POWERING AGAINST BLACKOUTS (PART 1) (LEVEL 3)

Description	In this project, learners will become familiar with scientific definitions and skills related to the understanding of electricity and the reasons why blackouts occur in their communities or around the world. They will design a prototype for their community's ideal power grid.
Leading Question	What is the best power grid structure for your community?
Total Time Required	~ 10 hours over 5 days
Supplies Required	Paper, pencils, post-it notes (if available), small papers, small rocks, electric bill, 2D batteries, 3 Small penlight bulbs, 3 Sockets, 2 switches, pieces of Insulated wire, and one of the following sets: i) balloon, ii) water, salt, pepper, a fine-tooth plastic comb, or iii) plastic pen, stream of water
Subjects	Science, Mathematics, Literacy
Supervision	Medium
Learning Outcomes	By the end of the project, learners will be able to: 1. Describe scientific crosscutting concepts of scale, proportion, and quantity; systems and system models; and energy. 2. Interpret text, images, and graphical displays of data to describe. 3. Develop a model to describe the functioning of power grids.
Previous Learning	Some basic understanding of physics, force, energy, and atoms is desirable. The concept of average, and the operations associated with it (division, addition).

DAY 1 - Today you will begin by learning about where electricity comes from and you will conduct an experiment focused on generating static electricity.

Suggested Duration	Activity and Description
10 minutes	• Electricity has always been around in nature. Think about the different forms that electricity comes in. • Write down some of the answers you come up with and come back later and discuss them after the experiments. *Some possible ideas include: lighting, static energy, friction, electric eels, how our bodies use it to send messages to muscles, when you touch and shock someone, etc.*

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	● Think about ways in which you can see that with the resources you have available at home or at school.
20 minutes	**You will be conducting an experiment focused on <u>generating static electricity.</u>** You can choose two experiments between the three options provided. Pay attention to possible differences or trends that begin to emerge across experiments. Before starting the experiment, make a hypothesis (or more) about what you think is going to happen; it can be about what you believe you can do with the materials, or what will happen if you do a specific action with the materials. **<u>Option #1</u>** (Resources: balloon) 1. Rub a balloon on your hair or sweater, and then try to stick it on a wall for a few moments. 2. What do you observe? How do you think that electricity was created? **<u>Option #2</u>** (Resources: water, salt, pepper, and a fine-tooth plastic comb. This works best when humidity levels are low.) 1. Mix equal parts table salt and black pepper in a shallow dish. 2. Use a fine-tooth plastic comb to comb through their hair. 3. Keeping the comb in the same hand, quickly hold the comb over the dish, without touching the salt and pepper mixture. 4. What do you observe? (the comb, which is now statically charged, should attract the pepper, lifting flakes from the dish). How do you think that electricity was created? **<u>Option #3</u>** (Resources: plastic pen, stream of water) 1. Rub a plastic pen on a wool sweater 2. Hold the pen near a stream of water. 3. What do you observe? How do you think that electricity was created?
15 minutes	Write down: ● One thought about what electricity is according to what you observed in the experiments ● One question that you would like to explore based on what you noticed in the experiments ● One analogy (comparison) that you would use to explain to somebody what electricity is

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<td>Share those answers aloud and note them down in a notebook or on a chart. Below is an example:

<table>
<tr><th>Thought</th><th>Question</th><th>Analogy</th></tr>
<tr><td>'Electricity' comes from rubbing</td><td>What if I rub different materials? Would electricity still be there?</td><td>Electricity is the result of a 'fight' between materials</td></tr>
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You do not need to have “correct” answers to these prompts. Just make sure that you are differentiating between a thought, a question, and an analogy.</td>
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<td>15 minutes</td>
<td>We will be exploring analogies.

Pay attention to the statement “Electricity is like water.” Electricity is the featured object, and the object being compared to electricity is water. Suggest what the statement might be trying to describe or communicate.
The statement “Electricity is like water” is an analogy. An analogy is a meaningful comparison between two things that may appear to be unrelated.
The criteria for a <u>powerful </u>metaphor or analogy is:

Accurate: correctly uses and describes scientific ideas
Creative: uses different or unique ideas or objects
Revealing: vividly describes or reveals important details about the objects being compared

Which analogy best describes electricity?

An example: Electricity can be compared to a gym full of bouncy balls that are “always moving” and “bouncing.” These are good words to describe electricity.

You will be able to refine and revise your analogy throughout the project.</td>
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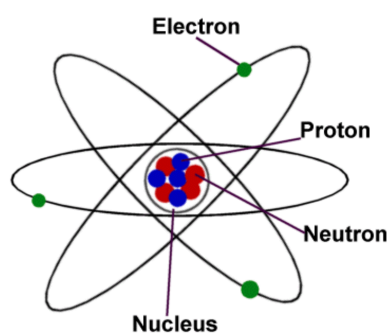
DAY 2 - Today we will continue learning about where electricity comes from.

Suggested Duration	Activity and Description
5 minutes	● Read the passage below about "The Origin of Electricity". ● Your task now is to identify the causes of electricity.

The Origin of Electricity

Everything in the universe – the sun, clouds, grass, dirt, toys, clothes, rocks, and even people – is composed of ***atoms****. Atoms are tiny. A copper penny (if it actually were made of 100% copper) would have 3.2x1022 atoms (32,000,000,000,000,000,000,000 atoms) of copper inside it!*

An atom is built with a combination of three distinct particles: protons, neutrons, and electrons. The protons and neutrons are inside the atom's nucleus (center) and the electrons orbit the nucleus.



The ***electrons*** *are critical to the workings of electricity (notice a common theme in their names?) and have a negative* ***charge****. Charge is a property of matter--just like mass, volume, or density. It is measurable. Just as you can quantify how much mass something has, you can measure how much charge it has. The key concept with charge is that it can come in two types: positive (+) or negative (-).*

Because of their charge, electrons will push away other electrons and be attracted to protons. They stay in orbit because the protons in the nucleus have a positive charge, which attracts the negative charge and keeps the electrons close. These forces of <u>attraction and repealing</u>

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	are the "glue" that holds atoms together, but also the tool we need to make electricity! *When outside forces, such as friction, upset the balance between neutrons and electrons, electrons can escape the orbit of the atom and become free.* ***Free electrons*** *allow us to move charge, which is what* ***electricity*** *is all about.*
30 minutes	**Discussion** ● After reading the piece, go back to the Thought-Question-Analogy exercise that you did on Day 1. ● Revise your set of thoughts, questions, and analogies based on the information that you have just read about: a. How did your initial thoughts evolve based on this reading? b. Are the original analogies *powerful*? (You can refer to Day 1 to identify the criteria of a powerful metaphor). c. Are there new metaphors/analogies that you can think about to describe the origin of electricity? d. If your analogies changed, what information or ideas prompted the change? If they did not change, why not?

DAY 3 - Today we will be learning about generating electricity and circuits.

Suggested Duration	Activity and Description
10 minutes	● Reflect on the properties and behaviours of electrons that you learned about on Day 2. Try to answer the following questions: ○ How does an electric charge cause mechanical motion or make things light up? ○ How do we move electrons? ○ Where do they move to?
20 minutes	In order to move the charge, we need **charge carriers**, such as copper. ● Copper is filled with countless copper atoms. ● When a free electron is floating in a space between atoms, it's pulled and prodded by surrounding charges in that space. ● In this chaos, the free electron eventually finds a new atom to latch on to.

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In doing so, the negative charge of that electron ejects another electron from the atom.
Now a new electron is drifting through free space, looking to do the same thing. This chain effect can continue on and on to create a flow of electrons called electric current.
This form of electricity exists when charges can constantly flow. As opposed to static electricity where charges gather and remain at rest, current electricity is dynamic, charges are always on the move.
Conductivity is the measure of the ease at which an electric charge or heat can pass through a material. Different materials have different measures of conductivity.

Arrange these materials from high to low conductivity – copper, glass, salted water.
Answer:
1. Copper (high conductivity),
2. Water with salt (medium conductivity),
3. Glass (low conductivity-insulator).
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<td>40 minutes</td>
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Now, we will learn about creating circuits. Look for the following materials:
a. 2 D batteries
b. 3 small penlight bulbs
c. 3 Sockets
d. 2 switches
e. Insulated wires

You will build different types of circuits using these materials.
Once the circuit is working in each case, you should show it to the teacher or a family member so they can check the circuit.
To record the observations, use the following symbols to draw the circuit that you created.

Symbols to use when you draw your circuits:


Images from http://whyfiles.larc.nasa.gov/text/kids/Problem_Board/problems/electricity/circuits2.html
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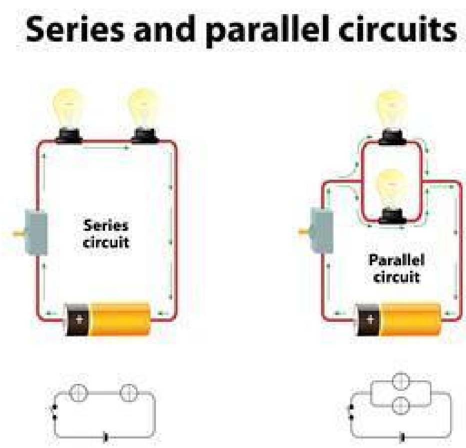
- Work on the following tasks and questions:

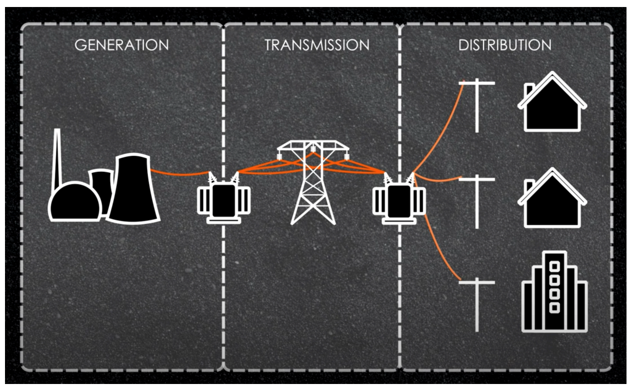
  Alternatively, you may observe this video:
  https://www.youtube.com/watch?v=-w-VTw0tQlE

Series Circuits	
Using one bulb, batteries and some wires, make one light bulb turn on.	Now make 2 light bulbs turn on with batteries and some wire
Using 3 bulbs, batteries, and some wires, make 3 light bulbs turn on.	What do you notice about the brightness of the bulbs in each circuit?
After you have made 3 light bulbs light, unscrew one bulb and record what happens.	Using one light bulb and a switch, make one bulb turn on and off with the switch.
Using 2 bulbs, batteries, 1 switch, and some wires, make 2 light bulbs light up and turn off at the same time with the switch.	Using 3 bulbs, batteries, and 1 switch, make 3 light bulbs light up and turn off at the same time with the switch.
With 3 light bulbs and a switch, can you make 1 or 2 light bulbs light up and not the other(s)? Why/Why not?	
Parallel Circuits	
Using 2 bulbs, batteries, and some wires, make 2 light bulbs light up. After they are lit, unscrew one bulb, what happens? If both lights go out, try the circuit again.	Make 3 light bulbs light up. Unscrew one bulb, what happens to the other 2? Unscrew 2 bulbs, what happens to the 3rd bulb?
Make 2 light bulbs turn on and off at the same time with a switch.	Make 1 light bulb turn on and off with a switch while the other bulb stays lit.
Challenge (optional): Make 2 light bulbs turn on and off with a switch while the 3rd bulb stays lit.	

	Use the image below for reference: 

DAY 4 - Today, we will be learning about power plants and will look into a prototype of a reliable power grid.

Suggested Duration	Activity and Description
15 minutes	• Describe the differences between a closed and open circuit. • What did you notice about the brightness of the bulbs in the series circuits as you added more bulbs to it? What did you notice in the parallel circuits as you added more bulbs? • How does removing a bulb or opening and closing a switch affect a series circuit? How does removing a bulb or opening and closing a switch affect a parallel circuit?
10 minutes	We will explore power plants and their importance. 1. Write down two or three possible explanations for the blackouts in your communities based on the experiments. You can try and explain why power cuts occur based on their learning so far. 2. The electricity for entire communities needs to be produced in **power plants**. Think and Answer: Why is this the case? Why don't we all have our own mini-generators? 3. Power plants use various resources– gas, coal, steam, or wind, for example – to generate electricity. a. Power plants use **chemical reactions (combination of substances)** or **mechanical forces (movement)** to alter atoms.

	For example, wind farms or water from a power dam causes huge wheels in turbines to rapidly spin, disturbing the electrons, and producing electricity. 4. Think about other sources of energy and try to explain how it is created in each case.
35 minutes	1. Look at the following resource: **An Electric Power Grid** *The electric power grid is a* ***complex system, a complex circuit,*** *composed of many pieces, including electric generators, step-up transformers, step-down transformers and wires all working together to deliver electric power to our homes.*  *After it is generated, electricity travels through wires into large transformers. The transformers increase* ***voltage*** *(the strength of the current), allowing the power to travel far away. The current continues through high-voltage power lines that extend across the area covered by the grid.* *Before electricity comes to your home or business, it travels to a* ***substation****, which converts the voltage from high to low. From there, it goes through a system of smaller power lines and another transformer to lower the voltage even more. Finally, electricity is sent to homes and businesses, where, with the push of a button or flip of a switch, it powers the devices of modern life!* 2. Identify the key elements of a power grid based on the reading. 3. Think of an analogy to describe a power grid. 4. Discuss with someone if the metaphor is accurate. Is it revealing? Is it creative?

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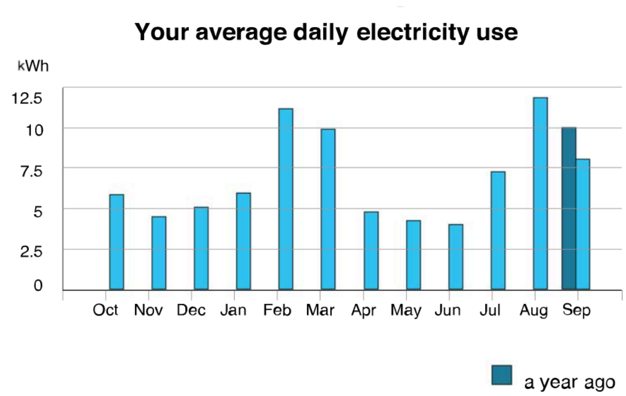
Day 5 - Today, we will continue learning about power grids and you will draw a power grid.

Suggested Duration	Activity and Description
50 minutes	1. **Watt** is the measure of power. A **kilowatt** is simply 1,000 watts Check how many watts a light bulb consumes. **Kilowatt Hour** is simply a unit of measurement that equals the amount of energy you would use if you kept a 1,000-watt appliance running for an hour. So, if you switched on a 100-watt light bulb, it would take 10 hours to get 1 kWh of energy. Calculate, in **kilowatts**, how much electricity is needed for the community to work. 2. Answer the following questions: a. How many households or businesses are there in the community? b. How much energy (in Kilowatts) does each household or business consume on average? c. For this calculation, you can use the information from your home's electric bill. If you don't have one available, consider this extract:  3. Is this amount of energy constant throughout the day? Throughout the year? Are there periods of the day or year when more appliances are turned on? 4. What is/should your community's power plant be based on depending on the available resources (wind farm, solar farm, hydroelectric dam, etc.) 5. What would be the best design for the grid? parallel or series?

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	6. Draw a prototype of your community's ideal power grid. Draw one light bulb for each household. Think of your power plant as the battery, and then consider the design that would allow you to turn all the lightbulbs at once. Present the prototype to your family members. <u>Some pointers to keep in mind</u> ● You need access to the resources that power the energy plant (water, wind, coal, nuclear, etc.). ● The more powerful the energy source, the more households can be reached. ● The demand on any power grid must be matched by the supply it is able to offer, and its ability to transmit that power. ● You need to avoid sudden changes in voltage. Any overload of a power line (when the demand for energy is much higher than the supply) can cause hard-to-repair and costly damage, so the power grid would be disconnected if a serious imbalance is detected. ● Electrical power cannot easily be stored over extended periods of time, and is generally consumed less than a second after being produced!

Modifications for Simplification	● Skip the activities on Day 5.

ASSESSMENT CRITERIA

By the end of the project, a majority of my learners were able to:

- ☐ Describe scientific crosscutting concepts of scale, proportion, and quantity; systems and system models; and energy.
- ☐ Interpret text, images, and graphical displays of data to describe.
- ☐ Develop a model to describe the functioning of power grids.