Begin with an introductory question for the group.

Discussion: This can be facilitator led or group-directed through the student handout. Adjust content and depth based on age group. Use this PowerPoint or (adjacent slideshow) along with content below to guide the class.

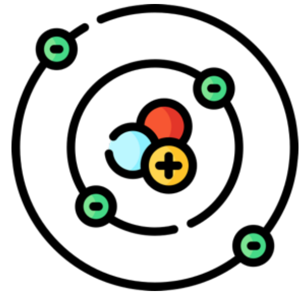
What is electricity?

Sides 3-4: Can you write down how many times you used electricity this morning? Let's make a list of everything you did this morning that required electricity." (Sample list on PowerPoint) What sources of electricity are used in our own community?" Examples may include electric cars, gas powered cars, windmills, or solar panels along highways or dams."

Slides 5-6: **Electricity** is a type of energy that can flow from one place to another. It is made from releasing energy stored in a variety of natural sources. Some **non-renewable** materials that store energy include coal, natural gas, nuclear and oil. These are non-renewable because they get used up. This process releases pollutants and greenhouse gases into the atmosphere and contributes to climate change Energy from **renewable** (or replenishable) environmental sources includes the sun, wind, and water -which never run out.

In most regions, electricity is a critical part of everyday life. For starters, it may keep our homes and school warm in the winter and cool in the summer. It is used to make lights, microwaves, and mobile devices work.

Slide 7: To understand electricity, you must first understand what an **atom** is because electricity comes from atoms. Everything in the universe is made of atoms. Atoms are tiny particles (way too small to see without special microscopes). They are so small a single ant is made of billions of atoms!



Atoms have three parts. The center (called the **nucleus**) is made of **protons** (which have a positive charge) and **neutrons** (which have no charge). The outer part of an atom has **electrons** which have a negative charge. Electrons can float and spin (or **orbit**) around the nucleus but they typically stay close because the negatively charged electrons are attracted to the positively charged nucleus. But electrons can also float from away from one atom to another. The flow of electrons from one material to another is called **current electricity**.

Electricity is made from releasing energy stored in materials and other natural sources by the flow of electrons to another material. Some materials that store energy include coal, natural gas, nuclear materials, and oil.

Slide 8: **"Where does electricity come from?**

It starts with an energy source like wind or solar power. This energy is then changed or **converted** into electricity as electrons flow along wires and ultimately travel to a home. Electricity can be stored at the community energy station and flows along wires to get to each home. It can also be stored in a **battery**. Students will be creating circuits with batteries in the project. The amount of energy the battery holds is called a **volt**.

Slide 9: A battery has two separate compartments divided by a barrier called an **insulator**. One side is considered positive and the other is considered negative. When electrons flow from the negative side of a battery, through a **conductor** (like a copper tape or metal wire) to the positive side, that is a complete circuit, or a **closed circuit**. This creates current electricity. If students connect a conductor directly to both sides of a battery, it's called a **short circuit.** When one creates a short circuit, two things happen...

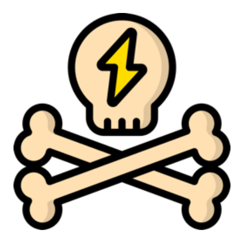
1. waste the electricity because this will drain all the energy out of the battery

2. the wires will get **REALLY HOT!** A short circuit is something that students should NEVER create. It can cause severe burns and fires.

The same is true for the electricity that comes through the wires in a home.

Slide 10: But if you put a **resistor** somewhere along the circuit, the electricity can be used to power something. A resistor is something that uses the electricity and converts it into usable energy (also called **a load**). It can be a light bulb, a motor, an appliance in your home, a car and lots of other things. If there is a load along the circuit, much of the energy is used by it so there is less energy being released as heat. The wires won't get quite as hot (but they can still burn you). When you add a light bulb, the energy is seen as light. When you add a motor, the energy is used to spin the motor.

Have you ever noticed that all electrical wires in your home are covered in plastic or rubber? Metal is a conductor, so electricity can flow through it. But conductors that have current electricity going through them can get very hot. Plastic is called an **insulator**: electricity cannot flow through it. Just as a jacket can lock in your warmth, an insulator does the same for electricity running through a wire. When you touch the plastic-covered wire, you will not get a shock or hot. If you were to put uncovered metal into a socket, you would get electrocuted!"



An optional quiz is available for download from the 3DuxDesign site to reinforce learning.

Slide 11: **Measuring Power.**

As mentioned above, **volts** are a unit of measurement to describe the amount of power an energy source contains or how much power a load (light, motor etc.) needs to work. In the kit, students should have a battery, a solar panel and wind turbine as the potential sources of power. The LED lights are the loads, they convert the electricity into light. Here are some important details about power in the materials in the kit:

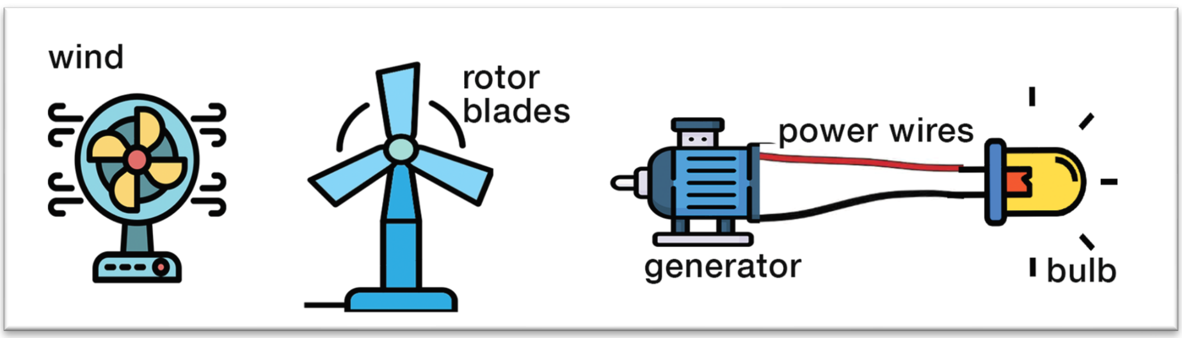
1. Lithium batteries are 3 volts (3V)
2. If using 2AA batteries, each one is 1.5 volts but based on the design of your battery holder (more on series circuits later), together, they add up to 3V.
3. Wind turbines can generate up to 20V.
4. Solar panels generate up to 3V.
5. The jumbo LED lights are all a bit different but in general, need about 2V to work.
6. The voltmeter in your kit will only turn on and read voltage when the source generates about 6V.

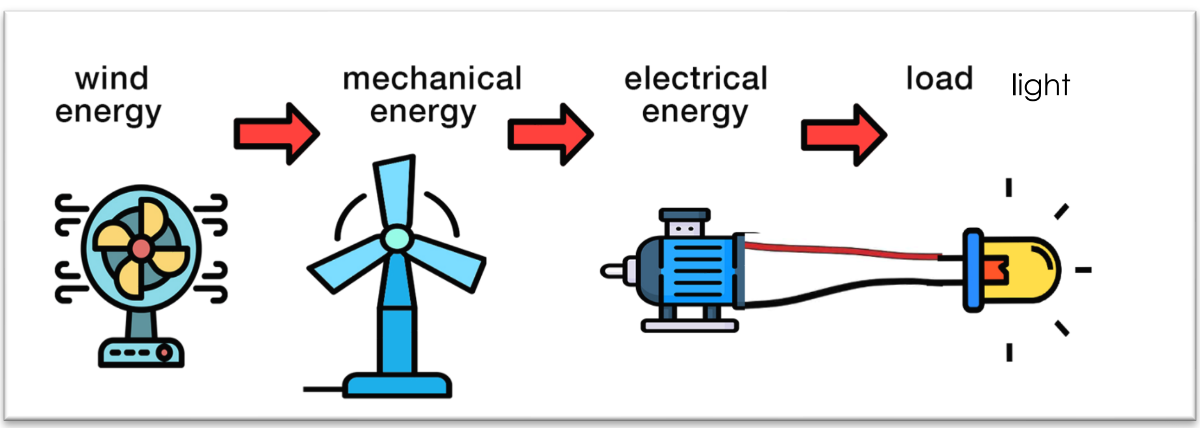
Here are the answers to some fun questions your students have in their packet

1. In a simple circuit with a single battery and one light bulb, will the light go on? Yes
    a. Will the voltmeter read voltage? No
2. In a circuit with two, 3V batteries connected in a row and one light bulb, will the light go on? Yes
    a. Will the voltmeter read voltage? Yes
3. In a circuit with a solar panel (in bright sunlight) connected to a battery and one light bulb, will the light go on? Yes
    a. Will the voltmeter read voltage? No
4. If you put two solar panels in a row (in bright sunlight), would a single light go on? Yes
    a. Would the voltmeter read voltage? Yes (with optimal lighting)

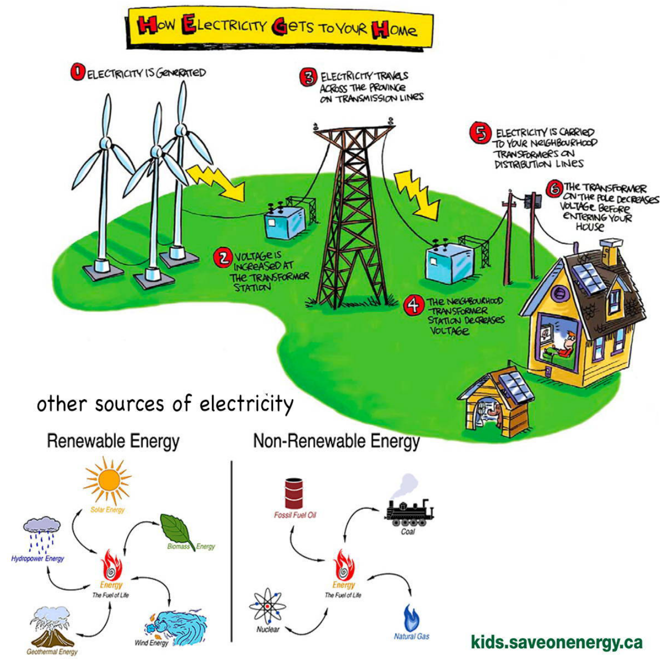
5. In a circuit with a wind turbine (in lots of wind) connected to a one light bulb, will the light go on, Y/N
    a. Will the voltmeter read voltage? Y/N
6. In a circuit with a wind turbine (in lots of wind) connected to two light bulbs in a row, will the light go on? Y/N
    a. Will the voltmeter read voltage? Y/N

Slide 12/13: **"How Does Renewable Energy Work?**
Discuss the following with students or allow student groups to follow the worksheets. Here is an example of the transfer of energy from wind to electricity and ultimately lighting a bulb. Notice there are several steps, and the energy takes on several forms.





Slide 14: **The Community Grid:** *this content is optional and ideal for advanced groups.*



It gets even more complex when huge wind turbines and lots of solar panels are used to power an entire city. Let's start with an energy source like solar power. The sun's energy is converted from light into electricity by solar panels. From there, it must travel along the conductor wires to get to the power plant where it is stored. When electricity must travel a very long distance, it needs to be very strong or **high voltage**.

A **transformer** can make electricity stronger or weaker. After electricity is made, a transformer collects it and makes it stronger. That high voltage electricity is strong enough to travel long distances. It can be stored at the power plant and then travel along more wires to get to individual buildings, structures, and homes across a city.

The voltage collected is extremely high and very dangerous, it needs to be transformed again to lower voltage before entering a home. Ever notice the metal boxes on the poles outside homes? Those are transformers that decrease voltage. Here's a diagram of an entire electrical grid system."

Review these vocabulary words or download and administer quiz: **atom, electricity**, **conductor, transformer**, **voltage**, **circuit**, **conductor**, **battery**, **load, insulator, resistor, proton, electron, nucleus (of an atom), renewable energy, nonrenewable energy.**

Slides 15-18. Activity 1: The Simple Circuit, switches and measuring volts

An important note for educator and students: The LED bulbs in the 3DuxDesign kit will typically require about 2-3 volts to light up and include resistors that will tolerate over 9 volts. An electrical current that supplies more than 9 volts *could* damage or blow out the Led bulbs. The wind turbine can generate up to 20 volts (unlikely with a blow dryer) so students should be instructed it is theoretically possible for a single LED bulb or multiple in parallel to blow during this lesson. That said, the 3DuxDesign team has run multiple tests using a single bulb with a bow dryer and has never experienced one of the 3DuxDesign jumbo bulbs burn out.

Familiarize students with materials to be used in the project including LED bulbs, wind turbines and generator, solar panel, conductive tape, insulators and conductors, voltmeter. If using a lithium or AA battery, introduce these as well.

Materials needed:

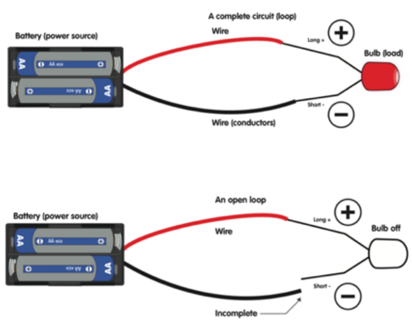
- One bulb
- Battery
- Copper tape
- Cardboard piece or paper

For making simple circuits, students may use lithium batteries or (2) AA batteries with battery holder in the GOBOX PRO Set. Teams of 3-4 students can use 3DuxDesign cardboard or scrap paper for making circuits.

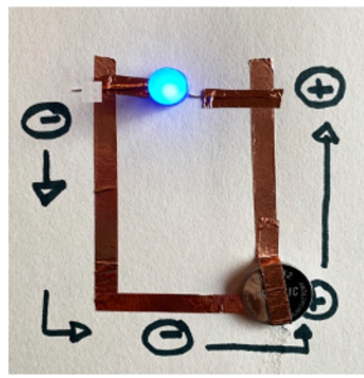
1. Draft: Using a pencil, draft out make simple circuit and label it with the following:
    a. energy source
    b. conductors
    c. insulator
    d. load
    e. positive and negative leads/prongs
    f. direction of electron flow
2. Students will make electricity flow from the power source through the LED bulb, and then back to the power source. They

will create a simple loop. Students will use one LED light. Explain that LED lights are like a one-way street; they only work when hooked up to the battery in one direction. Positive prong is the longer prong. By convention, black wires are typically negative but students can use any color alligator clips they want; they are all the same. Here's how an LED circuit should be set up.

Simple circuit closed and open

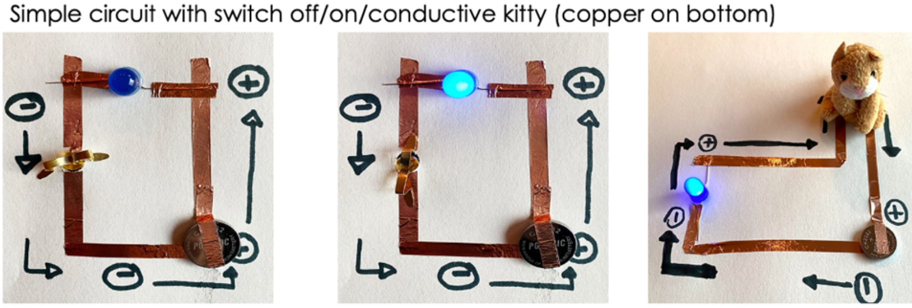


simple circuit



3. <u>Slide 19-22:</u> Add a switch: Students can make a tear in the copper tape to interrupt the flow of electrons. Now test several materials to reconnect the defect. If it is conductive, the light will go on. What materials did students try? What worked?
4. Draw conclusions: Have students determine what is a conductor, what is an insulator? Ask them to make a list of what they tested and if it is a conductor or an insulator. *Incorporate technology by having them make a data grid.*

Simple circuit with switch off/on/conductive kitty (copper on bottom)



Measuring Renewable Energy Materials.

If you would like to add a data-collection and technology extension, you may wish to have student teams create a data sheet to document their observations along the way. The student worksheets have space available for documenting the answers to the following questions…

1. Students will use the voltmeter to test the maximum voltage generated from the solar panel when exposed to light. Does it register voltage? Based on the information shared earlier, they can explain what's going on.
2. Next have students create a simple circuit with the solar panel as the electricity source and an LED light as the load. Does the light go on? Explain.
3. Next students will make a simple circuit using the wind turbine and a blow dryer (or fan) Does the light go on? What is the voltage generated?

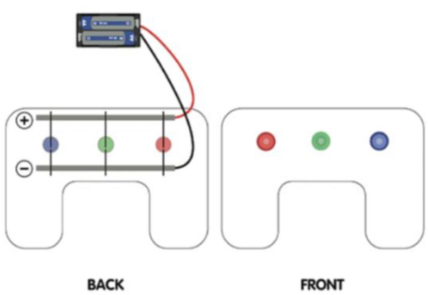
Slides 23-24: Understanding Complex Circuits:

Lead the class in the following discussion or allow small groups to use the student worksheet as a self-directed guide.

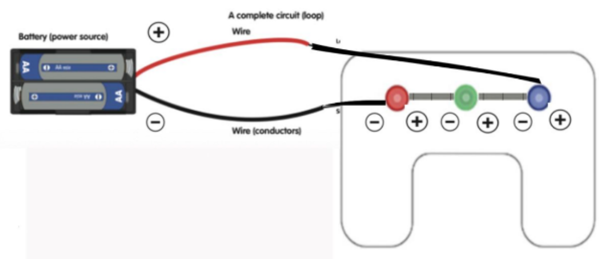
"There are two ways to create more complex circuits. In a **series circuit,** the things are connected one after the other, like a train. The volts add up, so if you connect two 1.5-volt batteries in series, you get 3 volts. In a series connection of LED lights, the LEDs are connected one after the other, so the current flows through one LED to the next, like a chain. The total voltage across the LEDs in series is the sum of the voltage across each LED. For example, if each LED has a voltage drop of 2 volts, and there are 3 LEDs in series, the total voltage drop across the LEDs would be 6 volts (2 volts x 3 LEDs). Series are typically easier but there is a downside, if the circuit breaks, all the lights go out! Christmas tree lights are often series.

In **parallel circuits**, things are connected side by side. The volts stay the same, so if you connect two 1.5-volt batteries in parallel, you still get 1.5 volts. In a parallel connection of LED lights, the LEDs are connected side by side, so the current flows through each LED independently, like friends holding hands. The voltage across each LED in parallel is the same. For example, if each LED has a voltage drop of 2 volts, and there are 3 LEDs in parallel, the voltage drop across each LED would still be 2 volts. In parallel, if one light goes out, the others still work. House lights are often parallel. "

Parallel circuit with 3 LEDS



Series circuit with 3 LEDs (note this will not work with 3 volts)



Activity 2: Making and comparing power in complex circuits.

Now it's time to make some complex circuits.

1. Students should make a parallel series using 2 or 3 bulbs with each of the following energy sources.
    a. One battery (or 2 AA's in battery pack)
    b. One solar panel
    c. One wind turbine
2. They may use the voltmeter to test the drop in voltage at different points along the circuit.
3. Student teams should document the data and draw some conclusions.
4. Using two bulbs in series, students should make a circuit using each of the following…
    a. One battery
    b. One solar panel
    c. One wind turbine
5. What do students notice about the bulbs? Do they illuminate? Is there a difference in light intensity? Any other observations? Students may use the voltmeter to test the drop in voltage at different points along the circuit.
6. Draw a labelled diagram of each circuit labeling and describing:
    a. Energy source / type
    b. Positive and negative sides
    c. Load
    d. Conductors
7. For the circuits that didn't work, students should explain why. Ask students if there something you can do to make the lights go on? **They may need to team up with other groups and pool materials; 2 3V batteries in series generate 6V

Notes and drawings

Activity 3: Design, build and light a community.

Materials:

- Cardboard
- Connectors
- 4 bulbs, conductive tape, batteries, solar panel, wind turbine,
- Drafting paper, pencils, Duxit ruler
- Markers or paint
- Scissors
- Site: 1-2 3DuxDesign Site Maps or 6'x6' taped white paper "site"
- Optional: alligator clips, on/off switch, assorted craft materials

Discussion: (est. 20 minutes)

Discuss as a class what structures students would like to include in their community build. Help you generate a list of everything to be included and then assist with project assignments. Each team should be responsible for 2 (or more) unique structures. They will design, build, and electrify their assigned structures. Some structures to consider include:

- residential housing
- schools
- hospitals
- stores
- police and fire stations
- parks and playgrounds
- city hall
- museums

Determine general site plan (est. 5 minutes)

One representative from each team should meet and create an overall plan for the community layout. Allow 5 minutes for planning. The final design will likely change.

Design/Build (30-60 minutes)

1. Each team will draft designs and consider:
    a. Each building's structural design
    b. Lighting design. Teams should be sure to use both solar and wind power, one parallel and/or one series circuit in a thoughtful way. They can also include the on/off switch provided or make a switch with any materials they can think of (like folded copper tape, paper clip etc.) The circuitry design should be determined by both how effective each energy source is and what the function of the light.
        i. How many lights in each structure?
        ii. What form of energy source?
        iii. Parallel vs series
    c. Overall layout of the structures and surrounding landscape
2. Prototype, test, refine.
3. Dismantle, decorate, rebuild and retest.

Assemble Community (10-20 minutes)
Teams will return to the site map and lay out their community. There will likely be an element of disagreement, heated discussion, and compromise.

Activity 4: Presentations

Students should create a 5 to 7-minute multimedia commercial or digital advertisement describing their contributions to the community. They can use a combination of video, photography, creative writing, PowerPoint, or any other technology for their presentations They should include:

- key design features
- value for the community
- how they used a variety of renewable energy sources and types of circuits and why.
- The presentations may be submitted to 3DuxDesign for possible acceptance to the global student showcase through the link on the website or via email.