education above all

POWERING AGAINST BLACKOUTS (PART 1)

Ages 8 to 10 (Level 2)

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.
Leading question:	What is the best power grid structure for your community?
Age group:	11-14
Subjects:	Science, Literacy, Math
Concepts covered:	electricity, atom, proton, electron, current, charge, chemical reaction, mechanical force, voltage, circuit, conductivity
Final product	Learners will create a model of a power grid to reliably supply power to the households and businesses in their community.
Total time required:	10 hours over 5 days
Self-guided / Supervised activity:	Medium/High supervision
Resources 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

Day	Time	Activity and Description
1		***Theme: Where Does Electricity Come From?***
	10 min	1. Guide the learners' attention to the fact that electricity has always been around in nature. Ask them if they know in what forms? 2. Write down some of their responses to come back later and discuss them after the experiments. *Some possible ideas include: lighting, static energy, friction, electric eels, our bodies use it to send messages to muscles, when you touch and shock someone, etc.* 3. Invite learners to think about ways in which they can see that with the resources they have available at home or at school.
	20 mins	**Experiment: Generating Static Electricity.** Choose any two experiments between the three options provided. Guide the learner's attention to possible differences or trends that are beginning to emerge across experiments. Before starting the experiment, ask the learners to make a hypothesis (or more, if they want) about what they think is going to happen; it can be

about what they believe they can do with the materials, or what will happen if they do a specific action with the materials.

<u>Option #1.</u> (Resources: balloon)

1. Ask learners to rub a balloon on their hair or sweater, and then try to stick it on a wall for a few moments.
2. What do you observe? What do you observe? How do you think that electricity was created?

<u>Option #2</u> (Resources: water, salt, pepper, a fine-tooth plastic comb. This works best when humidity levels are low.)

1. Mix an equal part table salt and black pepper in a shallow dish.
2. Have the students use a fine-tooth plastic comb to comb through their hair.
3. Keeping the comb in the same hand, have students 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). What do you observe? 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 mins

Experiment Debrief

1. Ask the learners to:
   - Draw a picture that explains what electricity is
   - Write down one question that they would like to explore based on what they noticed on the experiments

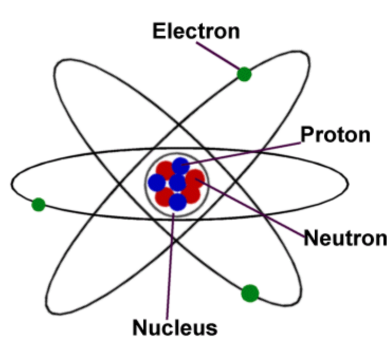
Have learners note these points down in a notebook or on a chart and share those aloud.
<u>Note</u>: Students at this point do not need to have "correct" answers.

15 mins

Literacy extension: Exploring analogies.

1. Draw the learners' attention to the statement "Electricity is like water." Prompt students to note that electricity is the featured object, and that the object being compared to electricity is water.

		2. Invite learners to suggest what the statement might be trying to describe or communicate.
		3. Explain that the statement “Electricity is like water” is an analogy. Suggest that an analogy is a meaningful comparison between two things that may appear to be unrelated.
		4. Use learners’ ideas to co-develop or present the criteria for a <u>powerful</u> metaphor or analogy:
		    ○ *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
		5. Ask: Which analogy best describes electricity?
		For example, students might suggest that electricity can be compared to a gym full of bouncy balls and note phrases such as “always moving” and “bouncing.”
		Assure students that they will be able to refine and revise their analogy throughout the project

2	30 min	***Theme: Where does electricity come from?*** 1. Invite learners to read the passage below about “The Origin of Electricity”. 2. Explain to the learners that their task 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.* 

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30 mins</td>
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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> 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.
Discussion

After reading the piece, invite learners to go back to the Thought-Question- Analogy exercise that they did on Day 1.
Ask them to revise their set of thoughts, questions, and analogies based on the information that they have just read about:
<ol type="a">
Direct their attention to how the initial thoughts evolved based on this reading.
Are their original analogies powerful? (See step 4 of the literacy extension to identify the criteria of a powerful metaphor).
At this point, address any misconceptions and clarify concepts such as charge, electron, atom if you find it necessary.
Are there new metaphors/analogies that they can think about to describe the origin of electricity?
If their analogies changed, what information or ideas prompted the change? If they did not change, why not?

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10 min</td>
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Theme: Generating Electricity and Circuits

Invite students to reflect on the properties and behaviours of electrons that they learned about on Day 2. Ask:
<ol type="a">
How does an electric charge cause mechanical motion or make things light up?

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		b. How do we move electrons? c. Where do they move to?
	20 min	2. Explain to the learners that, in order to move 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. ● 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 are able to 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. Ask: 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).*
	40 min	**Creating Circuits** 1. Ask the learners to look for the following materials: ● 2 D batteries ● 3 small penlight bulbs ● 3 Sockets ● 2 switches ● Insulated wires 2. Tell learners that they will be using these materials, they will build different types of circuits 3. Tell learners that, once the circuit is working in each case, they should show it to the teacher or a family member so they can check the

circuit.

4. To record the observations, ask the learners to use the following symbols to draw the circuit that they created

Symbols to use when you draw your circuits:

Images from http://whyfiles.larc.nasa.gov/text/kids/Problem_Board/problems/electricity/circuits2.html

5. Have learners work on the following tasks and questions:

Alternatively, learners may observe this video:
https://www.youtube.com/watch?v=-w-VTw0tQIE

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,	Make 3 light bulbs light up. Unscrew one bulb, what happens to the other 2? Unscrew 2 bulbs, what happens

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<tr><td>what happens? If both lights go out, try the circuit again.</td><td>to the 3rd bulb?</td></tr>
<tr><td>Make 2 light bulbs turn on and off at the same time with a switch.</td><td>Make 1 light bulb turn on and off with a switch while the other bulb stays lit.</td></tr>
<tr><td colspan="2">Challenge (optional): Make 2 light bulbs turn on and off with a switch while the 3rd bulb stays lit.</td></tr>
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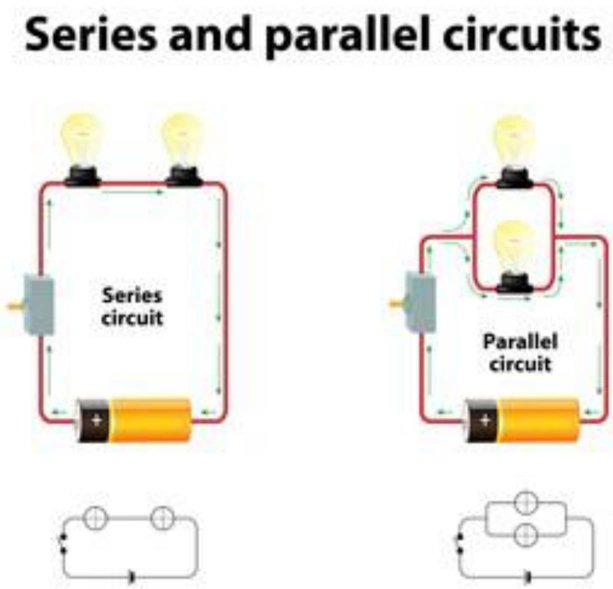

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15 mins

15 mins</td><td>Theme: Drawing A Prototype Of A Reliable Power Grid.

Debrief the experiment of Day 3

Describe the differences between a closed and open circuit.
What do 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?

Power Plants

Have the learners write down two or three possible explanations for the blackouts in their communities based on the experiments.
They can try and explain why power cuts occur based on their learning

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so far.

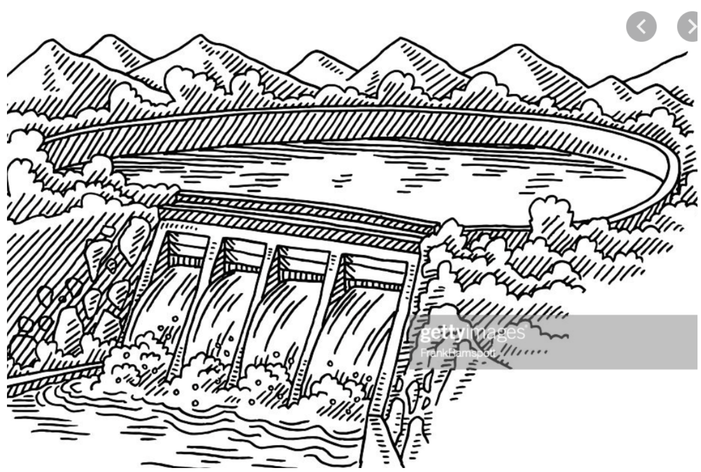
2. Tell learners that electricity for entire communities needs to be produced in **power plants** that are like giant batteries.

   Power plants use various resources– gas, coal, steam, or wind, for example – to generate electricity. Invite them to try to explain how this happens based on some of the things that they learned so far.

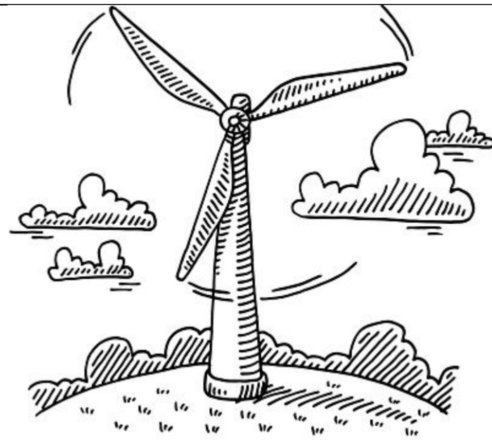
   Explain Power plants use a **transform movement into electricity** in a similar fashion to what we did using friction in the experiments of Day 1. For example, wind farms or water from a power dam causes huge wheels in turbines to rapidly spin. The dam stores lots of water behind it in the reservoir. Gravity causes it to fall through the penstock inside the dam.

3. Ask learners if they know examples of power plants around them, or if they have seen a dam or a wind turbine before. If not, you can share these images with them.

Example of a dam:

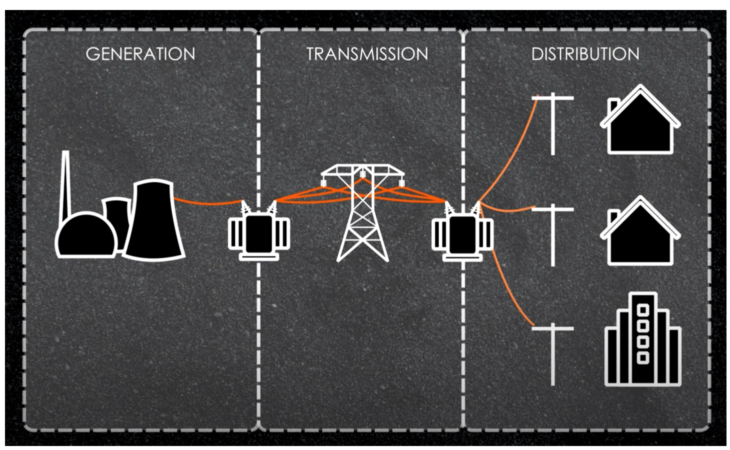


Example of a wind turbine:

	35 mins	 **Power Grid** 1. Share with the students 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. Invite students to identify the key elements of a power grid based on the reading. 3. Get the learners to think of an analogy to describe a power grid. 4. Discuss: Is the metaphor accurate? Is it revealing? Is it creative?
5	50 mins	**Theme:** *Drawing A Prototype Of A Reliable Power Grid.* 1. Ask the learners to interview their parents to get a sense of how much electricity is needed for the community to work ○ How many households or businesses are there in the community? ○ How much energy do each household or business consume? ○ Do households consume more energy than businesses? ○ 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?). ○ What is or should be your community's power plant based on the available resources (wind farm, solar farm, hydroelectric dam, etc.) 2. Recall the circuit's experiments and some of the main conclusions: What would be the best design for the grid? parallel or series? 3. Draw a prototype of your community's ideal power grid using the conventions we used in the circuit experiment. 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. **Some ideas/questions to keep in mind:** ● You need access to the resources that power the energy plant (water, wind, coal, nuclear, etc.). ● You need to avoid sudden changes in voltage. Any overload of a power line (when too much energy is being consumed) 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!
Assessment Criteria		- Students show their understanding of basic scientific texts by being able to come up with powerful analogies to describe scientific and engineering concepts such as energy and power grid. - Students fully conduct scientific experiments and can tell the difference between a close and an open circuit

Learning outcomes	• Understand more deeply the 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.
Required previous learning:	Some basic understanding of physics, force, energy, and atoms is desirable. The concept of average, and the operations associated to it (division, addition).
Inspiration:	• https://mrelectric.com/blog/how-to-explain-electricity-to-a-kid-mr-electri • https://tc2.ca/en/solar/division2/ • http://www.wired.com/wired/archive/11.09/start.html?pg=17 • https://www.youtube.com/watch?v=v1BMWczn7JM • https://teachersinstitute.yale.edu/curriculum/units/1989/7/89.07.01.x.html • https://learn.sparkfun.com/tutorials/what-is-electricity/all#:~:text=If%20we%20can%20free%20an,move%2C%20we%20can%20create%20electricity.&text=Using%20enough%20electrostatic%20force%20on,atom%20creating%20a%20free%20electron. • http://www.mysciencesite.com/Middle_School_Science_-_Basic_Circuits.pdf
Simplification	Skip the literacy extension activities.

POWERING AGAINST BLACKOUTS (PART 1)

Ages 11 to 14 (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.
Leading question:	What is the best power grid structure for your community?
Age group:	11-14
Subjects:	Science, Literacy, Math
Concepts covered:	electricity, atom, proton, electron, current, charge, chemical reaction, mechanical force, voltage, circuit, conductivity
Final product	Learners will create a model of a power grid to reliably supply power to the households and businesses in their community.
Total time required:	10 hours over 5 days
Self-guided / Supervised activity:	Medium/High supervision
Resources 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

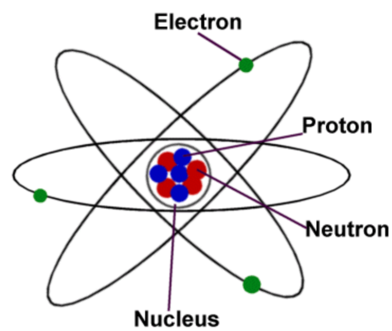
Day	Time	Activity and Description
1	10 min 20 mins	***Theme: Where Does Electricity Come From?*** 1. Guide the learners' attention to the fact that electricity has always been around in nature. Ask them if they know in what forms? 2. Write down some of their responses to come back later and discuss them after the experiments. *Some possible ideas include: lighting, static energy, friction, electric eels, our bodies use it to send messages to muscles, when you touch and shock someone, etc*. 3. Invite learners to think about ways in which they can see that with the resources they have available at home or at school. **Experiment: Generating Static Electricity.** Choose two experiments between the three options provided. Guide the learner's attention to possible differences or trends that are beginning to emerge across experiments. Before starting the experiment, ask the learners to make a hypothesis (or more, if they want) about what they think is going to happen; it can be

		about what they believe they can do with the materials, or what will happen if they do a specific action with the materials. **Option #1** (Resources: balloon) 1. Ask learners to rub a balloon on their hair or sweater, and then try to stick it on a wall for a few moments. 2. What do you observe? What do you observe? How do you think that electricity was created? **Option #2** (Resources: water, salt, pepper, a fine-tooth plastic comb. This works best when humidity levels are low.) 1. Mix an equal part table salt and black pepper in a shallow dish. 2. Have the students use a fine-tooth plastic comb to comb through their hair. 3. Keeping the comb in the same hand, have students 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). What do you observe? How do you think that electricity was created? **Option #3** (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 mins	**Experiment Debrief** Ask the learners to write down: ○ One thought about what electricity is according to what they observed on the experiments ○ One question that they would like to explore based on what they noticed on the experiments ○ One analogy (comparison) that they would use to explain to somebody what electricity is Have learners share those aloud and note them down in a notebook or on a chart. Below is an example:

		Thought "Electricity" comes from rubbing **Question** What if I rub different materials? Would electricity still be there? **Analogy** Electricity is the result of a "fight" between materials Note 1: students at this point do not need to have "correct" answers to these prompts. Just make sure that they are differentiating between a thought, a question, and an analogy.
	15 min	**Literacy extension:** Exploring analogies. 1. Draw the learners' attention to the statement "Electricity is like water." Prompt students to note that electricity is the featured object, and that the object being compared to electricity is water. 2. Invite learners to suggest what the statement might be trying to describe or communicate. 3. Explain that the statement "Electricity is like water" is an analogy. Suggest that an analogy is a meaningful comparison between two things that may appear to be unrelated. 4. Use learners' ideas to co-develop or present the criteria for a powerful metaphor or analogy: ○ *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 5. Ask: Which analogy best describes electricity? For example, students might suggest that electricity can be compared to a gym full of bouncy balls and note phrases such as "always moving" and "bouncing." Assure students that they will be able to refine and revise their analogy throughout the project
2	30 min	***Theme: Where does electricity come from?*** 1. Invite learners to read the passage below about "The Origin of Electricity". 2. Explain to the learners that their task 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 attraction and repealing 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 min

Discussion

1. After reading the piece, invite learners to go back to the Thought-Question- Analogy exercise that they did on Day 1.

2. Ask them to revise their set of thoughts, questions, and analogies based on the information that they have just read about:
    a. Direct their attention to how the initial thoughts evolved based on this reading.

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b. Are their original analogies powerful? (See step 4 of the literacy extension to identify the criteria of a powerful metaphor).
c. At this point, address any misconceptions and clarify concepts such as charge, electron, atom if you find it necessary.
d. Are there new metaphors/analogies that they can think about to describe the origin of electricity?
e. If their analogies changed, what information or ideas prompted the change? If they did not change, why not?
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20 mins</td><td>
Theme: Generating Electricity and Circuits

1. Invite students to reflect on the properties and behaviours of electrons that they learned about on Day 2. Ask:
a. How does an electric charge cause mechanical motion or make things light up?
b. How do we move electrons?
c. Where do they move to?

2. Explain to the learners that, in order to move 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.
• 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.
Ask: Arrange these materials from high to low conductivity – copper, glass, salted water.

Answer:
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1. Copper (high conductivity),
2. Water with salt (medium conductivity),
3. Glass (low conductivity-insulator).

40 mins

Creating Circuits

1. Ask the learners to look for the following materials:

    - 2 D batteries
    - 3 small penlight bulbs
    - 3 Sockets
    - 2 switches
    - Insulated wires

2. Tell learners that they will be using these materials, they will build different types of circuits
3. Tell learners that, once the circuit is working in each case, they should show it to the teacher or a family member so they can check the circuit.
4. To record the observations, ask the learners to use the following symbols to draw the circuit that they created

Symbols to use when you draw your circuits:

Images from http://whyfiles.larc.nasa.gov/text/kids/Problem_Board/problems/electricity/circuits2.html

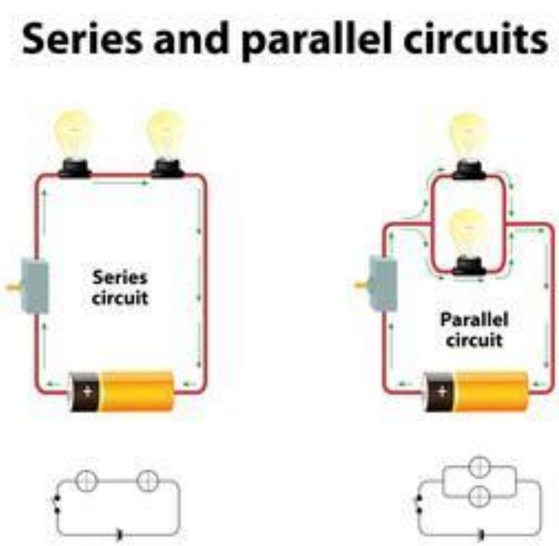
5. Have learners work on the following tasks and questions:

    Alternatively, learners 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	Using one light bulb and a switch,

light, unscrew one bulb and record what happens.	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:



4		**Theme:** ***Drawing A Prototype Of A Reliable Power Grid.***
	15 min	**Debrief the experiment of Day 3** ● Describe the differences between a closed and open circuit. ● What do 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 min	**Power Plants** 1. Have the learners write down two or three possible explanations for the blackouts in their communities based on the experiments. They can try and explain why power cuts occur based on their learning so far. 2. Tell learners that electricity for entire communities needs to be produced in **power plants**. Ask: 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. Invite them to try to explain how this happens based on some of the things that they learned so far. Explain: 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, producing electricity. 4. Invite learners to think about other sources of energy and try to explain how it is created in each case .
	35 min	**Power Grid** 1. Share with the students 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*

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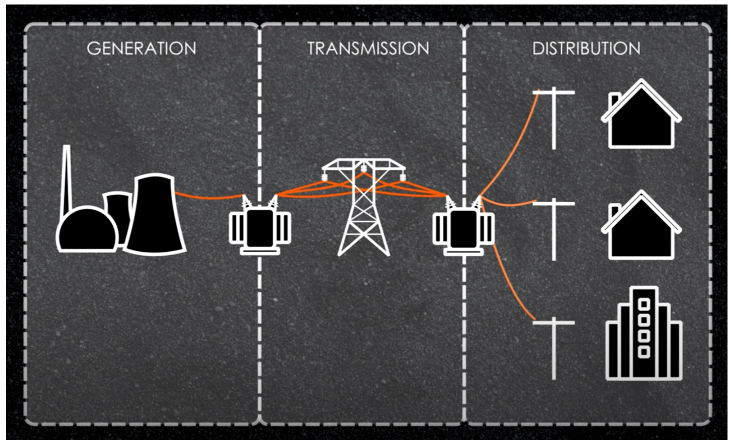
transformers, step-down transformers and wires all working together to deliver electric power to our homes.



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. Invite students to identify the key elements of a power grid based on the reading.
3. Get the learners to think of an analogy to describe a power grid.
4. Discuss: Is the metaphor accurate? Is it revealing? Is it creative?.

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Theme: *Drawing A Prototype Of A Reliable Power Grid.*

1. <u>**Numeracy Extension:**</u>
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

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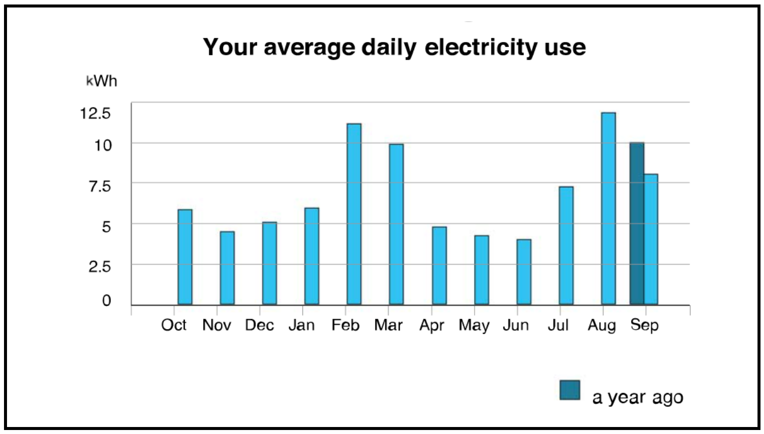
community to work.

2. Ask:
    - How many households or businesses are there in the community?
    - How much energy (in Kilowatts) do each household or business consume on average? For this calculation, you can use the information from your home's electric bill. If you don't have one available, consider this extract:



2. 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?
3. Identify what is or should be your community's power plant based on the available resources (wind farm, solar farm, hydroelectric dam, etc.)
4. What would be the best design for the grid? parallel or series?
5. 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!
Assessment Criteria		- Students show their understanding of basic scientific texts by being able to come up with powerful metaphors/analogies to describe scientific and engineering concepts such as energy and power grid. - Students fully conduct scientific experiments and are able to tell the difference between a close and an open circuit

Learning outcomes	• Understand more deeply the 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.
Required previous learning	Some basic understanding of physics, force, energy, and atoms is desirable. The concept of average, and the operations associated to it (division, addition).
Inspiration	• https://mrelectric.com/blog/how-to-explain-electricity-to-a-kid-mr-electri • https://tc2.ca/en/solar/division2/ • http://www.wired.com/wired/archive/11.09/start.html?pg=17 • https://www.youtube.com/watch?v=v1BMWczn7JM • https://teachersinstitute.yale.edu/curriculum/units/1989/7/89.07.01.x.html • https://learn.sparkfun.com/tutorials/what-is-electricity/all#:~:text=If%20we%20can%20free%20an,move%2C%20we%20can%20create%20electricity.&text=Using%20enough%20electrostatic%20force%20on,atom%20creating%20a%20free%20electron. • http://www.mysciencesite.com/Middle_School_Science_-_Basic_Circuits.pdf
Simplification	Skip the numeracy extension activity on Day 5.