Colorado Reader

AG IN THE CLASSROOM—HELPING THE NEXT GENERATION UNDERSTAND THEIR CONNECTION TO AGRICULTURE

COLORADO FOUNDATION FOR AGRICULTURE ~ WWW.GROWINGYOURFUTURE.COM

What is Hydro power?

Hydro means water so hydropower means water power. People have been using hydropower for over 2,000 years! In ancient Egypt, water flowing in streams was used to turn big stone wheels to grind grain into flour. Today, hydropower is used to generate electricity.

To understand how water can have energy, it helps to understand energy first. Scientists define energy as "the ability to do work." Energy makes things happen. For example:

- The sun gives out light and heat energy. Plants use this energy to grow.
- You use energy when you walk or run. You get your energy from the food you eat.
- Cars use energy to drive down the road. Cars get their energy from gasoline or other types of fuel.

From these examples, you can see that energy makes things happen. More important, energy makes **everything** happen!

There are two types of energy: **kinetic energy** and **potential energy**. Kinetic energy is the energy of motion or moving energy. Potential energy is stored energy.

When you throw a ball, the ball keeps moving even after it has left your hand. The moving ball has kinetic energy. The heavier a thing is and the faster it moves the more kinetic energy it has. Can you think of some examples of other objects that have kinetic energy? Here are some ideas to get you started:

A spinning top
A gust of wind
A car traveling down the road

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Potential energy, or stored energy, can also be described as the energy of position. Things with potential energy are waiting to convert their energy to another type of energy. When potential energy is released, it does work. Can you think of some examples of objects that have potential energy? Here are some ideas to get you started:

A coiled spring
Oil in a barrel
Water in a lake

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If you pushed both balls off the table, which would have more **kinetic energy**? The tennis ball or the bowling ball?

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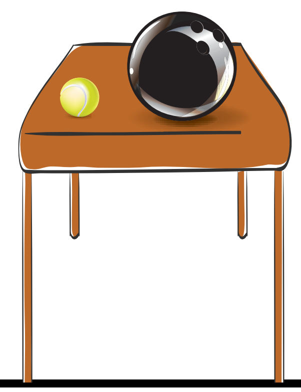

If you pushed the bowling balls off each table, which would have more **potential energy**? The bowling ball on the tall table or the bowling ball on the short table?

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Understanding Energy

Energy can also be described in other ways. For example, energy can be described as thermal (heat) energy, light energy, sound energy, chemical energy, electrical energy or gravitational energy. However, no matter what type of energy it is, all energy always follows two basic rules.

1. Energy can be transformed from one kind of energy to another.
2. Energy cannot be created AND it cannot be destroyed.

Energy has always existed in one form or another. Think about these ways energy changes from one form to another:

- Energy stored in flashlight batteries changes form when the flashlight is turned on: the potential energy in the batteries becomes electrical energy and the electrical energy becomes light energy.
- Food is stored energy. Your body uses chemical energy to break food down so your body can use it. When your body uses this energy to do work like walking or running, it becomes kinetic energy.
- The sun radiates heat and light. Solar energy trapped inside a closed car changes into heat or thermal energy.

Can you describe another way energy changes from one form to another?

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We all know about gravity. Gravity is the force that makes things fall to earth. Gravity or gravitational energy is a type of potential energy. The higher and heavier an object is, the greater the gravitational energy it contains. This type of energy plays an important role in hydropower when water is used to make electricity. Hydropower can be defined as "the process of changing the kinetic energy of flowing water into electrical power that we use."

On the lines below the pictures identify the different ways energy can be described in each picture.

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What are Watts?

A watt is a way to measure the amount of work electrical energy can do. Watts are named after Scottish inventor James Watt who lived from 1736 to 1891.

Kilo means 1,000 so a kilowatt is one thousand watts. Mega means 1,000,000 so a megawatt is one million watts.

Kilo and mega are both prefixes used in the International System of Units and in the metric system. These prefixes are used frequently in describing the storage capability of computers and in many types of science and engineering calculations. Here are some other commonly used prefixes:

giga 1,000,000,000 or 10^9
tetra 1,000,000,000,000 or 10^{12}
peta 1,000,000,000,000,000 or 10^{15}
deci .1 or 10^{-1}
milli .0001 or 10^{-3}

What can one watt do? Not a lot! If you pick up a can of corn and take a second to move the can one foot, you would use a little more energy than the equivalent of one watt of power. A watt is very small! That is why we often use prefixes like "kilo" and "mega" when describing electric power generation.

The power output of light bulbs is described in watts. Most electric appliances have a tag that tells how many watts of power they use when they are on.

The picture of this waterwheel was taken in a very early hydroelectric power plant located high in the mountains near Creede, Colorado. It was built in 1924 by a man named A.E. Humphreys.

The faster the water in the blue channel ran, the faster both wheels spun. The amount of electricity generated increased as the wheels spun faster.

Mr. Humphreys was not the first person to generate electricity with a water wheel. The first hydroelectric power plant in the United States was built near Appleton, Wisconsin on the Fox River in 1882. This hydroelectric power was used to operate a paper mill.

For many years the electricity generated by hydroelectric power plants had to be used near the location of the power plants. Over time, people learned how to build power lines to transport power to distant locations where it could be used in places far from the water.

Today, hydroelectric power plants are often located far away from the people who use the electricity generated by the power plant. Transmission lines carry power from the power plants to distant areas using a series of power substations and power lines. (See page 8.)

Using Energy Stored in Water

Did you list flowing water as an object with kinetic energy? You could have! Flowing water has the potential to do work.

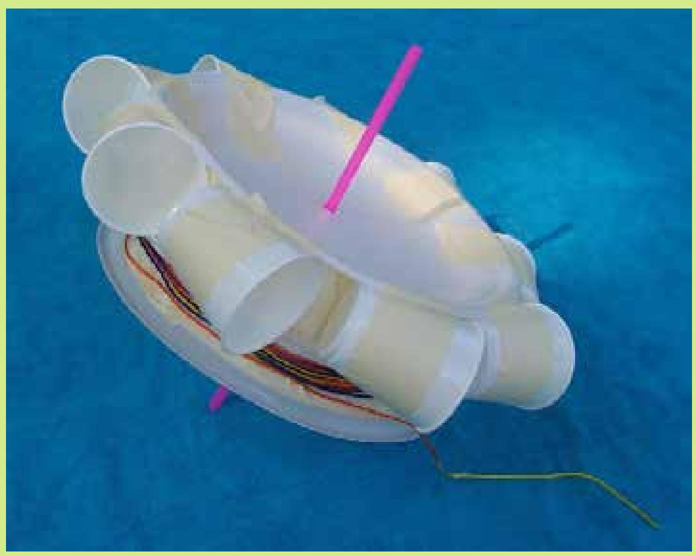
Picture a wheel with cups on each spoke like the one shown on the left side of the photograph of A.E. Humphrey's waterwheel. Now, picture a stream of water flowing through the blue box under that wheel.

Can you see how the moving water would cause the wheel to spin? The force of the water catches in each cup and moves it forward. As the cups filled with water reach the top of the wheel, the water splashes out on the cups below, providing additional energy causing the wheel to spin.

Can you figure out which direction this wheel would spin?
1 Determine which way the water is flowing.
2. Which way would the paddles be pushed by the water?
3. Draw a circle with an arrow showing the direction of the paddles. This would be the same direction the wheel would turn.

The shaft attached at the center of this spinning wheel causes the larger wheel on the right side of the picture to turn too. As this larger wheel turns, the belt wrapped around it turns a shaft connected to the inside of a small electric generator. This generator produced electricity.

Make your own water wheel. You will need paper cups, paper plates, long pencil or straw and tape. Study the picture below and make your own water wheel. You might even be able to design a better wheel. Experiment and see!



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TRI-STATE Generation and Transmission Association, Inc.
A Touchstone Energy Cooperative

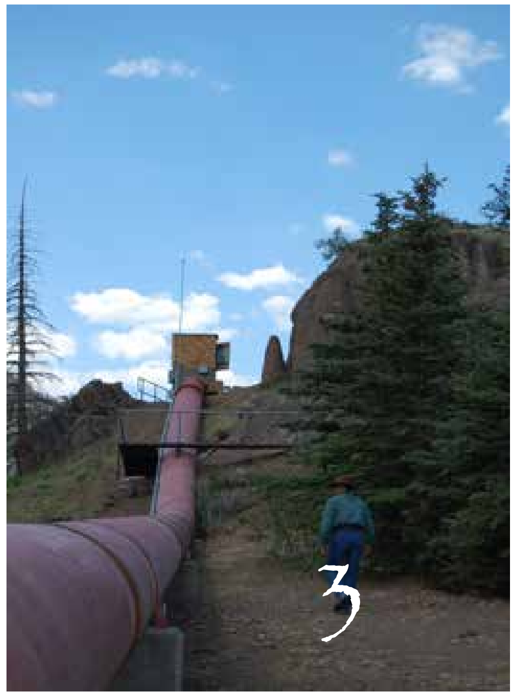
How Hydroelectric Power Plant Works

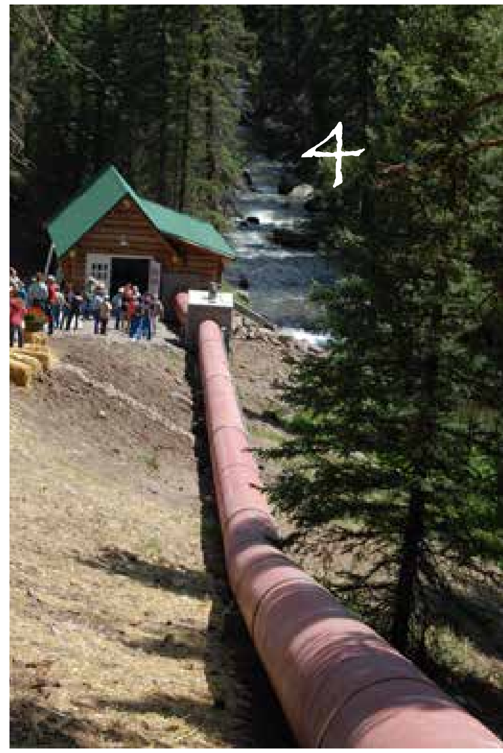
A concrete dam causes water to pool up in a reservoir. This water has potential energy waiting to be used. The reservoir can be used for fishing, swimming and boating.

Next to the dam, a spillway allows water to return to the stream. The spillway is just a little lower than the dam so water can flow over it. Water flows out the spillway into the stream below. Fish and other animals living in the steam rely on water from the spillway to sustain their habitat. Can you see the tree branch ready to go over the spillway? That branch was cut by a beaver!

Just above the spillway in the center of the picture, you can see a pipe leading into and out of a building. Inside that building are the controls to monitor the amount of water that will be used to generate electricity.

Water flows into the pipe on the left side, goes through the building and then out into the pipe on the right side. The enclosed pipe that the water travels through as it makes its way from the upper control building to the power plant is called a penstock. Penstocks are defined as a channel or pipe that carries water to a water wheel or turbine.





Photographs 3 and 4 were taken from the same spot. In photograph 3, the photographer is looking up the hill at the control building and in photograph 4 the photographer is looking down the hill at the power plant. From these photographs, you can see this pipe goes down a very steep hill. Based upon what you just learned about energy, can you explain why?

If your answer included "gravity" or "gravitational energy," you are correct! The potential energy in the water held in the dam becomes kinetic energy when it flows into the pipe and goes down the hill. The water in a pipe on a steep hill has more energy because gravity causes it to flow inside the steep pipe faster than it would if the pipe were on level ground. As you learned earlier, things that move faster have more kinetic energy. In this case, the water has immense power due to the great height at which it is kept in the dam.

The larger the difference between the height where the water enters the penstock and where it flows out, the more power can be generated. This difference in height of the water is called hydraulic head.

The building the penstock arrives at looks more like a cabin than a power plant from the outside. But once you go inside, you can see that this is not the sort of cabin you would want to spend much time in. It's very loud inside!

Normally, we think of power plants as big buildings; but small power plants like this one are becoming more and more common as people begin to develop local natural resources to meet their power needs. This 310 kilowatt power plant produces enough electricity for about 300 homes.

You can see where the penstock comes into the power plant on the right side of photograph 5. Water flowing inside the penstock turns the turbines. The turbines are inside the blue piece of machinery toward the left side of this photograph.

In photograph 6, you can see the shaft coming out of the center of the turbines. This shaft is connected to the generator. As the turbines spin from the force of the water, they turn this shaft which is connected to a magnet inside the generator. The magnet is surrounded by a coil of copper wire. The generator is shown on the left side in photograph 7. Behind the generator are gray control panels that monitor the water flow, the operation of the turbines and the operation of the generator.

As the magnet inside the generator spins, it creates an electric current within the copper wire coil. The energy changes form. The kinetic energy of the water becomes mechanical energy inside the turbine. The spinning mechanical energy of the turbine changes into electrical energy in the generator.

The electric current created in the generator travels through a control box and into power lines as electricity. The water from the turbines is discharged out from the bottom of the power plant (photograph 8) and back into the stream channel. It never flows inside the generator. The water and the electricity the generator creates are never in contact with each other.

Below the power plant, in the bottom center of photograph 9, you can see where the water returns to the stream channel. This water, along with the water that flowed over the spillway, join together in the natural stream channel that existed before the reservoir and power plant were built. This stream provides habitat for animals and recreational opportunities for people as it always has.

In the west irrigation canals are being studies as potential source for developing more hydropower. These will be mini-hydropower plants.

Energy Resources

So far, we have talked about electricity generated from hydropower. There are other ways to generate electricity. Electricity can be generated from many different energy sources including coal, natural gas and uranium.

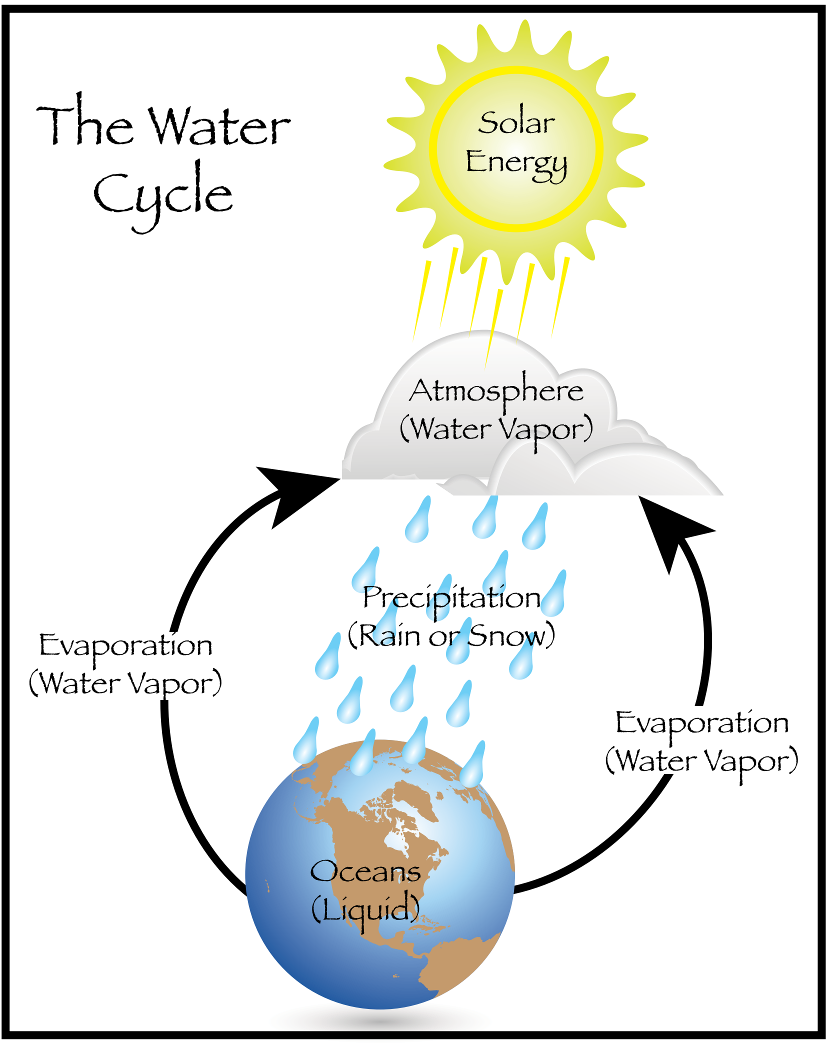
Energy sources are divided into two groups: non renewable energy sources and renewable energy sources. Renewable energy sources can be replenished or are not diminished by their use. Non renewable energy sources are consumed as they are used to produce electricity.

Coal and natural gas are two examples of non renewable energy sources. Oil, coal and natural gas are also called fossil fuels. They were formed from the remains of ancient plants and creatures.

As these plants and animals--mostly microscopic diatoms--died, they formed concentrated layers within the earth. Over millions and millions of years, heat from the Earth's core and pressure from overlying rocks and soil compressed these fossils until they became what we know today as coal, oil and natural gas.

Uranium is another non renewable fuel source. Uranium is used to generate electricity using a process called nuclear fission. Nuclear fission creates heat. This heat is used to create steam, which in turn, is used to spin turbines to create electricity.

Renewable energy sources include wind, water and sunlight. When these resources are used to make electricity, they are not used up.



Other renewable energy such as biomass generation, consume resources in energy production; but, the resources can be replaced. For example, when wood chips are burned to heat water for steam generation, the chips are consumed. But, new trees can be planted to replace those used in power generation.

Biomass generation is a broad term used for power production from many different types of plants, not just trees. In some areas, agricultural residues are used to generate power.

Water to create hydropower is considered a renewable energy source because the water is not used up. It remains for other uses after it has been used to generate power. Additionally, all water on earth is reused. The diagram on this page shows the Water Cycle.

The Water Cycle describes the continuous movement of water on Earth. Water changes states between liquid, vapor and ice. Some of these processes happen on the surface of the Earth, some occur deep within the Earth and some take place in the atmosphere. The transition between states can happen very quickly, or it can take millions of years.

The Biggest Hydroelectric Dam

Grand Coulee Dam in Washington is the biggest hydroelectric dam in the United States. Started in 1933 and completed in 1942, it is the largest concrete structure ever built.

It is 5,233 feet long and 550 feet high. It has four power plants with 33 generators. It makes enough electricity to power more than two million homes! It produces over 6,800 megawatts of electricity.

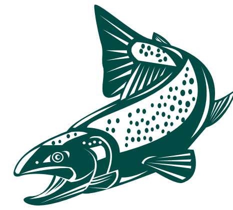
This dam was so important, it was commemorated in a postage stamp 50 years after the project was approved. In 1952, the United States Post Office issued this stamp showing the dam's spillway, a transmission tower and a farmer irrigating a field with water from the dam's reservoir.

The sixth largest dam in the U.S. is Hoover Dam located on the border between Arizona and Nevada. Once known as Boulder Dam, it dams the Colorado River. It was constructed between 1931 and 1936. Hoover Dam impounds Lake Mead, the largest reservoir in the U.S. by volume.

Word Search

Find and circle the following words in the letter block below:

boat	potential	electricity
power	energy	powerline
fish	renewable	generate
reservoir	gravity	spillway
hydro	swimming	irrigation
transmission	kinetic	turbine
penstock	water	



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l f p c d y r s f e f k w i e
z a x e g n p e l i e o r p l
t t i r n i w b s h n r r o e
v r e t l s a h s r i b f w c
w n a l n w t f r g l g w e t
e a w n e e o o a z r e e r r
y a t n s c t t c n e n n u i
y i e e f m i o y k w e i x c
x r c s r o i t p m o r b t i
t a o b n a x s e g p a r o t
s w i m m i n g s n j t u s y
y t i v a r g v h i i e t y w
r i o v r e s e r w o k u t t
h y d r o k w w l h p n t b g
u m k s s r a l g k c s a h a
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Power Up is a new game to see if you can choose the right type and amount of power to keep the lights on. Go to www.myamericanfarm.com to play.

How Important is Electricity to You?

How much do you depend upon electricity? For one day, try to write down each item you use that requires electricity to run. If an alarm clock wakes you in the morning, does that clock require electricity? Or, does your mom or dad wake you up? Do they rely on an alarm clock that plugs in or uses batteries?

Is it dark when you wake up? Do you turn a light on to get ready for school? Do you eat a breakfast that was stored in a refrigerator and/or cooked on a stove?

The water you use when you wash your face and brush your teeth required electricity to get into your home. If you live in a rural area, a pump may have moved the water from a well into your home. In the city, electricity is used by city water suppliers to deliver water down pipes and into your home. If you live in a city, electricity was used to run the city's water system that delivered the water to your home. Do you have to go through an intersection with a stop light on the way to school? Stop lights require electric power to operate. Fuel in cars and school buses is pumped using electric power.

These are just a few ideas to get you started. Try to track as many things as you can during the day. Don't forget battery-operated items that you plug in to charge.

Math Fun!

1. An acre-foot contains 325,851 gallons of water. A family of four uses about one acre-foot of water each year. How many gallons does each person in the family use?

2. The 310 kilowatt power plant shown on pages 4 and 5 produces enough electricity for about 300 to 350 homes. If this plant served exactly 320 homes, how much power would each house use?

3. Grand Coulée Dam has four power plants with a total of 33 generators. How much power does each generator produce if Grand Coulée produces 6,800 megawatts of electricity?

How much does it cost?

It is easy to calculate how much it costs to use any household appliance if you know the number of watts the appliance uses, the number of hours it is used each month and the cost of electricity. Here's how:

(Watts/1000) x hours of use = kWh (kilowatt hours of use)

kWh x the cost of electricity = total cost to run the appliance

Here is an example for an oven that uses 2,600 watts and is on for 1 1/2 hours where electricity costs 10 cents per kWh.

(2600 watts/1000) x 1.5 hours = 3.9 kWh of use

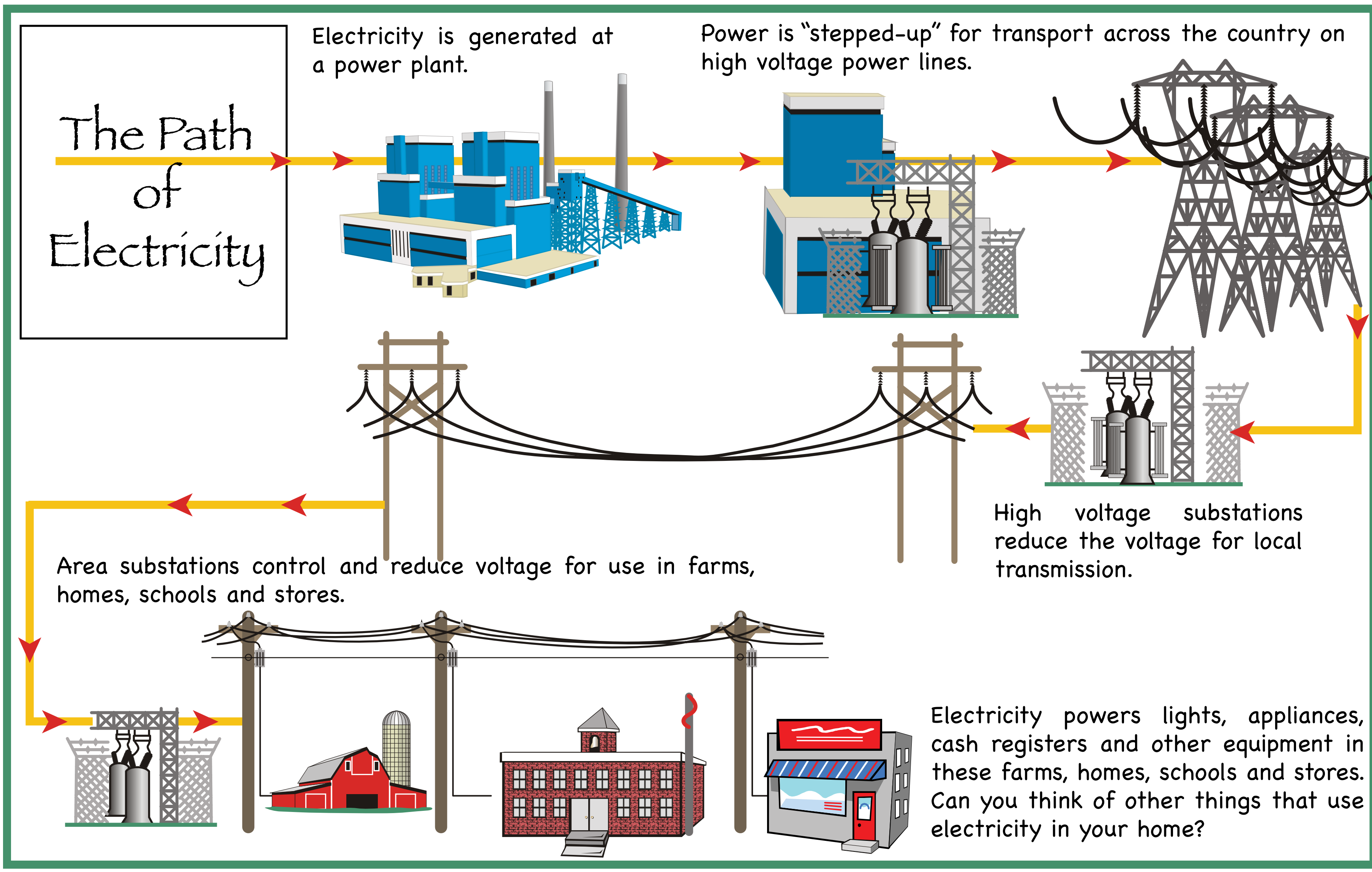
3.9 kWh x 10 cents = $0.39

Can you calculate how much it would cost to run these appliances if electricity costs 10 cents per kWh?

An 80-watt computer that used for 20 hours?

A 100-watt incandescent light bulb used for 150 hours in a month?

A 27-watt compact fluorescent lamp (equivalent to a 100-watt incandescent bulb in light output) used for 150 hours in a month?



Teacher's Guide

Resources:

Energy
The following YouTube videos have more information on energy:
Kinetic Energy
http://www.youtube.com/watch?v=ASZv3tIK56k
Force and Gravity
http://www.youtube.com/watch?v=LEs9J2IQIZY
Where does energy come from?
http://www.youtube.com/watch?v=aUa7I7D_myU
Using Energy
http://www.youtube.com/watch?v=z1xFrYkQwik

General Energy Resources
The Energy Story
http://www.energyquest.ca.gov/story/

EIA Energy Kids
http://www.eia.gov/kids/

Science Daily: Matter & Energy
http://www.sciencedaily.com/news/matter_energy/

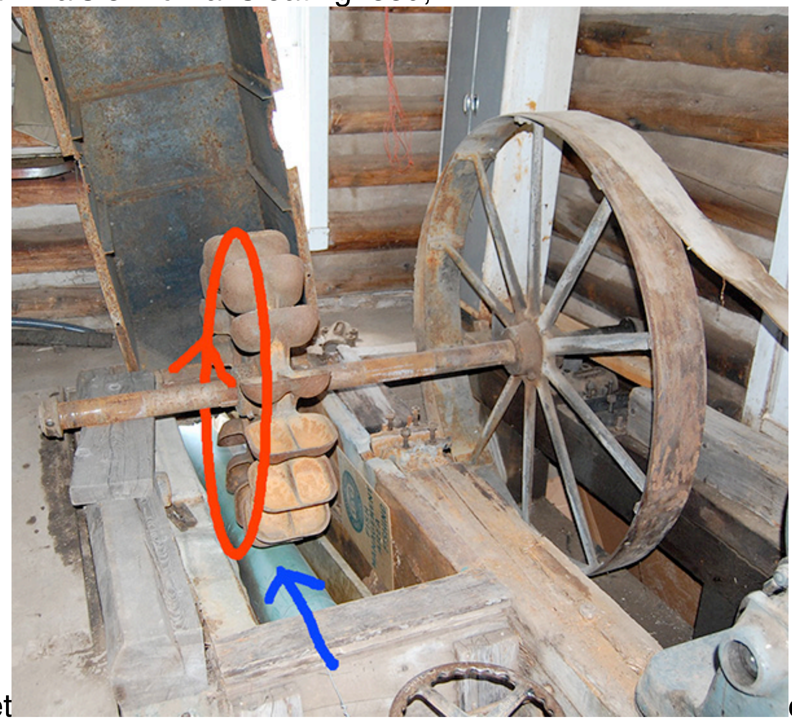
Other links
www.NEED.org
www.energyville.com
www.epa.gov/students/teachers.html
www.myenergygateway.org
www.myamericanfarm.com (interactive online learning games)
http://www.partselect.com/JustForFun/Electric-Math-Numbers-Behind-Appliances.aspx/
http://www.kidsenergyzone.com

Answers for the "Energy in Water" section:
Other examples of items with kinetic energy
falling rock, airplane flying through the air--ie. anything that is moving.

Other examples of items with potential energy
rock on a cliff, pencil on a table, any type of food--anything that isn't moving!

Ways energy changes from one form to another

Any type of vehicle using fuel, plants using sunlight, any kind of appliance in use, animals or humans eating food,



etc.

Sidebar Exercise on page 1
The bowling ball has more kinetic energy.
The bowling ball on the tall table has more kinetic energy.

Answers for Using Energy Stored in Water section:

Additional resources for “The Path of Power” section:

More about WAPA
http://ww2.wapa.gov/sites/western/Pages/default.aspx

More about the Bureau of Reclamation
http://www.usbr.gov

The 337 reservoirs the Bureau operate have the capacity to hold 245 million acre-feet of water. An acre-foot is equivalent to a one acre area covered with one foot of water. An acre-foot contains 325,851 gallons of water. A family of four typically uses about one acre-foot of water each year. The irrigation water provided by the Bureau produces 60 percent of our nation’s vegetables and 25 percent of the fruits and nuts grown in the United States.

The Bureau of Reclamation Builds dams. These reservoirs provide recreation opportunities like fishing and boating as well as water for irrigation. Dams are used to generate electricity at hydroelectric power plants. Electricity is sold to wholesale power distributors like WAPA, who in turn sell to regional power transmission companies. Tri-State Generation & Transmission Association is one example. Regional power transmission companies sell to local utilities. Businesses and families buy power from these local utilities to powers their communities and homes.

Tri-State Generation & Transmission Association
Tri-State serves a four-state region (and has a power plant in a fifth state, Arizona). Many of the students using the Reader will live in an area served by Tri-State: http://www.tristategt.org/AboutUs/locations.cfm

The illustration on the next page could be used to tell the story of hydroelectric power as it makes its way from mountain streams to families in the Western U.S. Allow students to use these illustrations as a starting point to explain the path of power from Bureau of Reclamation, WAPA and regional power transmission companies to the businesses and families who use electricity. Students could clip the illustrations apart and and paste them into their story as they like.

Additional resources on renewable and non renewable energy:
http://www.kids.esdb.bg/basic.html
http://education.nationalgeographic.com/education/encyclopedia/non-renewable-energy/?ar_a=1
http://www.greenmountain.com/resources/enviro-kids/renewable-energy-101

Supplemental Information:

New Ways to Use Water for Power
Because there is so much water on earth, scientists have been looking at other ways to use water to make electricity. In part, that's because conventional hydropower has been so successful.

Hydroelectric generation is clean and inexpensive. Electricity generated by hydroelectric power plants is some of the least expensive electricity available!

Scientists have looked at the places where water moves most as potential sources for power generation. This includes tidal flats at the edges of oceans. Tides are caused by the gravitational pull of the moon and sun and the rotation of the earth. In some areas, depending upon the shape of the shoreline, tides can vary up to 40 feet.

Where the tidal range between low and high tide is at least 10 feet, tidal power can be used to generate electricity. Tidal power has several benefits. An important one is that tides are very predictable, much more so than wind or solar power.

A two-way tidal generation system can generate power on both the incoming and outgoing tide.

There are some drawbacks, most important of which is that it is difficult to find an appropriate site to harness tidal power. So far, there are only two commercial-sized tidal power plants in the world--one in France and another in Canada. An experimental site is operating in Russia.

Other scientists are looking at the power of ocean waves. And yet others are evaluating the potential of using differences in ocean temperatures between warmer water at upper ocean levels and colder water near the ocean floor as a way to generate electricity So far, these potential ways of harnessing the power of water are still being researched.

http://www.cbsnews.com/8301-35040_162-57598262/powering-the-future-new-turbine-to-capture-energy-from-both-wind-and-waves-slated-for-testing/

http://www.cbsnews.com/8301-35040_162-57597091/powering-the-future-underwater-turbines-harness-river-power/

Word Search answers:

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L + P + + Y + S + E F + + I E
+ A + E G + P + L I E + R P L
T + I R N I + B S + N R + O E
+ R E T L S A H + + I + + W C
W N A L N W T + + G L G + E T
E A W N E E + O A + R E E R R
+ A T N S C T T C + E N N + I
Y + E E + M I O + K W E I + C
+ R + + R O I T P + O R B + I
T A O B N + + S E + P A R + T
S W I M M I N G S N + T U + Y
Y T I V A R G + + I I E T + +
R I O V R E S E R + O K + + +
H Y D R O + + + + + + N + + +
+ + + + + + + + + + + + + + +
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(Over,Down,Direction)

BOAT(4,10,W)

ELECTRICITY(15,1,S)

ENERGY(1,6,NE)

FISH(11,1,SW)

GENERATE(12,5,S)

GRAVITY(7,12,W)

HYDRO(1,14,E)

IRRIGATION(14,1,SW)

KINETIC(12,13,NW)

PENSTOCK(3,1,SE)

POTENTIAL(9,9,NW)

POWER(14,2,S)

POWERLINE(11,10,N)

RENEWABLE(2,9,NE)

RESERVOIR(9,13,W)

SPILLWAY(8,1,SW)

Page 8 Math Fun answers:

1. 325,851 / 4 = 81,462.75 gallons per person

2. 300 kilowatts * 1000 watts/kilowatt = 300,000 watts of power produced by the plant
   300,000 watts / 300 homes = 1,000 watts of power per house

3. 6,800 megawatts / 33 = 206.06 megawatts per generator

How much does it cost answers:

Computer that uses 80 watts, used for 20 hours?
(80 watts/1000) x 20 hours = 1.6 kWh of use
1.6 kWh x .10 cents = $.16

A 100-watt incandescent light bulb used for 150 hours in a month?
(100 watts/1000) x 150 = 15 kWh
15 kWh x .10 cents = $1.50

A 27-watt compact fluorescent lamp (equivalent to a 100-watt incandescent bulb in light output) used for 150 hours in a month?
(27 watts/1000) x 150 = 4.05 kWh
4.05 kWh x .10 cents = $.41

Hydropower

Evaluation ~ 2013

Colorado Reader ~ Agriculture in the Classroom

Please take a few minutes to evaluate your students' knowledge of this topic.
There is an area for additional comments.
Your comments help us improve future Colorado Reader issues. Thank you!

How many students used this reader? ______________

How many or what percentage of your students understand the difference between kinetic engergy and potential energy? ________________

How many or what percentage of your students understand that energy can be transfored from one kind of energy to another type of energy? ________________

How many or what percentage of your students understand that energy cannot be created or destroyed? ______

How many or what percentage of your students understand what a watt is? ________

How many of your students can describe how a water wheel works? _____________

How many or what percentage of your students can describe what hydropower is? _________

How many or what percentage of your students can name two non renewable energy sources? ___________

How many or what percentage of your students can name two renewable energy sources? ___________________

Additional Comments ______________________________

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SUBMIT THIS EVALUATION FOR A CHANCE TO WIN A $100 VISA CARD!

Please rate:	Good		Average		Poor
Student Activities Throughout Reader	5	4	3	2	1
Teacher's Guide	5	4	3	2	1
Reading Level	5	4	3	2	1

I would like to see mor activities like: ______________________________________

School ______________________________________ Grade Level ___________________

Subject Area (s) ______________________________________

Name ______________________________________ Phone ______________________________

Email ______________________________________

Fold and mail to Colorado Foundation for Agricuture, PO Box 10, Livermore, CO 80536