Hydropower

Hydropower An Introduction

The purpose of this subject area is to familiarize students with the production of hydropower at Bonneville Dam.

The first section includes activities which may be used to introduce hydropower concepts in the classroom. Next are self- guided tours of each powerhouse and an on-site activity. Finally, activities are included for after your visit to help reinforce what has been learned about the production of hydropower.

History Quickie

Bonneville Dam was built in the 1930's during the Great Depression. At this time Franklin D. Roosevelt campaigned for president of the U.S. promising, if elected, the would bring work to the Northwest by constructing the next federal hydropower dam on the Columbia River. Bonneville Dam was funded by the PWA or Public Works Administration. The dam was originally designed with only two generators and room for an additional four. People called it the "Dam of Doubt" and "Roosevelt's White Elephant" because they doubted whether they were going to be able to use all that electricity. Some believed that building the dam was an extravagant waste of federal funds.

Because the electricity made at Bonneville Dam was much less expensive than that from other sources, the demand for electricity grew rapidly. Even before the completion of the dam in 1938, four more generators were installed.

The addition of another four generators was started in 1939 and finished in 1943. This brought the number of generators in the first powerhouse to ten.

Important Concepts

The activities in this section will help the students understand the following concepts. Important vocabulary words are in bold print.

Energy is the work a physical system is capable of doing in changing from one state to another. Electricity is a form of energy.

An **electrical current** is the flow of electrons. An **electron** is a very small particle that orbits around the nucleus of an atom. Electrons have a negative electrical charge.

There are **atoms** that are good electrical **conductors**, such as copper or aluminum atoms. They have electrons that can be easily pulled from their orbit. Passing a magnet over a copper wire will excite the electrons in the copper atoms.

When there is work for electricity to do, we call it a "load." A load or the completion of an **electrical circuit**, will cause the excited electrons to jump from their original atom to the next atom, leaving a space to be filled by another excited electron. This exchange of electrons becomes a flow, this flow is an electrical current.

Generators produce electricity. A generator is a machine that spins magnets past coils of copper wire.

A commercial turbine generator unit, such as those at Bonneville Dam, consists of two main parts; the generator and the turbine. The generator (upper half of the unit) consists of two main parts, the **rotor** and the **stator.** The rotor is an electromagnet, the stator is coils of copper wire.

The generator is connected to the turbine (lower half of the unit) by a shaft. When a potential energy source is harnessed (i.e. wind, sun, water, or steam power) it can be forced to turn the turbine which is like a giant propeller.

Water falls through a hydropower dam (due to the force of gravity), turns the turbine, the turbine turns the shaft, the shaft spins the rotor which spins inside the stator and produces electricity.

Hydropower means water power, and is the term used for electricity generated at a dam.

The part of the dam that houses the generators is called the **powerhouse.** There are two powerhouses at Bonneville Dam, one on the Oregon side and one on the Washington side of the Columbia River. The part of the dam in the middle is called the spillway.

The **spillway** is the part of the dam that holds back, or releases, extra water. The spillways along the river help control the water so that it can be used for many uses. Water is spilled at Bonneville Dam mainly in the springtime for two reasons: 1) to help fingerlings that are on their way to the ocean; and 2) to pass river flow that exceeds the hydroelectric capacity of the two powerhouses.

We measure electricity in watts. 1 volt x 1 ampere = 1 watt. Amperage is the amount of electricity that is present, voltage is the force of the electricity. A **kilowatt** is a thousand watts. A **megawatt** is a million watts. Bonneville Dam can produce over a million kilowatts of continuous output when operating at full capacity. That is over one thousand **megawatts.**

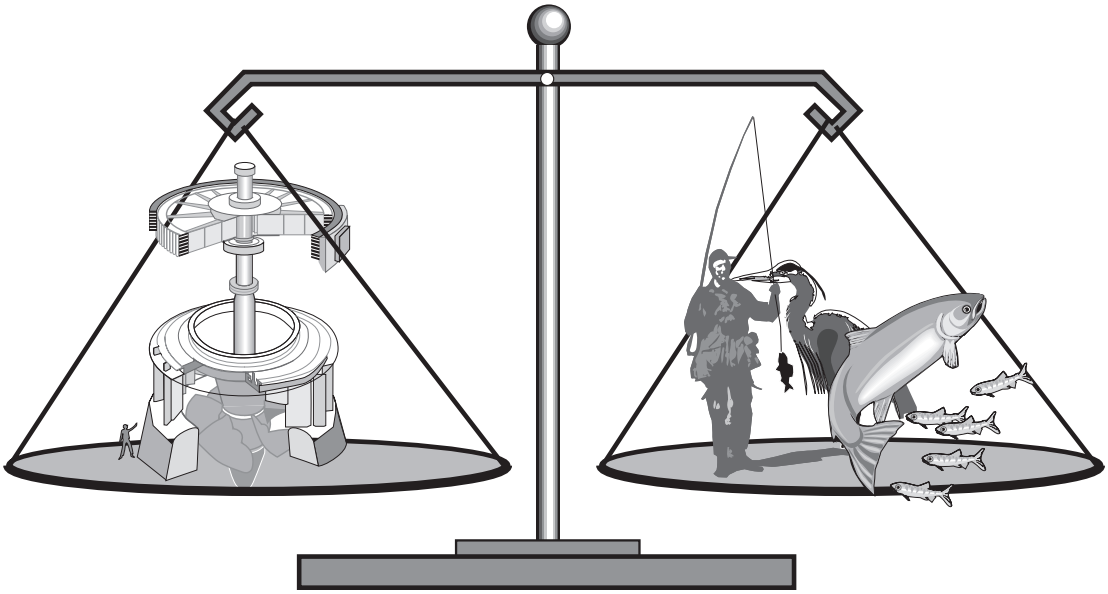
The electricity is delivered to your house through transmission lines. The excited electrons in the copper coils of the generator cause the electrons in the connecting wires to also be excited and flow.

Transmission lines are built by the **Bonneville Power Administration.** The B.P.A. is a **government marketing agency** formed to market and distribute the electricity produced at federal dams. They sell electricity to local utilities, the **local utilities** sell the electricity to users.

Conservation means using a **resource**, such as a river, to fulfill people's needs while not overusing it and depleting or destroying it. At Bonneville Dam we use the Columbia River to make electricity, facilitate transportation and to provide recreational opportunities. We also manage the natural resources in order to protect the river's fish and wildlife.

When we attempt to practice conservation we become involved in **trade-offs**. A trade-off means balancing one **benefit** against another. When we build a hydropower dam we trade a wild and

natural river for electricity, easier river navigation etc.. Some of the advantages associated with hydropower are: it is **renewable** due to the **water cycle**; it rarely **pollutes** the air or water; it can create or enhance habitat for some fish and wildlife; and it provides relatively inexpensive power. Some of the disadvantages associated with hydropower are: the high monetary costs to build a hydropower dam; the lake behind the dam covers up lands that may have had farms, towns, wildlife, and fish spawning grounds on them; dams and the lakes they create are difficult for **anadromous fish** like salmon to get past; and the loss of wild river scenery and recreation.



Hydropower
Before Your Visit

The following activities about hydropower are designed to be used before you bring your students to Bonneville Dam.

Activities

Label The Powerhouse:

Students should be given a copy of the activity "LABEL THE POWERHOUSE." They may label the powerhouse by reading the descriptions of the various "parts" and by filling in the blank spaces which have been provided. Students may also color the different parts of the powerhouse.

What Is A Watt?

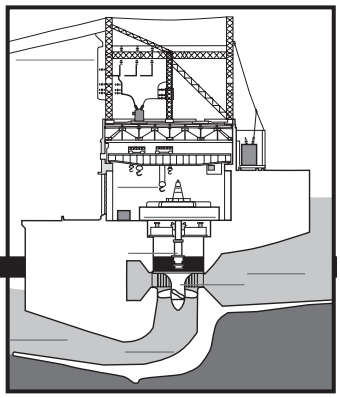
This sheet, to be completed by the student, will help students learn about watts. Utility companies use watts for billing users. They charge according to the number of watts used multiplied by the amount of time they have been used.

You And Your Electric Bill/Energy Eaters:

These activities will give students an idea about what appliances in the home use the most electricity and about how much these appliances cost to operate.

Energy Riddles:

These energy riddles are designed to help build a "hydropower" vocabulary. We suggest that you first have your students complete the activity, "LABEL THE POWERHOUSE," before you try the riddles.



Label The Powerhouse

Read the following definitions of the "parts" of a powerhouse. Then, label the powerhouse. There is one space on the diagram for each word.

Turbine A turbine is a large metal machine which is turned as the water passes through the power house. It looks like a giant pinwheel or propeller.

Generator A generator is the part of the powerhouse which makes electricity. Part of the generator is attached to the turbine. So, when the turbine turns, so does a part of the generator. The generator has two parts, coils of wire and magnets.

Intake The opening in the dam that lets water through to turn the turbine.

Shaft The shaft connects the turbine to the generator so that when the turbine spins it also spins the rotor which is inside the generator.

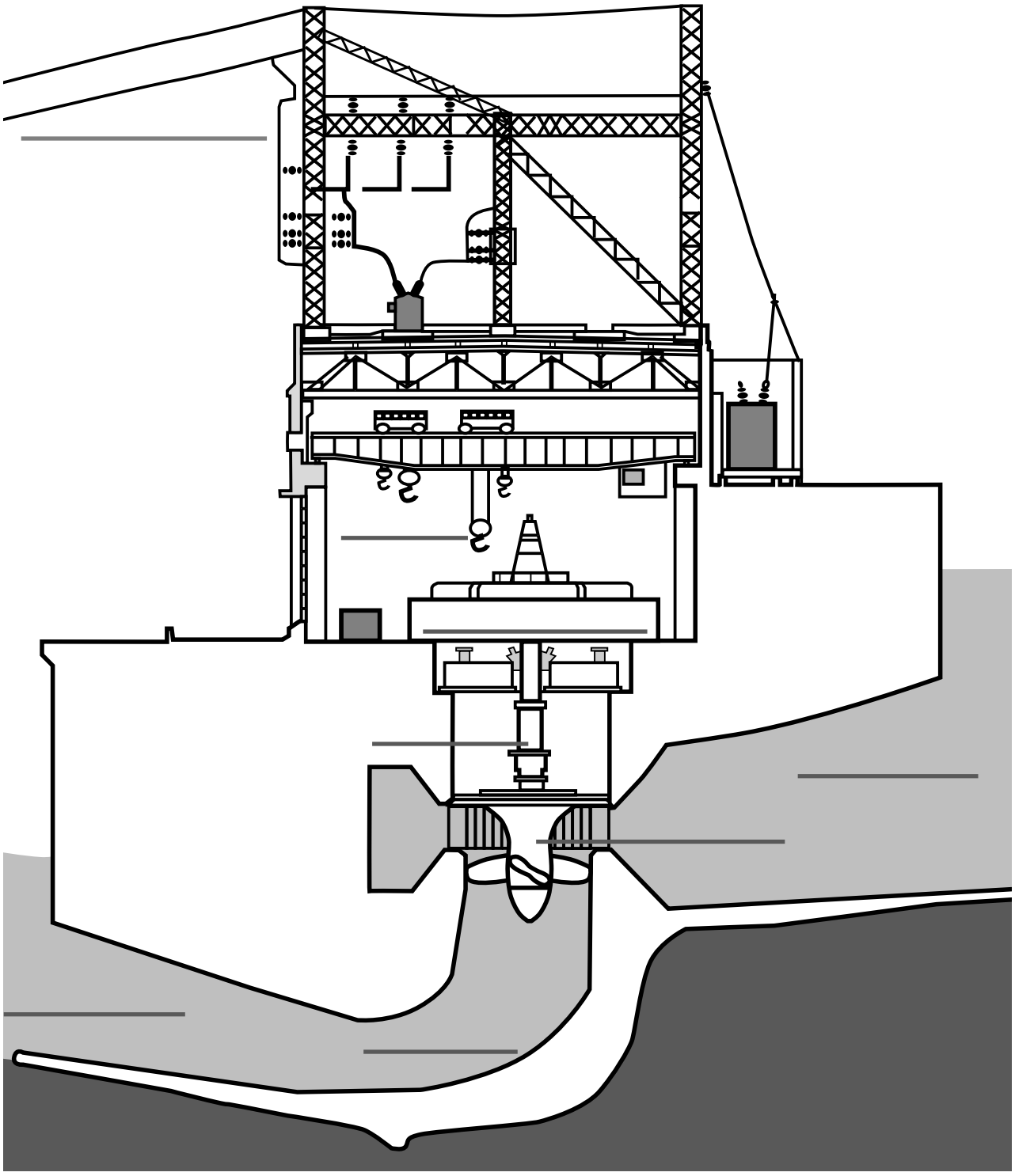
Exit The exit is where the water goes immediately after falling through the turbine.

Transmission Lines The transmission lines carry electricity from the powerhouse to your house.

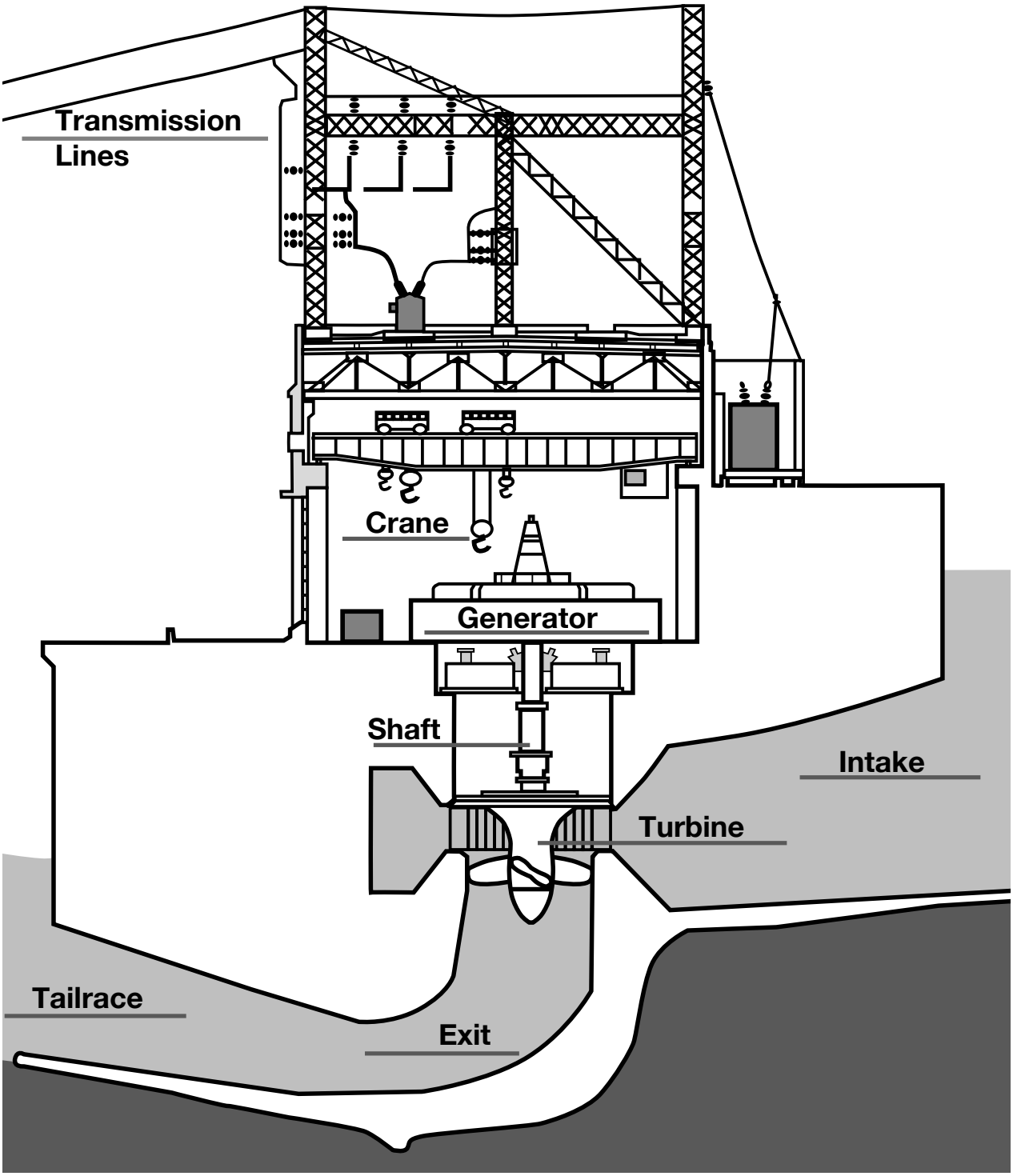
Tailrace The tailrace is where the water comes out of the powerhouse. If you stand on the down river side of the powerhouse you will see the water, or tailrace, churning and bubbling.

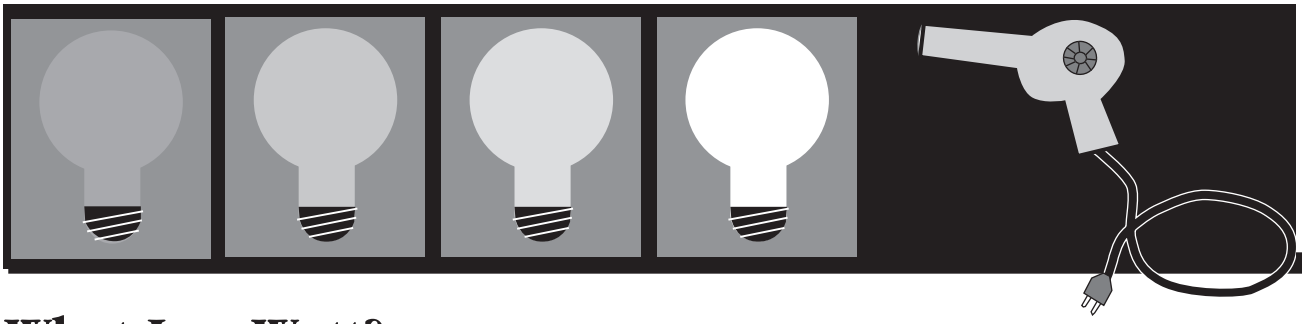
Crane The crane is used to lift parts of the generator straight up so that the generator can be fixed. It slides across the ceiling of the powerhouse on rails.

Label the Powerhouse



Label the Powerhouse, Answers:





What Is a Watt?

A **Watt** is an amount of electrical power. For example a 60 **Watt** light bulb uses 60 **Watts** of electricity. Likewise, a 100 **Watt** light bulb uses 100 **Watts** of electricity.

When you go home tonight, ask your Mom and Dad to help you find out how many **Watts** are used by any of the following things in your home. The number of **Watts** that an appliance uses should be written on the appliance.

1. Any light bulb in your home _____WATTS
2. An electric toaster _____WATTS
3. A television _____WATTS
4. A plug-in radio _____WATTS
5. A hair dryer _____WATTS
6. An electric blanket _____WATTS
7. A refrigerator _____WATTS
8. _____(other) _____WATTS

Kilowatts: Bonneville Dam generates so much electricity that it is measured in thousands of Watts. Another name for 1,000 Watts is a **Kilowatt. Kilo** means 1,000. Bonneville Dam produces over **One Million Kilowatts!**

How many 100 watt light bulbs would it take to use one kilowatt of electricity?

_____

How many 50 watt light bulbs could be lit by one kilowatt?

_____

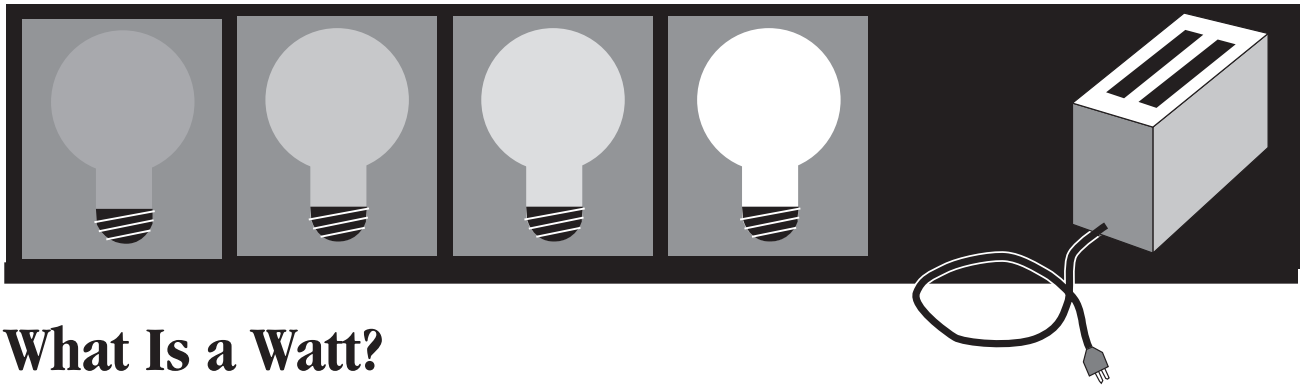
Kilowatt Hours: If you use 1 kilowatt for 1 hour you will use 1 kilowatt hour!
One kilowatt x 1 hour = 1 kilowatt hour.

When you use ten 100 watt light bulbs for one hour how many kilowatt hours would you use?

_____

If you used a 6,000 watt air conditioner for 2 hours, how many kilowatt hours would you use?

_____



What Is a Watt?

Answers:

1.	**Any light bulb in your home**	**100 WATTS**
2.	**An electric toaster**	**1,146 WATTS**
3.	**A television**	**145 WATTS**
4.	**A plug-in radio**	**71 WATTS**
5.	**A hair dryer**	**600 WATTS**
6.	**An electric blanket**	**630 WATTS**
7.	**A refrigerator**	**1,450 WATTS**
8.	**(other)**	**_____ WATTS**

Kilowatts: Bonneville Dam generates so much electricity that it is measured in thousands of Watts. Another name for 1,000 Watts is a **Kilowatt. Kilo** means 1,000. Bonneville Dam produces over **One Million Kilowatts!**

How many 100 watt light bulbs would it take to use one kilowatt of electricity? 10

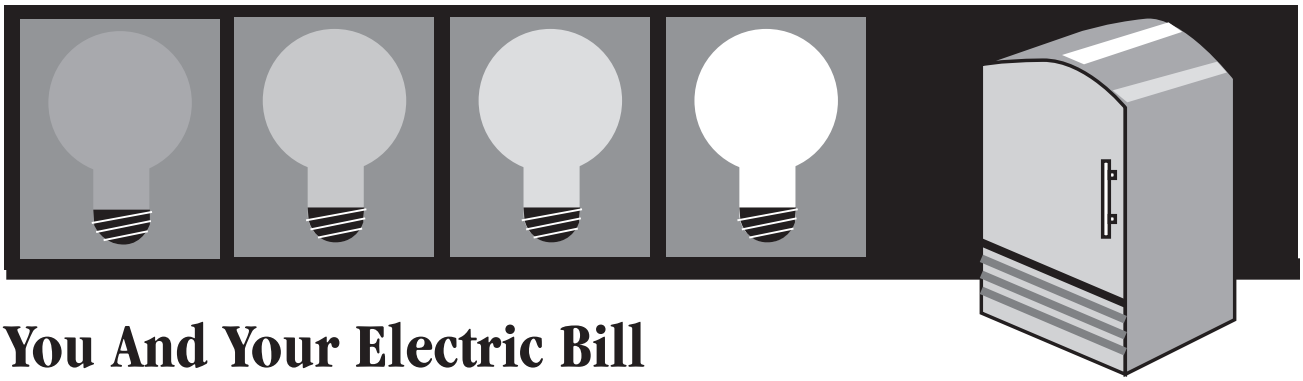
How many 50 watt light bulbs could be lit by one kilowatt? 20

Kilowatt Hours: If you use 1 kilowatt for 1 hour you will use 1 kilowatt hour!

One kilowatt x 1 hour = 1 kilowatt hour.

When you use ten 100 watt light bulbs for one hour how many kilowatt hours would you use? 1

If you used a 6,000 watt air conditioner for 2 hours, how many kilowatt hours would you use? 12



You And Your Electric Bill

Before you read this page, be sure you have read the page titled, **What Is A Watt?**

Look at the electric bill from your electric company. Who is your electric company? What do they charge for a kilowatt hour of electricity?

Let's suppose that it costs you 5 cents for 1 kilowatt hour. That means if you use 1000 watts (one kilowatt) for one hour you will use 5 cents worth of electricity!

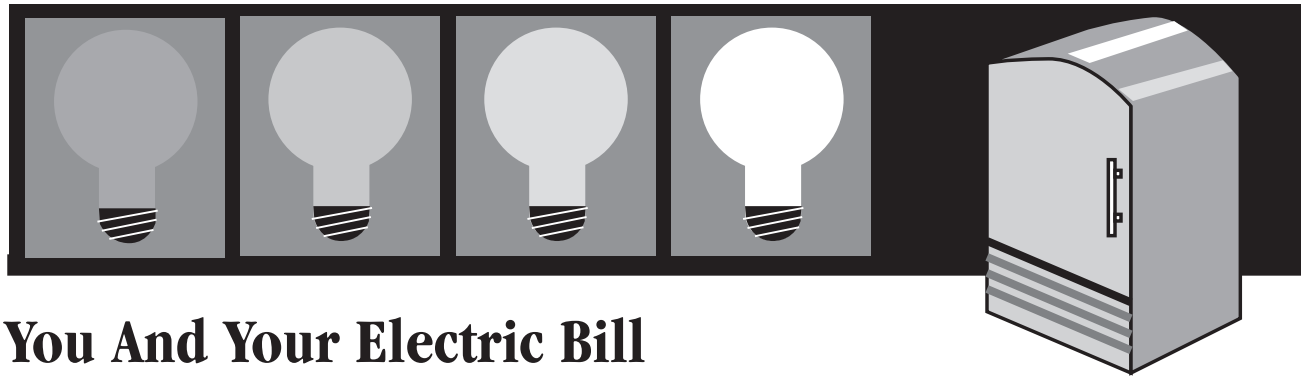
Assume that electricity costs you 5 cents for one kilowatt hour. How much would it cost to run the following: (see the sample below)

1. **A 1000 watt light bulb for 2 hours** _____
2. **A 100 watt light bulb for 24 hours** _____
3. **A 50 watt stereo for 10 hours** _____
4. **A 1000 watt refrigerator for 24 hours** _____
5. **A 2000 watt air conditioner for 24 hours** _____

SAMPLE: How much would it cost to run a 2000 watt clothes dryer for 3 hours if electricity costs 5 cents a kilowatt hour?

SOLUTION: 2000 watts = 2 kilowatts
2 kilowatts for 3 hours = 6 kilowatt hours (because 2x3 = 6)
6 kilowatt hours x 5 cents = 30 cents (6x5 = 30)

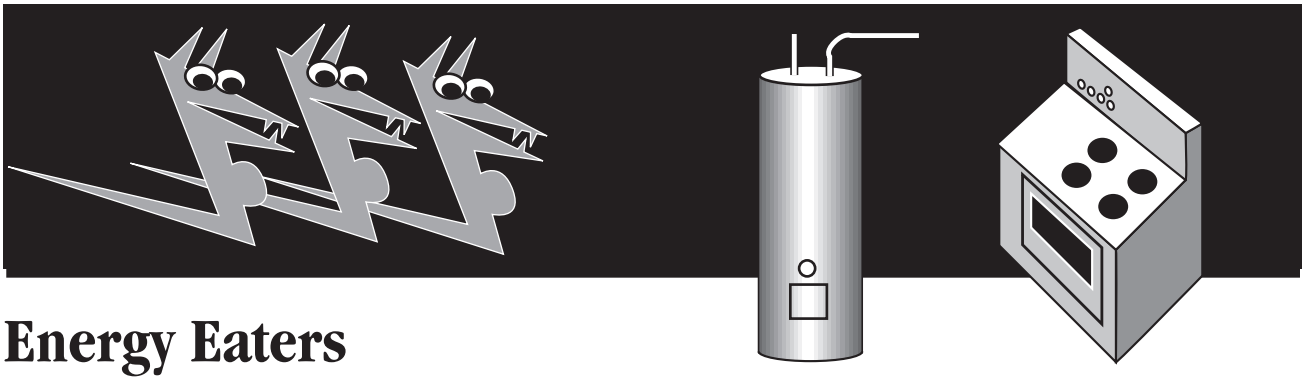
SO: It costs 30 cents to run a 2000 watt clothes dryer for 3 hours.



You And Your Electric Bill

Answers:

1.	A 1000 watt light bulb for 2 hours	$.10
2.	A 100 watt light bulb for 24 hours	$.12
3.	A 50 watt stereo for 10 hours	$.025
4.	A 1000 watt refrigerator for 24 hours	$1.20
5.	A 2000 watt air conditioner for 24 hours	$2.40



Energy Eaters

Find some "energy eaters" in your home. How much electricity do they use? (it should be written on them somewhere)

List the "energy eater" and how much electricity it uses.

1. _____

2. _____

3. _____

4. _____

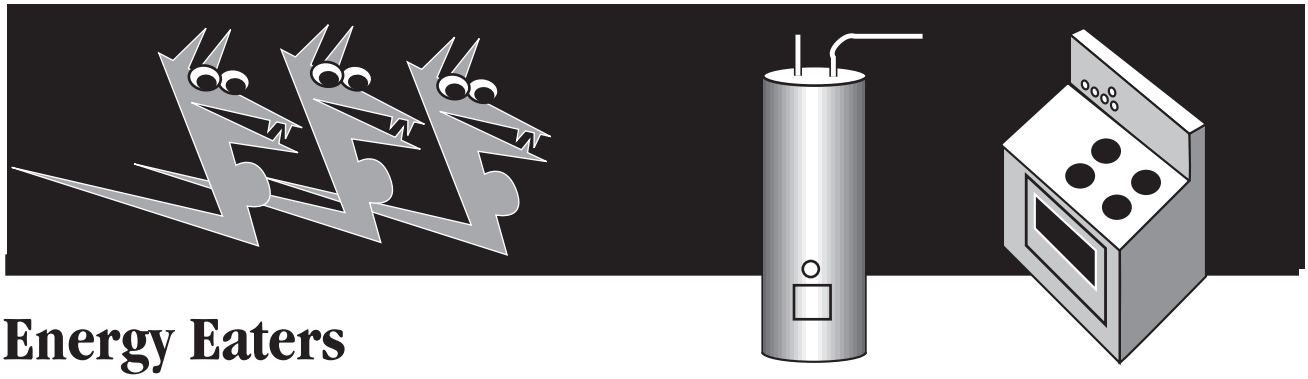
List four ways you can save electricity and save your parents some money and help conserve our Natural Resources.

1. _____

2. _____

3. _____

4. _____



Energy Eaters

Answers:

Some appliances in your home use a lot of electricity. We call these "energy eaters." They include: freezers, refrigerators, dishwashers, clothes dryers, heaters, air conditioners and hot water heaters.

Find some "energy eaters" in your home. How much electricity do they use? (it should be written on them somewhere)

1.	**range and oven**	**12,000 watts**
2.	**clothes dryer**	**5,000 watts**
3.	**air conditioner**	**2,300 watts**
4.	**Water heater**	**2,475 watts**

List four ways you can save electricity and save your parents some money plus help conserve our natural resources.

1. **turn off lights and other appliances when done using them**
2. **turn thermostat down to 55 degrees at night and 68 degrees during the day**
3. **use air cooler in only one room**
4. **use alternatives to your oven such as, toaster or microwave**

Energy Riddles

We have included these riddles to help you become familiar with some hydropower vocabulary words.

I spin like a top, but I'm made of steel. Water makes me turn, like a giant pinwheel.

What am I?_____

We built the dam you are going to see. We run it night and day to make electricity.

Who are we?_____

I am a kind of energy sent through the lines. I am moving electrons to run things of all kinds.

What am I_____**?**

I spin around and around for you see, my magnets move past coils of wire to produce electricity.

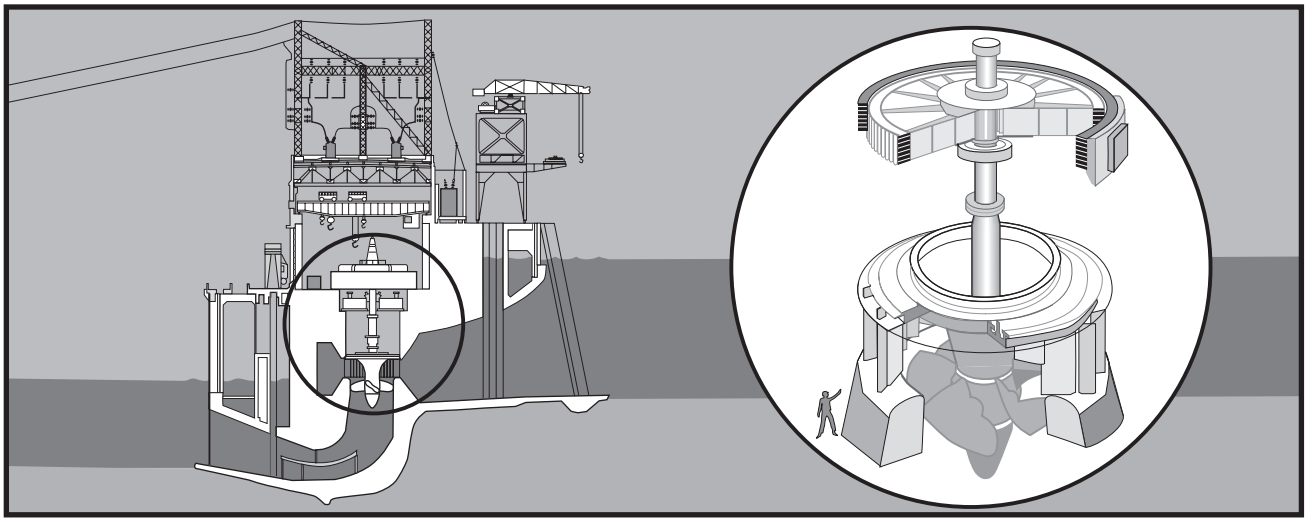
What am I_____**?**

I'm part of a dam, and see me you will! I can hold water back, I can let water spill!

What am I_____**?**

I'm the part of the dam, where power comes from. You can come inside me and hear my machines hum! _____

What am I?



Energy Riddles

Answers:

I spin like a top, but I'm made of steel. Water makes me turn, like a giant pinwheel.

What am I? **a turbine**

We built the dam you are going to see. We run it night and day to make electricity.

Who are we? **U.S. Army corps of Engineers**

I am a kind of energy sent through the lines. I am moving electrons to run things of all kinds.

What am I? **electricity**

I spin around and around for you see, my magnets move past coils of wire to produce electricity.

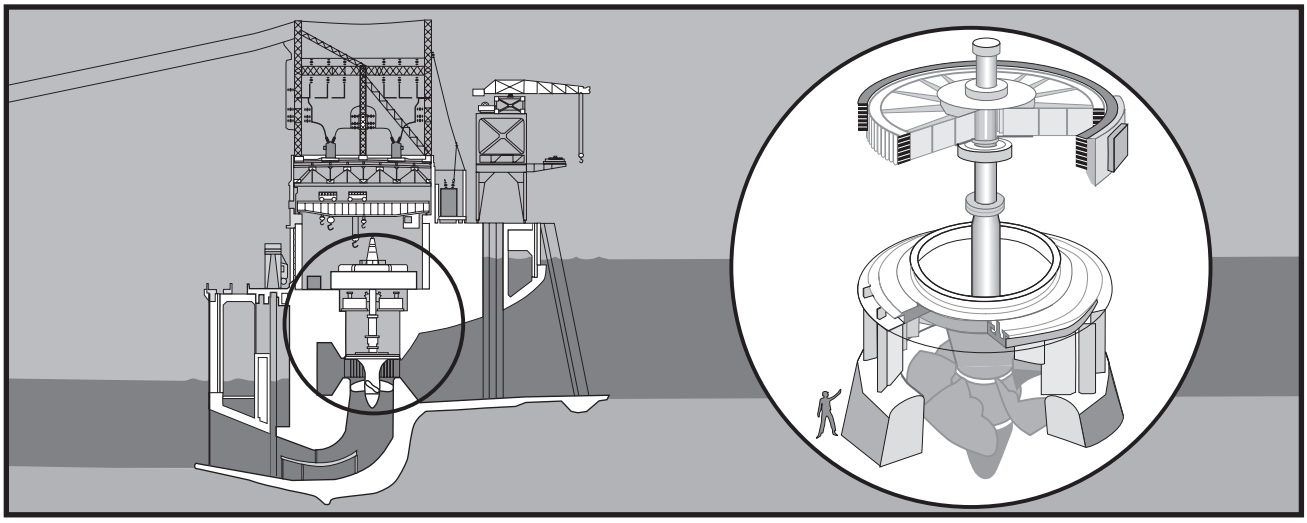
What am I? **a generator**

I'm part of a dam, and see me you will! I can hold water back, I can let water spill!

What am I? **the spillway**

I'm the part of the dam, where power comes from. You can come inside me and hear my machines hum!

What am I? **a powerhouse**



Hydropower During Your Visit

The activities in this section are intended for use during your visit to Bonneville Dam. They will give your students a chance to learn about electricity and the production of electricity at their own pace.

Activities

On Your Way To Bonneville Dam:

Ask your students to look for transmission lines, power poles and other things which have something to do with electricity.

What To Do At Bonneville Dam:

There are two powerhouses at Bonneville Dam. The first powerhouse is accessible from Oregon, the second powerhouse from Washington. The second powerhouse provides better access to the generators. It is possible to make reservations for a guided tour at both powerhouses. (541)374-8820.

I Am A Copper Atom:

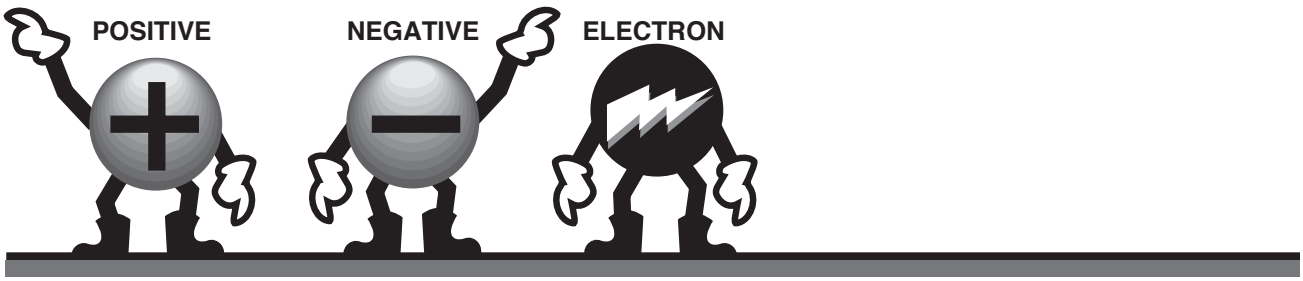
This activity has students model the production of electricity. It will require some pre-planning and some leadership from the teacher. It will be helpful to do this activity prior to the following activities.

Electricity: From The Powerhouse To Your House (Powerhouse One Version)

Every student, or group of students, will need a copy of this "self-guide" to the first powerhouse.

Electricity: From The Powerhouse To Your House (Powerhouse Two Version)

Every student, or group of students, will need a copy of this "self-guide" to the second powerhouse.



I Am A Copper Atom

"**I Am A Copper Atom**" is a game in which you pretend you are generating electricity. It will require your teachers direction and explanation of what an atom and its parts are. Ask the rangers to let you know where a diagram of a generator is. The diagram can be a reference for understanding this activity.

Ask volunteers to make two circles, one inside the other. The outside group of volunteers pretend that they are electrons in the stator. The stator is coils of copper wire. The inside group of volunteers pretend that they are the rotor. The rotor consists of magnets which spin inside the stator.

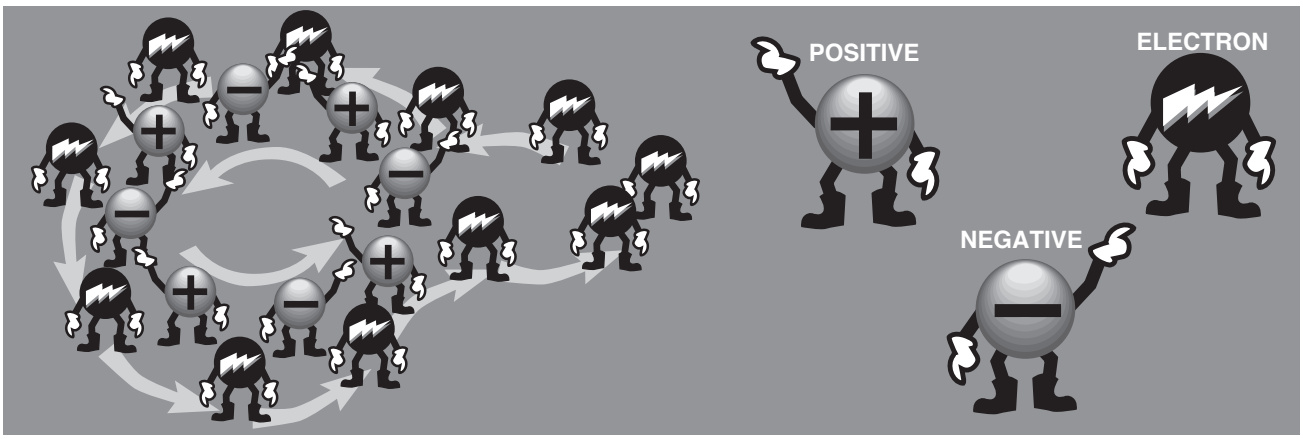
Water coming through the dam spins the turbine, which spins the shaft, that is connected to the rotor. The rotor spins around inside the stator. As the magnets of the rotor spin inside the stator, the electrons in the coils of copper wire become excited.

Those the inside group are magnets and those in the outside group are electrons in the atoms of the copper coils.

The inside group walks in a circle holding hands. Every other set of hands should be held up, this represents the positive pole. As the inside group walks around and the set of upheld hands comes by, each member of the outside group becomes excited and bumps the person next to them and stands in their place. When the teacher says "negative pole", the inside group will hold up the opposite set of hands, causing the outside group to bump their neighbor in the opposite direction.

After the current leaves the generators, it travels through transmission lines to get to our homes. You can add a transmission line. Two lines of students, with one on the end connecting the two lines, can be attached to the outside circle.

This game demonstrates alternating current (A. C.) electricity.



Electricity:
From The Powerhouse To Your House!
(*First* Powerhouse Version)

This is a "do it yourself" tour of the first powerhouse at Bonneville Dam. You will discover how electricity is made and how it is sent from the powerhouse to your house.

To get to the powerhouse, contact Bonneville Rangers to schedule a program, 541-3748820.

Stop #1 Look At The Large, Steel Turbine Blade.

This is just one of five turbine blades on each turbine! Imagine how much water it must take to turn each turbine. Every second, each turbine blade is struck by enough water to fill an average three bedroom house!

When the turbine spins, it causes the generator to spin. Go to the model of the generator next.

Stop #2 Spin The Generator!

What are the green coils?_____

What are the red and blue pieces of metal?_____

If you answered coils of wire, and magnets, you are really thinking! The real generators work just the opposite way with the magnets spinning around inside the coils of wire.

When the magnets spin inside the coils of copper wire, they cause the electrons (which are small parts of the atoms) in the coils of wire to get exited and move. The electron is pulled to a different atom and another electron jumps in to take its place. Pretty soon all the electrons are jumping from one atom to the next in a sort of "flow". This flow is electricity. You cannot see the electrons move but you can tell it is happening if you look at the gauge.

How many volts did you make?_____

Stop #3 Go To The Diagram Of The Powerhouse.

Look at the wires on top of the powerhouse in the drawing. After the electricity is generated, it is sent to wherever it is needed (maybe your house).

Most of the electricity used in the Northwest is generated at dams.

Where do dams get their "fuel" to keep them going? Go to the exhibit labeled "THE WATER CYCLE AND ELECTRICITY" and find out.

Stop #4 Hydropower And The Water Cycle.

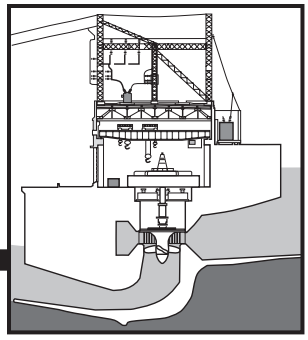
Stand behind the rotating discs and while spinning them, look at the display. You will see how water gets "recycled" by nature.

Stop #5 Have One More Look At The Generators.

If a light bulb uses 100 watts, can you figure out how many light bulbs you could light with all the generators in the powerhouse? Together, the generators in this powerhouse can generate 518,000,000 watts.

Stop #6 The Last Stop Of This Tour Is Your House.

That is where some of this electricity may go. We make a lot of electricity at Bonneville Dam. That does not mean you can waste it. You can see how we had to block the river to build this powerhouse which is not good for some fish and wildlife. The more electricity we use the more powerhouses we may have to build. You know that your parents must pay money for the electricity you and your family uses. Those are two good reasons to CONSERVE ELECTRICITY!



Electricity:
From The Powerhouse To Your House!
(*Second* Powerhouse Version)

This is a "do it yourself" tour of the second powerhouse at Bonneville Lock and Dam. You will discover how electricity is made and how it is sent from the powerhouse to your house!

Start in the glass-walled building (The Visitor Orientation Building). Go up the escalator and cross the skywalk toward the Powerhouse.

Stop #1 On The Skywalk

In the middle of the skywalk, stop and look at the difference between the levels of the water upstream and downstream. (The water is about 60 feet higher on the upstream side.)

Stop #2 Go To The Display Gallery

Look at the generators. How many are there? _____

How many are turned on? _____ (look for the ones with lights lit up on top)

These generators make enough electricity to meet the electrical needs of about 250,000 homes for one year! Next learn how they work.

Stop #3 Go To The Generator Model

Turn the generator with your finger.

What are the green coils?_____

What are the red and blue pieces of metal? _____

If you answered coils of wire, and magnets, you are really thinking! The real generators work just the opposite way with the magnets spinning around inside the coils of wire.

When the magnets spin inside the coils of copper wire, they cause the electrons (which are small parts of the atoms) in the coils of wire to get exited and move. The electron is pulled to a different atom and another electron bumps in to take its place. Soon all the electrons are jumping from one atom to the next in a sort of "flow". This flow is electricity. You cannot see the electrons move but you can tell it is happening if you look at the gauge.

How many volts did you make? _____

Stop #4 Go to the Transformer Model.

Electricity is transformed before it leaves here. Transformers increase the voltage to give the electricity a "push" so it can travel to your house. A transformer is like the nozzle on your garden hose at home. What happens to the water in the hose as it passes through the nozzle? It comes out with more force. This is what a transformer does to electricity.

Stop #5 Look at the Water Cycle Display

Water is recycled by nature. This makes it a renewable resource.

Stop #6 Go to the "power Planning" Display

The Bonneville Power Administration (BPA) is a government marketing agency set up to sell the electricity produced on the Columbia River and elsewhere. Push the button and the transmission lines light up. The BPA builds these transmission lines to get the electricity to the buyers.

Stop #7 The Last Stop of this Tour is Your House

That is where some of this electricity may go. We make a lot of electricity at Bonneville Dam. That does not mean you can waste it. You can see how we have had to block the river to build this powerhouse which is not good for fish and wildlife. The more electricity we use the more powerhouses we will have to build. The more electricity you use the more your parents must pay their electric bills. Those are two good reasons to CONSERVE ELECTRICITY:

You can continue on down through the powerhouse by following the arrows painted on the floor beginning through the double doors on the other side of the gallery.

Hydropower
After Your Visit

In this section, you will find activities to be completed after your visit to Bonneville Dam. These activities are intended to reinforce vocabulary and important concepts learned earlier.

Activities

Fill In The Energy Blanks:

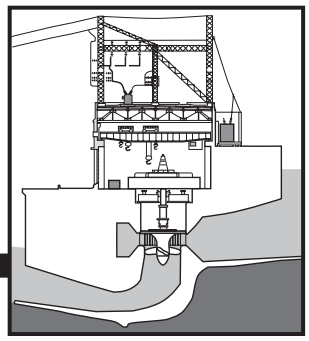
This activity works well either for individuals, small groups or large groups. If done individually, every student will need a copy.

The Water Cycle And Energy Relay Race:

If you have some active students, this game may be a good alternative way of teaching the important concepts of a renewable resource and transfer of energy.

Different Ways To Generate Electricity:

You may want your students to understand that waterpower is not the only resource used to power generators that make electricity. To facilitate this understanding you could ask students to write a small paper on forms of energy used to run generators that make electricity and the trade-offs associated with each.



Fill In The Energy Blanks

Fill in the energy blanks. Use each word from the list only once.

Word List:

salmon
Bonneville Power Administration
powerhouse
magnets
electricity
conserve
U.S. Army Corps of Engineers
generator
turbines
kilowatt hours
hydropower

_____is a form of energy. When it is produced at a dam, it is often called _____, which means water power.

When electricity is generated at a dam, water must fall through the dam and strike the _____causing these pinwheel-like machines to turn. When these large machines turn, they cause a part of the_____to spin and generate electricity.

Generators make electricity by spinning_____past coils of copper wire. After electricity is generated in the_____(which is the building at the dam where electricity is generated) it is sent through power lines to your house.

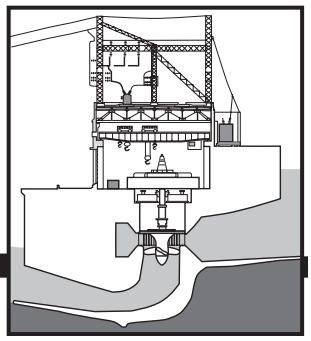
The dam is operated by the_____which is a part of the federal government that builds dams, navigation locks, harbors, and other water-related structures.

When electricity leaves the dam, it becomes the responsibility of another part of the government called the_____This agency may sell electricity to your power company.

Your electric power company charges you according to how many_____you use. A kilowatt is 1,000 watts and if you use that much electricity for an hour it is called a kilowatt hour.

Generating electricity at a dam is clean and does not use coal or oil, which are in limited supply. One of the major disadvantages to generating electricity at Bonneville Dam is that it makes life difficult for_____which must get past the dam twice during their lives.

Remember to _____, or use less electricity whenever you can!



Fill In The Energy Blanks

Answers In Order:

electricity

hydropower

turbines

generator

magnets

powerhouse

U.S. Army Corps of Engineers

Bonneville Power Administration kilowatt hours

salmon

conserve

Electricity is a form of energy. When it is produced at a dam, it is often called **hydropower**, which means water power.

When electricity is generated at a dam, water must fall through the dam and strike the **turbines** causing these pinwheel-like machines to turn. When these large machines turn, they cause a part of the **generator** to spin and generate electricity.

Generators make electricity by spinning **magnets** past coils of copper wire. After electricity is generated in the **powerhouse** (which is the building at the dam where electricity is generated) it is sent through power lines to your house.

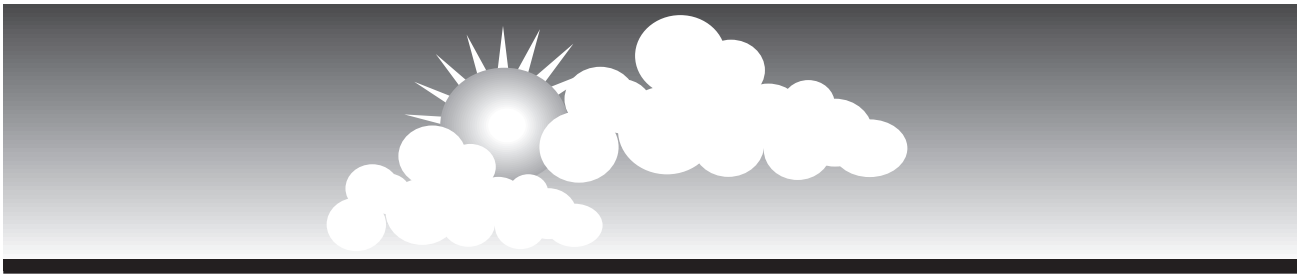
The dam is operated by the **U.S. Army Corps of Engineers** which is a part of the federal government that builds dams, navigation locks, harbors, and other water-related structures.

When electricity leaves the dam, it becomes the responsibility of another part of the government called the **Bonneville Power Administration**. This agency may sell electricity to your power company.

Your electric power company charges you according to how many **kilowatt hours** you use. A kilowatt is 1,000 watts and if you use that much electricity for an hour it is called a kilowatt hour.

Generating electricity at a dam is clean and does not use coal or oil, which are in limited supply. One of the major disadvantages to generating electricity at Bonneville Dam is that it makes life difficult for **salmon** which must get past the dam twice during their lives.

Remember to **conserve** or use less electricity whenever you can!



The Water Cycle And Energy Relay Race

Materials:

This activity consists of three phases. A discussion phase; an active phase and another discussion phase. Materials needed are: identical shallow bowls or spoons or anything in which it is difficult to carry water!

Briefly discuss the water cycle and it's importance to hydroelectric production. Good questions include: Where does the energy come from which powers the water cycle? (sun, gravity) What makes water evaporate? (the sun) Where does the water go? (it eventually condenses and rains) How does it get to the river? (run-off from the land) What makes the water flow in the river and through the powerhouse? (gravity)

By discussing the above questions, you have come to understand that the water moves through the powerhouse because of gravity. Everybody knows that water flows downhill but not everyone realizes that hydroelectricity is made possible by gravity. As the water falls through a powerhouse, the gravity energy is changed to mechanical energy. This takes place when water strikes the turbine blades causing rotation of the turbines. The turning turbines are attached to generators. Therefore, as the turbine spins, so does the generator. The mechanical energy of the turbine is changed to electrical energy as the magnets of the rotor are spun past the coils of copper wire in the stator. The transformer increases the voltage so electricity may be sent more efficiently through transmission lines. The transmission lines usually take it to another transformer which decreases voltage again and it is then sent to homes and businesses for people to use. This sequence should be quickly explained to the group before the next phase of this activity.

For the active phase, divide the group into teams of seven people each. Any "leftover" people can help decide the winner. The seven people in each team will represent **1.** river; **2.** turbine; **3.** a generator; **4.** a transformer; **5.** a transmission line; **6.** a transformer in their neighborhood; **7.** a light bulb. Each team should be arranged as shown just before the race begins.

■ ■ ■ ■ ■ ■ ■

7 5 3 1 2 4 6

Every player should have an identical container in which to carry water. The best containers are spoons or anything which is likely to spill. Get the teams into the starting positions and fill the first player's (the person in each team that represents the river) container as full as possible. Water will symbolize energy. In this relay race, the winner will be the team with the most water at the end of the race! That team has "saved the most energy!"

To start, the first player must race to the second player and "transfer" the energy (water) to that person. The second player races to the third and so on until the water (if there is any left) is "transferred" to the last player, the light bulb.

Next, congratulate the team who has saved the most energy (the team with the most water). Dis-

cuss how energy is lost in the form of heat every time it is transferred. This game illustrates the second law of thermodynamics which, simply stated, says that whenever energy is transferred, some is lost in the form of heat. Heat, of course, radiates away from the earth and approximately equals what comes in from the sun. Discuss the importance of conserving energy.