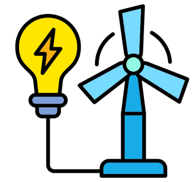
3DuxDesign



Sustainable Energy Student Project Guide

Overview of project

Most people use electricity every day. Understanding electricity, renewable energy, and circuits is crucial for a sustainable future with clean air, fresh water, and a livable environment. It can also be lots of fun to learn about. Imagine building a model house that lights up when you flip the switch or building an entire new school that is powered by the wind and sun! their own power grid and electrify an entire city. In this lesson, you will make circuits, and work in teams to design and build architectural structures run on renewable energy.

What is electricity?

Electricity is a type of energy that can flow from one place to another. It is likely a huge part of your everyday life. For starters, it may keep your home and school warm in the winter and cool in the summer. It is used to make lights, microwaves, and mobile devices.

Make a list of all the things you did this morning that require electricity.

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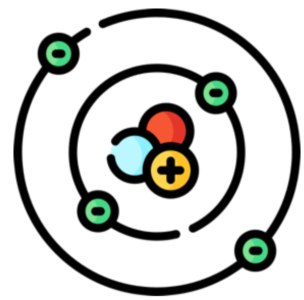
How does electricity work?

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**.

Some materials that store energy include coal, natural gas, nuclear materials, and oil. These are **non-renewable**, they get used up. This process releases pollutants and greenhouse gases into the atmosphere which contribute to climate change.

Energy can also be from **renewable** (or replenishable) environmental sources like the sun, wind, and water. This form of energy does not cause pollution.

As a group, make a list of what sources of renewable and non-renewable energy are used in your own community. Examples may include electric or gas-powered cars, windmills, oil tanks for heating and cooling, solar farms feeding the energy grid, or dams generating hydroelectric power.

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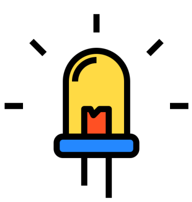
Where does electricity come from?

The easy answer is that it comes from a socket in the wall. But that's not where it *really* comes from. It starts with an energy source like coal, oil, wind, or solar power. This energy is then **converted** into electricity as electrons flow along wires and ultimately travel to your home. Electricity can be stored at your community energy station and flows along wires to get to your home. It can also be stored in a **battery**. We will be creating circuits with batteries in our project. The amount of energy the battery holds is called a **volt**. The amount of energy something needs to work can also be measured in volts.

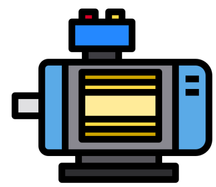


The LED lights in your 3DuxDesign kit need about 3 volts to work.

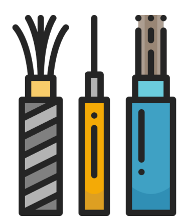
A battery has two separate compartments divided by a barrier called an **insulator**. One side is considered positive and the other is considered negative. When electrons flow from the negative side of a battery, through a **conductor** (like a copper tape or metal wire) to the positive side, that is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

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

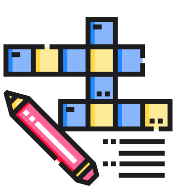
2. The wires will get **REALLY hot!** A short circuit is something that we should NEVER create. It can cause severe burns and fires. The same is true for the electricity that comes through the wires in your home.



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 one example of 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!



Your facilitator may have some puzzles for you to review what you learned.

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 your kit, you 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 your 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 this 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 3V to work.
6. The voltmeter in your kit will only turn on and read voltage when the source generates about 5V.

Here are some fun questions:

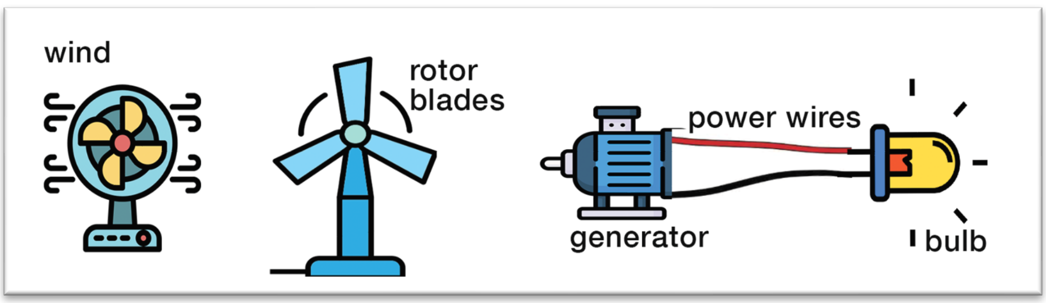
1. In a simple circuit with a single battery and one light bulb, will the light go on? Y/N
    a. Will the voltmeter read voltage? Y/N
2. In a circuit with two3V batteries connected in a row and one light bulb, will the light go on? Y/N
    a. Will the voltmeter read voltage? Y/N
3. In a circuit with a solar panel (in bright sunlight) connected to a battery and one light bulb, will the light go on? Y/N
    a. Will the voltmeter read voltage? Y/N
4. If you put two solar panels in a row (in bright sunlight), would a single light go on? Y/N
    a. Would the voltmeter read voltage? Y/N
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

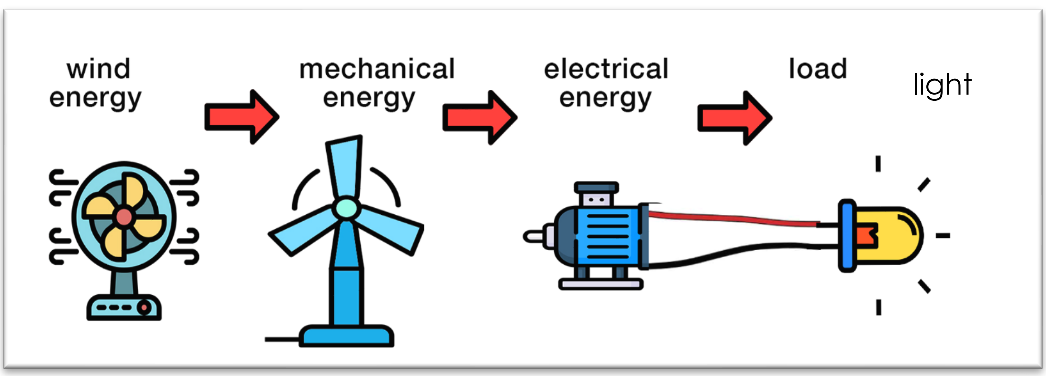
a. Will the voltmeter read voltage? Y/N

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

How Does Renewable Energy Work?

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.



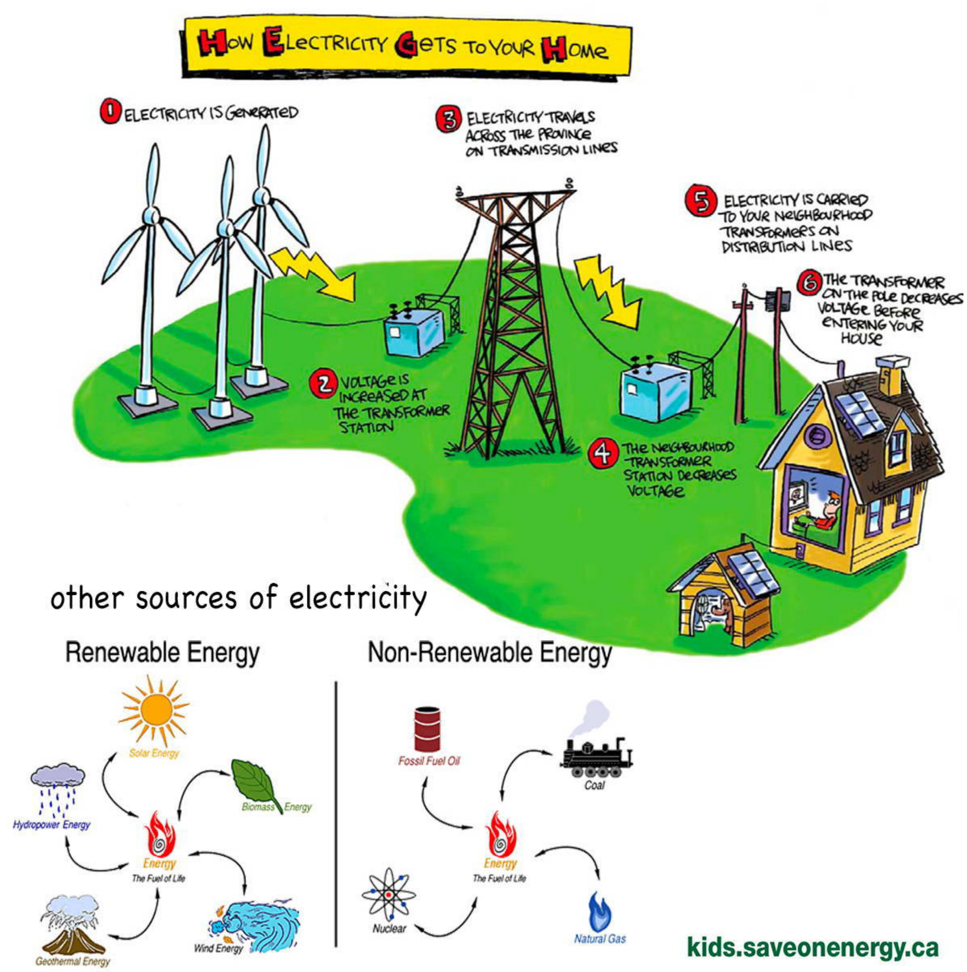


The Community Grid

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.



Project 1: Make a simple circuit, a switch, measure voltage.

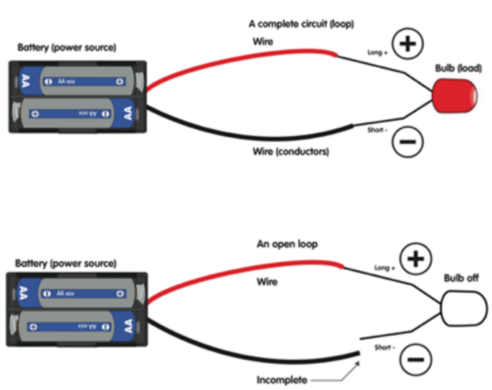
Materials needed:

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

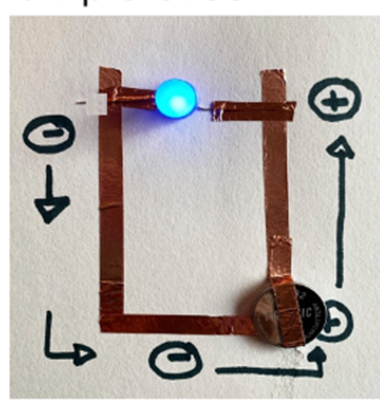
1. Draft: Using a pencil, draft out make simple circuit and label it.

a. energy source
b. conductors
c. insulator
d. load
e. label positive and negative along the way
f. direction electron flow

Simple circuit closed and open



simple circuit

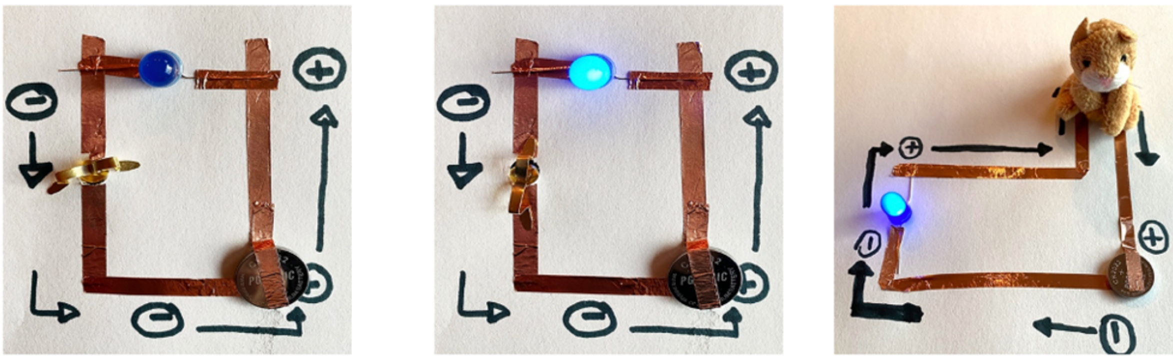


2. Build: Using materials, provided, make a simple circuit. You will know it is right if the light goes on.
3. Add a switch: Make a tear in the copper tape to interrupt the flow of electrons. Now test several materials to “fix” the defect. If it is

conductive, the light will go on. What materials did you try? What worked?

4. Draw conclusions: what is a conductor, what is an insulator? Make a list of what you tested and if it is a conductor or an insulator.

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



Measuring your Renewable Energy Materials.

** Your facilitator may ask you to create a data sheet to document your observations along the way.

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, explain what's going on.

Next 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.

Next make a simple circuit using the wind turbine and a blow dryer (or other wind source available), Does the light go on? __________

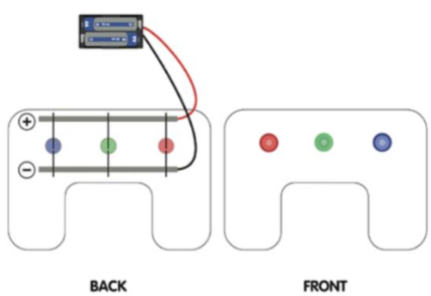
What is the voltage generated?

Understanding Complex Circuits:

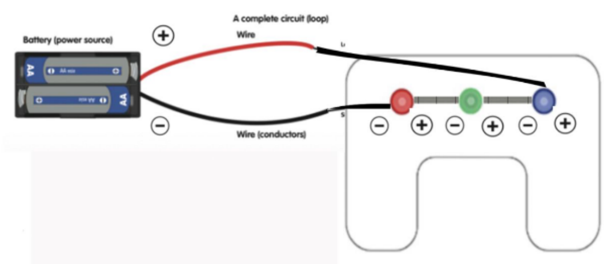
There are two ways to create more complex circuits. In a **series circuit,** the things are connected one after the other, like a train. The volts add up, so if you connect two 1.5-volt batteries in series, you get 3 volts. In a series connection of LED lights, the LEDs are connected one after the other, 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. Try using two (or even three) bulbs in **parallel** using each of the following.
    a. One battery (or 2 AAs in a battery pack)
    b. One solar panel
    c. One wind turbine

   Record observations. Do the bulbs illuminate with each energy source? Does one power source make the bulb brighter than others?

2. Use the voltmeter to test the drop in voltage at different points along the circuit.

3. Document the data and draw some conclusions.

4. using two bulbs in **series**, create a complex using each of the following energy sources and record observations. Do the bulbs illuminate? Are they equally as bright in each example? Do you notice anything else? Explain what's going on.
    a. One battery
    b. One solar panel
    c. One wind turbine

Use the voltmeter to test the drop in voltage at different points along the circuit.

5. Using the space below, draw a labelled diagram of each circuit describing:
    a. Energy source / type
    b. Positive and negative sides, flow of electrons
    c. Loads
    d. Conductors
6. For any circuits that didn't work, why do you think that is? Is there something you can do to make the lights go on? **hint: you may need to team up with other groups and pool your materials.

Notes and drawings:

Activity 3: Design, build, and light a community.

Discuss as a class what structures you would like to include in your community build. Your facilitator may help you generate a list of everything to be included and then assist with project assignments. Some structures to consider include:

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

Your team should be responsible for 2 (or more) unique structures.

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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. You may also include the on/off switch provided or make a switch with any materials you can think of. 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.

Draft out your designs,

Build a rapid prototype with structures, layout, and plans for electrical components. Once you're satisfied with the design, disassemble, electrify, decorate, and reconstruct.

Putting it All Together

1. As a group, lay out your city.
2. Present your part of the community. Be sure to include design features, lighting solutions and your reasons for the decisions you made.

Activity 4: Presentations

Student team can create a 5 to 7-minute multimedia commercial or digital advertisement describing your contributions to the community. Your facilitator will help you pick a combination of video, photography, creative writing, PowerPoint, or other technology for presentations

Be sure to make it enticing to a potential visitor. Content 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 publication on the global student showcase.