1 How is Electricity Part of our World KEY

April 22, 2019 8:28 AM

Science 9

UNIT 3: PHYSICS

BOOK 1: HOW IS ELECTRICAL ENERGY PART OF YOUR WORLD?

name: Key block: _____

1

Part A: How is Electricity Part of our World?

- The first generator to provide a constant source of electrical energy was developed in 1844. This development made it possible to use the first practical light bulb, patented in 1879. Less than 150 years later, North America is lit up by so many electrical lights that it can be seen from a satellite at night. Despite the convenience they provide, these lights also have a dark side: Light pollution
- Light pollution seems to have a widespread, negative impact on many different species. The evidence for the impact of light pollution in migratory birds, hatchling sea turtles, and insects is striking.

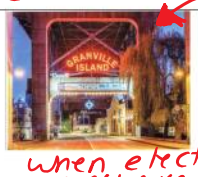
ELECTRICAL ENERGY HAS MANY APPLICATIONS

From the first ring of your morning alarm clock to when you turn the light off to go to bed, your day is filled with different applications of electrical energy.

Heart Rate monitor

moving your eyes relies on electrical signals in your muscles + nerve cells ... breathing, heart pumping

- tablets, touchscreens
- internal circuits so that when you use them, your finger completes the circuit.



Neon signs.

when electrical energy excites the electrons of a noble gas, they "glow" different colours.

Japan is using electrical signal that are surprisingly life-like => robots.

"Bullet Train"

Trains "hover" above electrified tracks, and run on a magnetic field. This decreases friction => 500 km/hr.

PRACTICE Describe 3 ways that you have depended on electrical energy today?

1.
2.
3.

Let's look at how electricity use has changed over time. How does it affect the world and our lives?

Imagine what your life would be like without the use of electricity.
Do you think you could live for one day without electricity? One week? How might doing so be challenging? What problems would you encounter, and how would you deal with them?

Imagine your world without electricity...

BC Hydro
Power smart

THAT WAS THEN, THIS IS NOW...

"kitchen"

Doing dishes inside a log cabin

Washing clothes in a washtub

"laundry room"

What do you notice about the kitchen in this photo? What is missing? dishwasher, sink, microwave, oven/stove

How do you think the women will get hot water to do the dishes? Kettle over fire

Looking outside, it appears to be night – how will they see to do the dishes? fires, candle, oil lanterns

What time period do you think this is? late 1800's

Why do you think so?

What do you notice in this photo?

How do you imagine this process compares to the washing machines we use today?

- time consuming
- energy
- hang to dry

Part B: History of electric household appliances

From 1890 to 1910, many experiments took place to find new ways to cook and heat using electric technology.

- first small appliance was an electric fan
- irons, stoves, sewing machines.

"Live better electrically" campaign

From 1920 to 1940, the use of electricity gradually became widespread across Canada.

Early, elegantly styled electric stoves started to become integral to kitchen decor.

By 1940 approximately 700,000 to 1,000,000 Canadian households used electricity, but Canada's population was 8 million at that time.

Note that even though electricity and electric appliances were being advertised, there were still 7 million people in Canada who did not have electricity in their home in the 1940s

Do you think there are people who live without electricity in Canada today? ✓

Where? far North, rural communities, Laskiti

oven

oven

Electric stove, Findlay Brothers Company Limited.

What time period do you think these appliances are from? Why?

washing machine from 1950s

How do these appliances compare to the ones in your homes?

smaller, takes longer (not efficient)

What would families have used before these early electric appliances?

buckets.

What are the biggest changes in the appliances over the last 60 years?

more energy efficient. work better; use less electricity.

Do you think the appliances of today use the same amount of electricity as the ones from the past? Why do you think so?

No new appliances are more efficient.

4

PRACTICE What is the biggest technology change you've experienced in your lifetime?

electric cars (Tesla); appliances are quieter

What do you predict to be the next major change in your lifetime? How do you think electricity will be involved?

=> transitioning to more renewable energy sources (solar, wind, tide)

Homework **Assignment #1: "That was then, This is Now" Worksheet Q #1-2**

Complete this assignment in the space provided below.

That was then, this is now

1. Think of all the electrical devices you use in your everyday life. As a group, make a list of the activities you do during the day that require electricity.

8:00 – 12:00

student answers will vary.

12:00 – 4:00

4:00 – 9:00

5

2. Imagine life without lights and devices. Think about how people and communities lived before electricity. Review the list you made on the previous page and, in the spaces below, write down what people used before they had electricity. For example, before light bulbs, people used a candle, a gas lamp, or the light from a fire to see in the dark.

Activities requiring electricity	Before electricity
staring food	→ cold room
cooking food	→ wood stove / fire
washing clothes	→ wash board / hang to dry
TV / entertainment	→ play ; games ; Live show
car / travel	→ horseback ; bike ; buggy
phone	→ letters ; travel to communicate face to face.

BC Hydro
Power smart

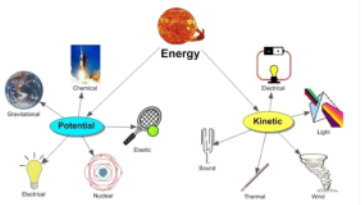
Part C: Energy Transformations Create Electrical Energy

Many different types of energy can be transformed into electrical energy.

Energy is the ability to do work.

Kinetic **energy** is energy a moving object has because of its motion.

Potential **energy** is the energy stored in an object.



Types of Energy

Use your phone or a computer to research the definition of each of the types of energy below. Try to come up with an example of that type of energy below. Work/discuss with a partner.

Type of Energy	Definition & Example
Kinetic	*Definition:* **kinetic energy** of an object is the **energy** that it possesses due to its motion.
	Example:
Potential	*Definition:* potential energy is the energy held by an object because of its position relative to other objects, stresses within itself, its electric charge, or other factors
	Example:
Electric	*Definition:* **Electrical energy** is a form of **energy** resulting from the flow of **electric** charge. The movement of charged particles through a wire or other medium is called current or electricity.
	Example:
Thermal	*Definition:* **Thermal energy** is an example of kinetic **energy**, as it is due to the motion of particles, with motion being the key.
	Example:
Radiant/Light	*Definition:* Vibrations of an electrical charge or magnetic field that produce electromagnetic waves
	Example:
Gravitational	*Definition:* Energy associated with place or position
	Example:
Elastic	*Definition:* Stored energy that results from deforming an elastic object (stretching a band)

	Example:
Nuclear	*Definition:* Energy stored in bonds between particles in the nucleus of an atom
	Example:
Sound	*Definition:* **Sound energy** is a form of **energy** that is associated with vibrations of matter that result after an object applies a force to another object.
	Example:
Chemical	*Definition:* A type of potential energy that is stored in bonds between particles in atoms, molecules or compounds
	Example:

The electrical energy stored in a battery is called **Electric potential energy** because the **electrons** have a *stored energy* and the ability to **Do work** after they leave the battery.

The Law of Conservation of Energy states that: **Energy can neither be created, nor destroyed. Instead, it is transformed from one kind of energy into another kind of energy**

For example:

An automobile engine changes chemical energy to mechanical and heat energy.

A thermonuclear reaction changes nuclear energy to radiant and heat energy.

A tree changes radiant energy to chemical energy.

An electric mixer changes electrical energy to mechanical and heat energy.

The electrical energy that runs your phone, hairdryer, TV, and all other electrical devices was transformed FROM another type of energy.

Many different types of energy are transformed into electrical energy for our use.

PRACTICE *Can you think of some?*

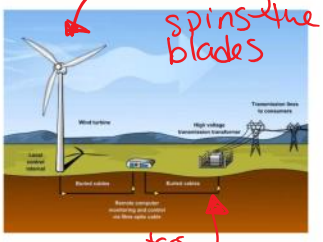
flashlight, radio ... battery (chemical → electric)
solar panel (light/radiant → electric)

1. Mechanical Energy

Mechanical energy is the sum of kinetic energy and potential energy. Kinetic energy is the energy of motion. Any moving object has kinetic energy, even air. Potential energy is stored energy that a system has due to its position or condition.

For example, the water at the top of a waterfall, just before it falls, has potential energy because of its position, and kinetic energy because it is moving. The potential energy is converted into more kinetic energy as the water falls due to gravity

Kinetic energy in moving wind, spins the blades



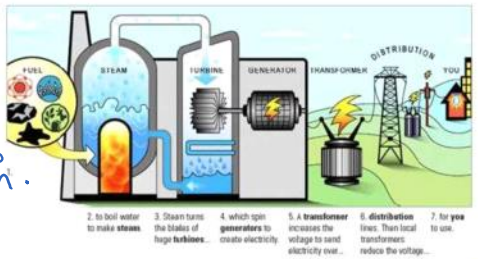
generators convert into electrical energy.

2. Chemical Energy

Chemical energy is stored in chemical bonds. It is released when a chemical reaction occurs. Batteries store chemical energy. Chemical energy stored in animals and in plants, such as these trees, is called BIOMASS. Fossil fuels *(coal, oil, natural gas)* also store chemical energy.

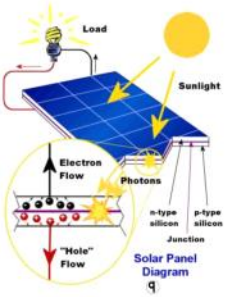
Renewable Energy 101: How Does Biomass Energy Work?
Green Mountain Energy

Burning of a fuel type (biomass or fossil fuel) boils water to create steam.

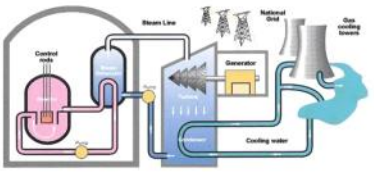


3. Solar Energy

Solar energy is energy carried by electromagnetic radiation given off by the sun. Fossil fuels and biomass are the result of energy from the Sun being captured by plants and plant-like organisms. photons from the sun create a flow of electrons that moves through a connected circuit. Solar cells are connected to a charge converter and battery in order to store available energy for later use.



4. Nuclear Energy

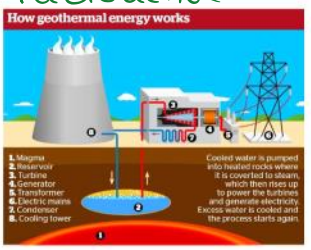


Nuclear energy is generated by forming new atoms. In nuclear fusion, new atoms are made as smaller atoms collide and fuse. Fusion reactions occur in the Sun and other stars. (and the Large Hadron Collider)

"Fusion" does NOT occur in nuclear power plants.

In nuclear fission, new atoms are made by splitting larger radioactive atoms. Fission reactions are carried out in reactors on Earth. (nuclear power plants) ← (create a lot of radioactive waste)

5. Geothermal Energy



Thermal energy is the energy due to the rapid motion of particles that make up an object. We detect it as HEAT. It can come from many sources, such as nuclear reactions or from Earth's interior *(geothermal energy)*, where steam and hot water form naturally. These are seen in areas of active geysers, volcanoes and hot springs.

Renewable Energy 101: How Does Geothermal Energy Work?
Green Mountain Energy

Although we currently do not have any Geothermal Power Plants in Canada, they are common along the west coast of the USA, and other active tectonic regions. (moving plates) According to the International Geothermal Association, there is a planned project in Alberta for the near future.

PRACTICE

1. Explain the difference between kinetic energy and potential energy

Kinetic energy is "movement energy" (objects in motion)
Potential energy is "positional/stored".

2. describe the relationship among solar energy, biomass and fossil fuels.

although they originate from different sources (sun, plants/animals, coal/gas) they can all be transformed into electrical energy.

10

Part D: Electrical energy is generated in different ways from Different Sources

Many different types of energy can be transformed into electrical energy.

Most of the electrical energy in Canada is generated by transforming kinetic energy into electric energy. The source of kinetic energy may be moving water or wind. It may also be moving steam produced by thermal energy generated in nuclear reactions, or by burning fossil fuels.

In each case electrical energy is generated using a generator system.

All generator systems have 3 parts:

1. Turbine 2. Shaft 3. Generator

A generator system is a system that transforms kinetic energy to electrical energy.

[ie: moving parts are transformed into moving e⁻ (charges)]

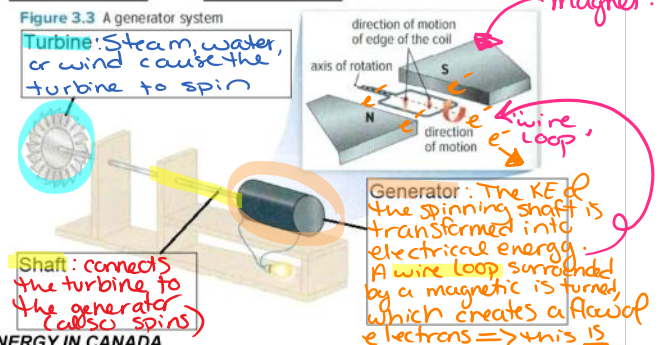


Figure 3.3 A generator system

Turbine: Steam, water, or wind cause the turbine to spin

Shaft: connects the turbine to the generator (also spins)

Generator: The KE of the spinning shaft is transformed into electrical energy. A wire loop surrounded by a magnetic is turned, which creates a flow of electrons => this is electrical energy.

magnet.

wire loop, e⁻

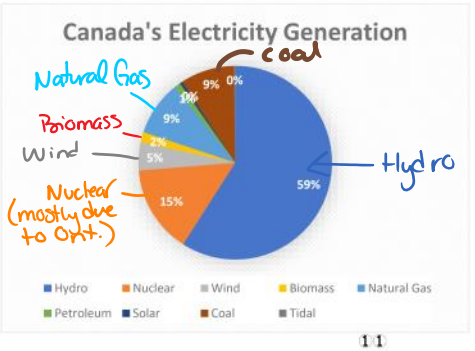
GENERATING ELECTRICAL ENERGY IN CANADA

Most of the electrical energy used in Canada comes from river flow, fossil fuels, and nuclear reactions. In B.C., river flow is the main source, but B.C. also uses fossil fuels to generate electrical energy.

66% of Canada's electricity comes from renewable sources and 81% from non-greenhouse gas emitting sources

Canada is the world's second largest producer of hydroelectricity

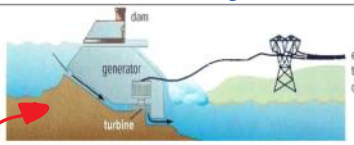
Canada exports nearly 11% of the electricity it generates to the United States. There are 34 active major international transmission lines connecting Canada to the U.S.



11

1. Hydroelectric Energy from River Flow

Electrical energy from river flow is called Hydroelectric energy



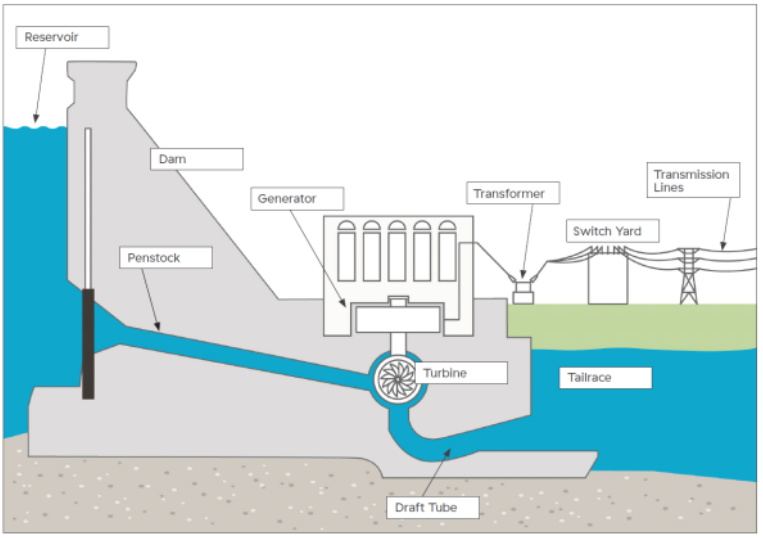
Water flowing through a dam spins giant turbines, which spin a generator to produce electrical energy.

At a run-of-river station *(below)* water flowing freely in a river is diverted to turn a turbine.

At the dam station *(above)*, water stored behind the dam has Potential energy. As it flows downhill, it gains kinetic energy, which turns a turbine connected to a generator.

Watch the Video: "How a Dam Works" , BC Hydro https://www.youtube.com/watch?v=PvJHjnELVSM

Name the parts of the dam

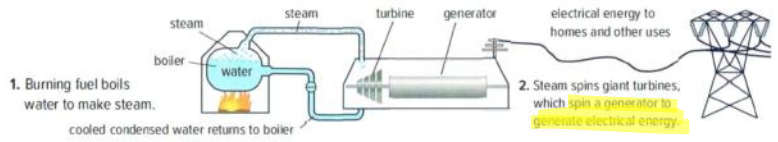


1 2

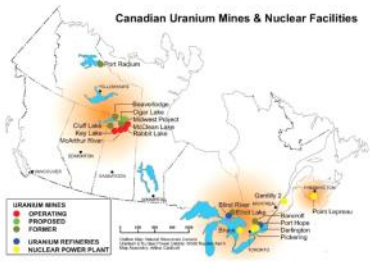
Renewable Energy 101: How Does Hydroelectricity Work?
Green Mountain Energy

2. Electrical Energy from Fossil Fuels

In the generating station shown here, thermal energy from burning fossil fuels (like coal) is used to boil water into steam. Pressure associated with the moving steam turns the blades of turbines connected to generator systems.



3. Electrical Energy from Nuclear Reactions

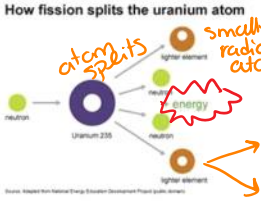


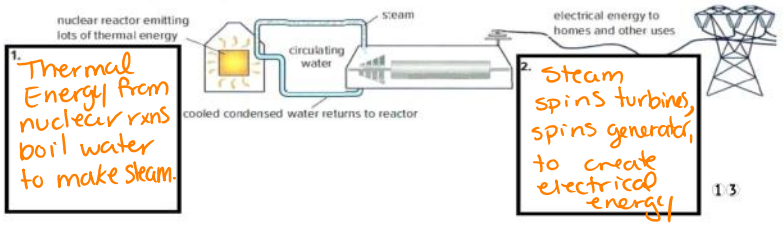
Inside a nuclear reactor, uranium or plutonium atoms (large radioactive atoms) undergo FISSION reactions. Splitting one atom sets off a chain reaction that causes more atoms to split.

The nuclear reactor contains and controls these reactions and the energy they release.

Most of this energy is thermal energy, which is used to boil water into steam. Pressure associated with the moving steam turns turbines connected to generators. (just like in a coal system)

How fission splits the uranium atom





1. Thermal Energy from nuclear rxns boil water to make steam.

2. Steam spins turbines, spins generator, to create electrical energy

13

Part E: Generating Electrical Energy from Other Energy Sources

Transformation of kinetic energy from wind and solar energy to electrical energy is on the rise in B.C. and Canada as a whole. Geothermal sources, waves, and tides are small players now, but they hold promise for the future.

Watch the Video: "Renewable Energy 101"
https://www.youtube.com/watch?time_continue=83&v=T4xKThjcKaE

What is renewable energy?

Definition

a group of energy sources that
- do not deplete
- can be replenished within a humans lifetime

Types
- solar
- hydropower
- wind
- biomass
- tidal
- geothermal

Renewable energy

Why should we use it?
- clean source of energy (does not directly produce GHG emissions or air pollutants)

What are some challenges involved in using it?
- low efficiency
- high captital cost
- intermitancey (ie: doesn't work all the time)

14

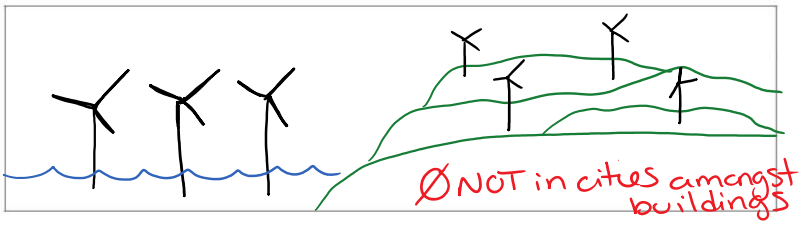
Can 100% renewable energy power the world? - Federico Rosei and Renzo Rosei
TED-Ed

Renewable Energy 101
Student Energy

Watch the Video: "Wind Power 101" https://www.youtube.com/watch?time_continue=6&v=Z5c50-_hcD0

Energy transformations: Wind power

1. Describe (or draw) places that might be good sites for wind power.



2. Three forms of energy are involved when a wind turbine makes electricity—electrical energy, kinetic energy and mechanical energy. Label each energy type.

Moving air	Turbine blades spin	Electromagnetic generator creates electricity
mechanical energy	Kinetic energy	electrical energy

3. List advantages and challenges of using wind turbines to create electricity. Can you think of others that weren't listed in the video?

Advantages	Challenges
• no direct CO_2 emissions • more expensive than conventional electricity generation sources (but is getting cheaper)	• intermitancy (not windy all the time) • land use, bird disruption, noise

15

1. ELECTRICAL ENERGY FROM WIND

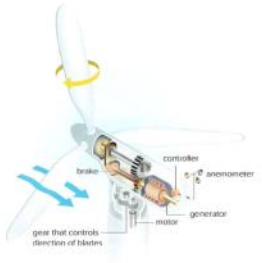


Figure 3.5 A wind turbine and generator transform kinetic energy to electrical energy.

The Kinetic energy of wind is transformed into electrical energy as the moving air turns the turbine of a generator system.

The most common type of wind turbine in Canada is mounted on a high tower to take advantage of greater wind speeds higher above the ground. This height also reduces turbulance from wind blowing around buildings.

A wind turbine starts to produce electrical energy when wind speed is about 13 km/h. Gears on the shafts increase the speed of the generator. This process increases until wind speed reaches about 55 km/h.

For safety, a controller shuts the turbine down when the wind speed reaches 90km/h An anemometer is used to measure wind speed.

Renewable Energy 101: How Does Wind Energy Work?
Green Mountain Energy

2. ELECTRICAL ENERGY FROM SUNLIGHT

Some materials produce electrical energy when they are exposed to Light.

This is called the photovoltaic effect.

Photovoltaic cells generate electrical energy when visible light strikes their surfaces. The cells are made of thin layers of silicon crystals

Figure 3.6 A photovoltaic cell transforms solar energy to electrical energy.

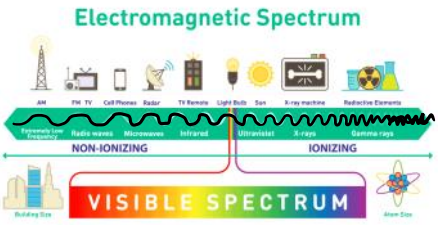
When visible light strikes electrons trapped in the cells, the electrons absorb just enough energy to flow freely and generate electrical energy.

The Sun emits enormous amounts of solar energy, but converting this energy to electrical energy is a challenge.

Currently, photovoltaic cells only transform the energy of visible light to electrical energy. However, scientists are working to create cells that transform other types of electromagnetic radiation into electrical energy.

16

Renewable Energy 101: How Does Solar Energy Work?
Green Mountain Energy



3. ELECTRICAL ENERGY FROM GEOTHERMAL SOURCES

Figure 3.7 A geothermal generating station transforms thermal energy to kinetic energy to electrical energy.

Where Earth's crust is thin and molten rock comes close to the surface, hot steam can be used to turn turbines to generate electrical energy.

Some parts of the world have greater access to geothermal sources than others.

For instance, the volcanic island nation of Iceland generates 25% of its electrical energy from these sources.

4. ELECTRICAL ENERGY FORM WAVES AND TIDES

The vertical rise and fall of the waves can compress an air column, which turns a turbine.

→ but also ecologically damaging.

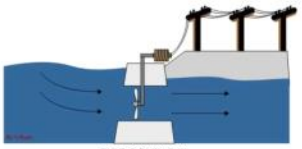
Figure 3.8 A tidal generating station transforms kinetic energy from tides to electrical energy.

The B.C. coast is considered one of the best places to generate electrical energy from waves.

Tides can spin turbines to produce electrical energy.

However, they are only effective where they vary by 5m or more

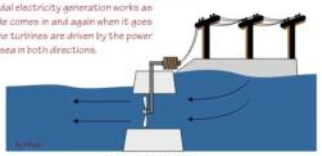
At high the gates of the tidal generating station shown here close and trap water in a basin.



TIDE COMING IN

When the tide goes out, the water is directed through pipes to turn a turbine.

This tidal electricity generation works as the tide comes in and again when it goes out. The turbines are driven by the power of the sea in both directions.



TIDE GOING OUT

Such stations only generate electrical energy for about 10hrs a day, as the tide moves in or out.

*Canada's largest tidal power station: Bay of Fundy in NB/NS

17

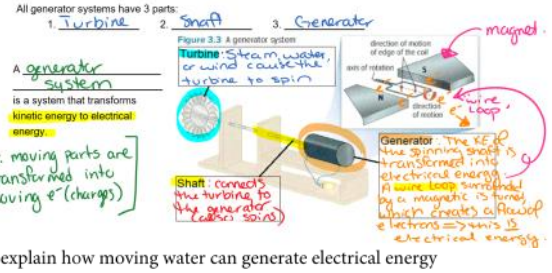
PRACTICE

1. List the three key parts of a generator system. Briefly describe their functions.

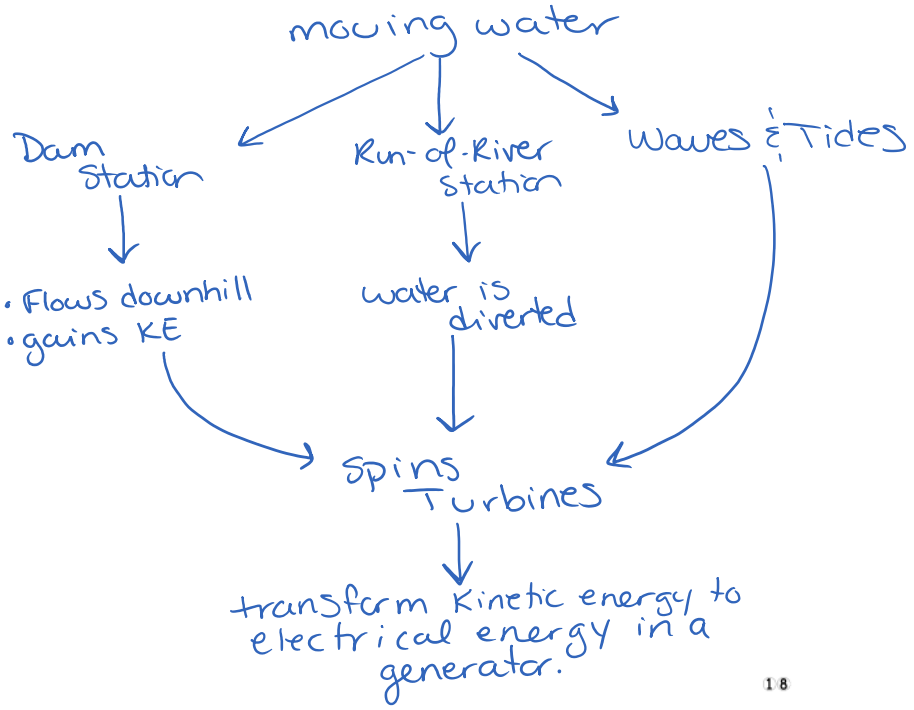
All generator systems have 3 parts:
1. Turbine 2. Shaft 3. Generator

A generator system is a system that transforms kinetic energy to electrical energy.

ie: moving parts are transferred into moving e⁻ (charge)



2. Use a flowchart to explain how moving water can generate electrical energy



18

Homework **Assignment #2: "Make a Difference: People Power"**
Complete this reading and answer questions #1 + 2a on a different page

TAKE Action

Make a Difference
People Power

British Columbia: Max Donelan of Simon Fraser University has designed a device that transforms human-generated energy into electrical energy. The PowerWalk® Kinetic Energy Harvester is secured around the knee. Each time we take a step, our leg muscles speed the movement of the leg and then slow it down at the end of the step. The Harvester could harvest the energy of leg motion at all times, but walking would become tiring. Instead, it extracts energy only when the muscles are slowing leg motion, making walking easier. How much electrical energy can be generated this way? An hour of walking can charge up to four smartphones.

Japan: Something unique happens when special materials, called *piezoelectric materials*, are compressed or pulled. The mechanical energy associated with the force or stress is transformed into electrical energy. Piezoelectric materials include quartz crystals, some ceramics, amber, and even cane sugar (although the crystals break too easily to be used in applications). It is possible to use these materials and human energy to generate electrical energy on a large scale. For instance, the floors in several Japanese subway stations are made out of piezoelectric materials. As people walk on the floor, they compress the materials, which generates electrical energy.

Apply and Innovate

1. Come up with some possible applications for the two examples discussed in this feature. What factors would you need to consider?
2. Ann Makosinski, a 15-year-old student in B.C., designed a flashlight that transforms human body heat (thermal energy) into electrical energy.
   a) Why would this and other human-powered electrical devices be especially useful to people and communities in developing countries?
   b) Find out more about initiatives that are bringing human-powered electrical energy to people in developing nations. Choose a specific project. How could you get involved? Come up with an action plan.

Suggested Answers:

1.
   a. Possible applications for the PowerWalk Kinetic Energy Harvester could be during long hikes, could generate your own electricity to power items you need such as flashlights, radio, communication devices, etc.
   b. Piezoelectric materials used in Japanese subway floors…utilize human mechanical energy (stress forces) to transform into electrical energy. This could be used to power lights, communication for subway announcements, phones, etc.
2. .
   a. People in developing countries do not have regular or any (in some places) access to electricity. This would enable communities to develop materials/sources that require electricity: schools, hospitals, water stations to filter and clean water for drinking and agricultural use.

Homework **Assignment #3: Check your Understanding**
Answer questions #1 -9 on a separate page. Answer in ***full sentences***

Understanding Key Ideas

1. Describe the role electrical energy plays in robotics.
2. Identify the type of energy associated with each source below.
   a) the Sun
   b) river flow
   c) a battery
   d) wind
   e) uranium
   f) hot springs
   g) garbage
3. Use a table to compare the similarities and differences among the use of river flow, the burning of fossil fuels, and nuclear reactions to generate electrical energy.
4. Some photovoltaic cells, like the ones shown below, are mounted on towers that let them follow the Sun's path. What is the
   b) Describe two different cases in which a wind turbine would be a good choice.

Connecting Ideas

6. Imagine that a wind turbine has a faulty controller. Predict a problem that could arise as a result of this manufacturing defect.
7. You are waiting outside school for a friend. It is a cold day in January, and you reach into your bag for your gloves and phone. You are early and decide to send a text while you wait. However, the screen is not responding to your touch commands. You take off your gloves and find that your screen now works. What type of touch screen do you most likely have and why did it not work when you wore gloves?
8. Photovoltaic cells are commonly used to provide electrical energy for satellites.

Suggested Answers:

1. Electricity powers moving parts in robotics, such as motors, lights, etc.
2. .
   a. light/radiant/solar
   b. Mechanical
   c. Chemical
   d. Kinetic
   e. Nuclear
   f. Thermal
   g. Biomass
3.

River flow	Burning Fossil Fuels	Nuclear Reactions
• Renewable • Generator system converts mechanical energy into electrical energy	• Non-renewable • Thermal energy from boiling water creates steam to turn a turbine • Generator system converts thermal energy into electric energy	•

4. Would decrease problems associated with intermittency if the photovolatic cell was able to move as the sun moved in the sky throughout the day. Solar cells that are stationary are only able to generate electricity when the sun is shining directly on them.
5. Coastal Community
   a. ONE: Building a tidal generating system would allow the community to generate electricity from the tides. TWO: they could decrease their usage of non-renewable energies like fossil fuels
   b. ONE: Building wind turbine system would allow the community to generate electricity from the wind…however it is intermitant. TWO: they could decrease SOME of their usage of non-

PA E C

4. Some photovoltaic cells, like the ones shown below, are mounted on towers that let them follow the Sun's path. What is the advantage of such designs? PA E AI

5. Consider a coastal community. CP E AI
   a) Describe two cases in which a tidal generating system would be a good choice for the community.

PA E AI

8. Photovoltaic cells are commonly used to provide electrical energy for satellites. Suggest an advantage that photovoltaic cells might have in space, compared with similar cells on Earth. PA E AI

Making New Connections

9. Imagine there was a large-scale power failure that left your region without electricity for two weeks during the summer months. E AI C
   a) What would be the most serious consequences for you and for your community?
   b) How might the problems be different if the event took place in January?
   c) What alternative energy sources, if any, could be used?

fuels
   b. ONE: Building wind turbine system would allow the community to generate electricity from the wind…however it is intermitant. TWO: they could decrease SOME of their usage of non-renewable energies like fossil fuels
6. The **controller** on a Wind Turbine shuts down the turbine at high wind speeds (90 km/h). If the controller was faulty, the wind turbine may not shut down as it was designed to for safety reasons at high wind speeds. This could result in any number of problems, burn out motor, damage to wind turbine or blades….worst case scenario? The blades could spin so fast they break off and cause significant damage to the surrounding area.
7. If your touch screen does not work with gloves on, but does with no gloves. It is most likely that your touch screen responds to thermal energy (the heat in your hands/body).
8. Photovoltaic cells in space have a more direct, unfiltered access to the suns light energy (photons). Depending on their placement in space, they could be closer than Earth to the sun and receive MORE light energy which is then converted into electrical energy. Also, on Earth we experience day and night due to the Earths rotation…in space, there is no photovoltaic problem of intermittency, the suns light is shining all the time.
9. Student answers will vary…suggestions:
   a. Without electricity there would be several problems. I would consider some of the more serious to be storing and cooking food (no refrigerator/freezer/oven/microwave). No fans or air conditioners…heat waves can be dangerous to the health of the young and elderly. Transportation would be an issue for people with electric cars, also gas station pumps would not operate, so you also wouldn't be able to fill gas or diesel cars.
   b. many problems would be the same in january, but the major different concern would be warmth/heating. There wold be no electric heat of your home, relying entirely on wood, or gas. The delivery of which would soon run out if vehicle transport was limited.
   c. Solar, batteries, propane/gas/diesel, wood burning, human powered (mechanical) eg. Crank flashlights/radios, etc.