. Even if you haven't cut and built the home, you can measure its sides.



2. In the US, the average home measures about 25 meters by 25 meters. What is the scale of our house?

10 m = about __ inch.

3. How big is the solar panel in your kit?

4. In the real world, each solar panel is about 2 meters by 1 meter. Homes will have multiple solar panels, making up an array. This grouping of solar panels will measure about 20 meters by 10 meters. Consider the size of your solar panel and the scale of your first building. Do you think your kit's solar panel models a single panel or an array of panels?

5. Use the scale you calculated in step 1. How wide will the roads need to be in your community to match the scale of the house? In the real world, a 2-lane road is about 10 meters wide.

If your work is correct, the road will be about 1 inch wide. If you have a different answer, look back at how you got it. You will want to have the correct scale in question 2 before continuing.

Let’s make a new model! Choose a structure other than the house, apartment building, and retail store in your kit. You might choose to make a school, a bank, or even a light post.

6. Do some research to find out how big the structure would be in the real world. You might be able to find information in meters. If you need to convert meters into feet, 1 meter = 3.3 feet.

Length: _____ m

Width: _____ m

Height: _____ m

7. Re-scale your structure using your answer from step 2 above.

Length: _____ in

Width: _____ in

Height: _____ in

8. Create a pattern for your structure! If you're making a building, don't forget to include 4 walls and a roof. If you want, you can add tabs to attach the walls, roof, and base. Last, decorate and build your structure.

Create a Second Model: Explain

1. Why do we make models?

2. What would happen to your model if your buildings were scaled differently?

3. What would happen if an architect used more than one scale to plan a real-world building?

4. Meters are an international standard unit for length. Inches are not. We used inches because it made scale conversions easier. Do you know any jobs that use non-standard units like inches? (Even non-standard units of measurement can be important!)

5. Was there anything about making a pattern that was difficult? How would you overcome that difficulty next time?

Design Your Neighborhood: Explore

You now have two structures. Your community is growing! Let's take some time to design the rest of the neighborhood before we build more.

City planners help decide what kinds of buildings go where. Homes are often built near each other. The same is true of different types of businesses. City planners don't make these decisions alone, though! They listen to a lot of community members' ideas. People who build infrastructure like the power grid have especially important ideas!

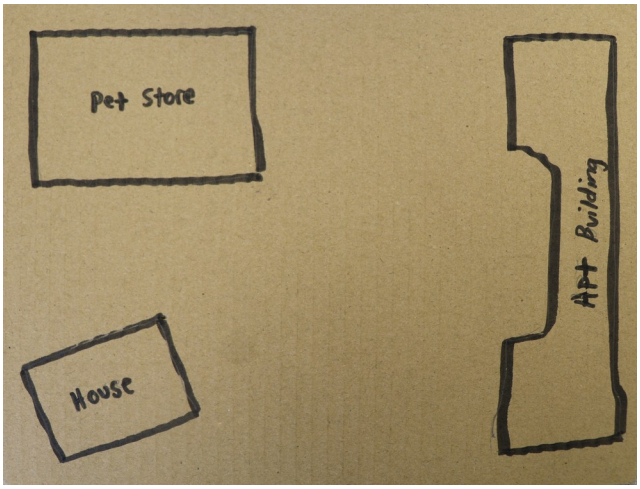
You will be organizing your community on your cardboard land area. Place your two pieces of cardboard side-by-side. As you organize your structures, consider the following constraints. (A constraint is something that limits the choices you can make.)

- The amount of land area is limited. You may be able to fit 3-6 buildings in your community. It depends on their size.
- You have 6 LEDs to work with. You may want to use more than 1 LED on some structures. If so, that will limit the number of structures.
- You need space for the solar panel that will power the community. Do you want the solar panel to be in the center of the community? Toward the edge? Will it be on top of a building or part of a green space like a park?

Set your buildings on the cardboard base and arrange them. Add more buildings so your community is more complete. What type of buildings would you like to add? Should the new buildings be near one of your existing buildings?

You can also draw roads, parks, sidewalks and more. Go back to the last section (*Create a Second Model*) if you need to revisit scale.

Once you are happy with your community plan, trace the bottom of the buildings. This will help you keep track of your plan as we proceed.



Design Your Neighborhood: Explain

1. What were some things you thought about when designing your neighborhood? Which of these do you imagine a city planner thinks about too?

2. If you are working with someone, did you have to compromise with them? If so, what did you discuss?

3. Compromise and information gathering are important roles for a city planner. If this were a city in the real world, is there anyone whose opinion you would ask? Why?

Create an Electrical Plan: Explore

You should have seen earlier that our LEDs must be put in parallel circuits. In parallel circuits, current can flow through all the wires at the same time.

Each of the black ground wires must be connected to the ground wire on the solar panel. The ground wire on the solar panel is connected to the negative (–) sign. Each of the colored wires must be joined as well. It is best to connect wires with a wire nut. Not all of the wires have to be in the same nut, though. A wire can be used to bridge two wire nuts.

How will you connect the wires in your model community? Where are your lights going to go?

Sketch your electrical plan.

Create an Electrical Plan: Explain

1. Look back at your electrical plan. Do all the ground wires connect? Do all the colored wires connect? (They should!)

2. In which direction will current flow? Add arrows to your diagram where: – → +.

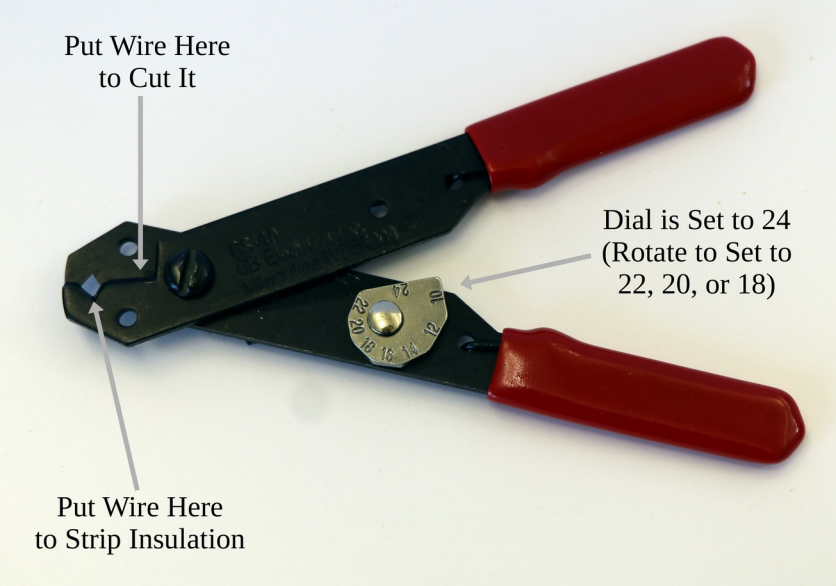
Complete Your Community: Explore

Now that you know how you're going to set up your community, make sure you have all your parts nearby. You should have:

- 3 or more structures
- 6 LEDs
- Black and colored wire
- a wire cutting/stripping tool

Measure how long you need your longest wire to be. You can use a ruler, or just unspool the wire to length and mark where you need to cut it. Measure from where your solar panel is to your farthest LED and add another two inches.

To cut using your wire tool, release the locking lever (if it has one) and let the tool spring open. Place the wire deep into the tool (where you see flat blades about half an inch long). Check that your fingers are clear, then squeeze the tool until the wire is cut.



The wire we are using today has a coating. The coating insulates the wire. It makes sure the wires can't touch each other by mistake. To connect wires, we must remove some insulation.

Adjust the cutter to strip the wire. Turn the dial on the side. It should likely be set on 22, but if you find this setting cuts into your wire, you might need to change it to 20. The dial keeps the jaws open. The V-shaped part will cut through the plastic coating but not the wire itself.

Place the wire in the V so about 1cm (½ in) of wire is sticking out. Make sure your fingers are clear, then squeeze the wire in the V. Use one hand to hold the long side of the wire and another to squeeze the tool. Try to keep the wire straight as you pull the wire and tool apart.

If you are using stranded wire, you may lose strands when you strip it. Losing one or two strands isn't bad, but more than that may be a problem. You may need to change the setting to 20 or 18 and try again.

Repeat these steps to strip the other end of the wire.

You want all your wires and wire nuts to run under the cardboard to keep things neat. Make a path for the wire to travel into your structure. Ask an adult for help or carefully use a sharp pencil to make a small hole in the cardboard beneath your structure. If you are poking a hole, make sure your fingers are not where the pencil will poke them.

Next, ask an adult for help or carefully poke a hole in the structure where you want your LED. Remember: you can make a small hole larger, but you cannot make a large hole smaller.

Push the LED into the hole from the inside. Use a little tape or glue if you need to hold it in place.

Carefully feed the two wires from your LED into the hole. The wires should not be seen from outside the structure. When you are sure the wires are beneath the cardboard, tape or glue your structure down. If you have tabs, use them to hold the structure down.

As soon as you secure each structure, secure the wires as well. Place tape over the wires near the hole to hold them underneath the cardboard.

Continue adding LEDs and feeding wires under the cardboard. Connect your wires and check them with your electrical plan. When you have connected all your wires, see if your LEDs work!

If they do not work, check that:

- All your ground wires are connected to each other.
- All the colored wires are also connected to each other.
- Black and colored wires should only be connected to each other by the solar panel or LEDs.
- All your wire nuts are secure.
- The solar panel is under bright light. Natural sunlight works best!

Finally, finish your community. Do you want to add roads, trees, and other features? If so, just check that you are building or drawing things to scale!

Complete Your Community: Explain

1. You did a lot in this exploration! What tasks do you think a city planner would do?

2. What tasks do you think an electrical engineer would do?

3. What tasks do you think an electrician would do?

4. Everything we have done here is a model of the way things work in the real world. What parts of the model are accurate?

5. What parts of the model are inaccurate? How could they be made more accurate?

6. In the real world, why are most wires run underground? Where else do we see wires outside?