WATER: ENDLESS ENERGY SOURCE

Overview:

In this lesson students learn that energy comes in various forms and can be transformed many times. Students explore the transfer of energy in everyday objects and the potential power of water to create useable energy in their communities.

Objectives:

The student will:

- distinguish between potential and kinetic energy;
- identify and explain common energy transformations;
- identify the sequence of energy transformations involved in converting water (hydro) power to electrical power; and
- discriminate between the advantages and disadvantages of a hydropower project in their community.

Targeted Alaska Grade Level Expectations:

Science

[7-8] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating.

[7] SB2.1 The student demonstrates an understanding of how energy can be transformed, transferred, and conserved by explaining that energy (i.e. heat, light, chemical, electrical, mechanical) can change form.

[8] SB2.1 The student demonstrates an understanding of how energy can be transformed, transferred, and conserved by identifying the initial source and resulting change in forms of energy in common phenomena (e.g., sun to tree to wood to stove to cabin heat).

Vocabulary:

energy—the ability to do work; energy can exist in a variety of forms (potential, kinetic, thermal, radiant, electrical, gravitational, mechanical, chemical, nuclear) and can be transformed from one form to another

potential energy—the energy stored in an object as a result of its position or condition such as a raised weight, a coiled spring or a charged battery

kinetic energy—the energy possessed by a body as a result of motion; the amount of kinetic energy is dependent on mass and velocity of the object

mass—the measure of the amount of matter contained in a physical body

velocity—the rate at which an object moves in a specified direction

volume—the amount of space occupied by a three dimensional object or region of space

reservoir—a natural or artificial pond or lake used for water storage

penstock—a conduit, usually an enclosed pipe, used to control the flow of water to a turbine or power plant

renewable resource—a resource that is constantly replenished by natural systems at a rate that is equal to or greater than the rate at which it is used

turbine—a simple machine in which the kinetic energy of a moving fluid (water, steam or gas) is converted to rotary motion

generator—a machine that converts movement or mechanical energy into electrical energy; generators create an electric current by means of a coiled wire that rotates between two magnets

transformer—a device used to transfer electric energy from one circuit to another by means of inductively coupled, coiled wires (conductors)

Whole Picture:

Scientists define energy as the ability to do work or the rate of movement of molecules. Humans have learned how to change energy from one form to another and these energy transformations are an essential part of

our everyday lives. Although most of Alaska's energy needs are supplied by fossil fuels, 37 hydroelectric plants supplied 24% of Alaska's energy in 2009.

There are many paths that water can take as it cycles through Earth's hydrologic system: evaporating from lakes and oceans, forming clouds, falling back to Earth as precipitation, percolating through soil to groundwater, and flowing to the ocean. However, it is important to realize that the hydrological system is dynamic and nonlinear. Water is constantly cycling through all parts of it.

Hydroelectric plants harness the kinetic energy of water moving through Earth's hydrologic system. The sun's energy drives this system. Since water is neither consumed nor destroyed, hydroelectric plants are considered renewable energy sources.

Hydroelectric plants produce electricity by transferring energy from moving water to a turbine. Most hydropower projects involve a dam that stores water in a reservoir. The water intake is usually near the bottom of the dam. Gravity causes the water to accelerate as it flows from the reservoir, through the intake, through the penstock to the turbine. Water moving through the turbine then spins a metal shaft inside a generator creating a flow of electrons (electricity).

Hydroelectric projects involve many transformations of energy. Remember energy is never created or destroyed, so let's begin with radiant (electromagnetic) energy from the sun. This energy is transformed in Earth's hydrologic cycle and becomes potential energy in the reservoir. This potential energy is transformed to kinetic energy in the penstock (under the influence of gravity) and to mechanical energy in the turbine. It finally becomes electrical energy in the generator.

Most Alaska hydroelectric plants are located in Southcentral, Southeast and the Alaska Peninsula regions. Communities in other parts of the state are also interested in using moving water to generate electricity. Plants that harness water moving through major rivers and streams or even the ocean to generate power are called hydrokinetic power plants. Alaska's many rivers, streams and coastal areas provide great potential for developing this renewable energy resource. The communities of Ruby and Eagle currently use hydrokinetic energy.

Materials:

- Thick rubber bands (size 64 is recommended, one per student)
- Slinky™ or coil spring
- Set of Dominoes™
- Pinwheel
- Balloon
- Light stick
- Hand warmer
- Yo-Yo™
- Spinning top
- Colored pencils (two per student)
- TEACHER INFORMATION SHEET: "Energy Transformation in Everyday Objects"
- STUDENT INFORMATION SHEET: "Hydropower"
- STUDENT WORKSHEET: "Hydropower Word Search"
- STUDENT WORKSHEET: "Energy Transformation"
- STUDENT WORKSHEET: "Hydropower in My Community"

Activity Preparation:

Using an Internet search engine enter the search terms "fish wheel", then choose to view available videos. Locate one or more examples of a fish wheel in use, then bookmark for later use.

Activity Procedure:

1. Ask students how many of them walked to school. How many traveled by ATV, snow machine, car or truck? What do these forms of transportation have in common? They all use energy! (Our bodies use energy from food just as a vehicle uses energy derived from burning fossil fuel.)

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2. Ask students to suggest definitions for the word energy. Energy is the ability to do work. Explain that students will investigate how energy changes (transforms) from one form to another.
3. Introduce the terms potential and kinetic energy. Remind students that as energy moves throughout Earth's systems it changes form but is never destroyed. Ask students to think about a fish wheel in the river. This is a good example of how energy is moved through Earth's systems, changing form. Show a video of a fish wheel in motion (see Activity Preparation 1). Ask students to describe the energy turning the fish wheel (kinetic).
4. Divide students into up to eight groups (at least two students per group). Pass out STUDENT WORKSHEET: "Energy Transformation" and one rubber band to each student.
5. Clearly and carefully instruct students to hold the rubber band up to their lips. (The flat surface of the rubber band should be against their top lip.) Students should carefully stretch the rubber band, and then allow it to return to its normal size. They should repeat this a few times. Ask students what they observe. Do they notice any change in the temperature of the rubber band?
6. The heating and cooling students feel on their lips is evidence of an energy transfer. Read aloud and review the chart on STUDENT WORKSHEET: "Energy Transformation." Ask students to describe the energy transfer they observed in the rubber band. (See TEACHER INFORMATION SHEET: "Energy Transformations in Everyday Objects" for a description of this transfer.)
7. Pass out one toy per group: SlinkyTM, pinwheel, DominoesTM, top, Yo-YoTM, balloon, light stick, hand warmer. Instruct students to work with their group to determine what the toy does and what energy transfer it illustrates (using the terms from STUDENT WORKSHEET: "Energy Transformation.") Give them about 5-10 minutes to investigate and determine how to demonstrate and describe the energy transfer to the class. Walk amongst the groups to answer questions as needed.

NOTE: Students will create a short film about permafrost for the final project associated with this UNITE US unit. Each lesson leading to the final project contains ideas about what students might film as they compile clips. Students are not limited to the list and are encouraged to use their imagination and creativity when filming.

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8. Allow groups time to share and discuss their energy transformations. See TEACHER INFORMATION SHEET: "Energy Transformations in Everyday Objects" for more information.
9. Complete questions 1-6 on STUDENT WORKSHEET: "Energy Transformation" as a class. Students can fill out the worksheet as you go.
10. Distribute STUDENT INFORMATION SHEET: "Hydropower" and STUDENT WORKSHEET: "Hydropower in My Community." Read and complete together as a class or in small groups.

Extension Ideas:

1. Distribute STUDENT WORKSHEET: "Hydropower Word Search." Use as a review or for homework.

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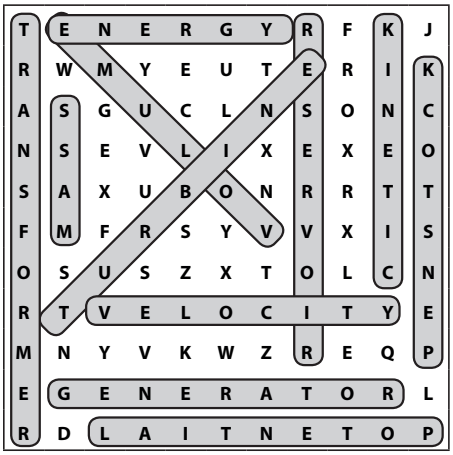
Answers:

STUDENT WORKSHEET: "Hydropower Word Search"



STUDENT WORKSHEET: "Energy Transformation"

	Event	Original Energy Form	Transformed Energy Form
1.	Lighting a match	Chemical	Radiant/Thermal
	Alarm clock going off	Electrical	Sound
	Using a hand warmer	Chemical	Thermal
	Boiling water on the stove	Electrical or Chemical	Thermal

2. D. Potential energy stored in the rubber band is transformed into kinetic mechanical energy used by the propeller.
3. A. chemical ➔ mechanical ➔ thermal
   The chemical energy of the student's food is transferred to mechanical energy in his/her muscles which becomes thermal energy (friction) as they rub their hands together.
4. ***Kinetic sound energy*** is transferred to ***electric energy*** (by the microphone) that is converted to ***radiant (electro-magnetic) energy*** and transmitted through the air. The reverse happens when the signal is received on the other end.
5. ***Potential electric energy*** in the atmosphere changes into ***kinetic energy (thermal, radiant and sound)***. A forest fire resulting from a lightning strike represents ***radiant, thermal and mechanical kinetic energy***. It can release the ***potential chemical energy*** contained in living things as it burns.
6. The fluorescent bulb is more efficient then the incandescent, but the LED light bulb is the most efficient. The LED bulb produces the least heat and requires the least energy input to create the same amount of light.

STUDENT WORKSHEET: "Hydropower in My Community"

1. D, C, E, A, B
2. Advantages and Disadvantages of Hydroelectric Plants

Advantage	Disadvantage
B	A
E	C
G	D
H	F
	I

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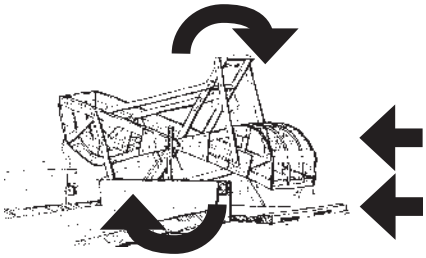
3. Answers will vary by location.
4. Arrows should go from right to left to indicate the flow of the river. Arrows should go clockwise to indicate the movement of the fish wheel. (See diagram at right.)
5. The kinetic energy of the moving river turns the fish wheel.
6. Answers will vary but could include information about proximity to a water source, availability of funding, community interest in renewable energy projects, fuel costs and energy needs.



ENERGY TRANSFORMATIONS IN EVERYDAY OBJECTS

The energy transfers described below are simplified so that most begin with the mechanical kinetic energy of the students' hands as they manipulate the object. Each of them can be traced back further to the chemical energy provided by food. Depending on the food source this energy may have gone through many transformations itself, but it ultimately originated as radiant energy emitted by the sun which came from nuclear energy (fusion)…

Remember that energy is never created or destroyed so this could be a never ending exercise!

The **rubber band** feels warm as it is stretched because the molecules move past each other, creating heat from friction. Mechanical kinetic energy from students' muscles ➔ thermal energy (friction) and potential mechanical energy (stored as tension in the stretched rubber band).

The **Slinky™** converts mechanical kinetic energy from students' muscles ➔ potential gravitational energy of the slinky in position to climb down ➔ mechanical kinetic energy as it climbs down (some energy may also be transferred to sound energy).

The **Dominoes™** convert mechanical kinetic energy from students' muscles ➔ potential energy of the dominos in position ➔ mechanical kinetic energy of the dominos as they fall (some energy may also be transferred to sound energy).

The **pinwheel** converts mechanical kinetic energy from students' muscles➔ kinetic energy of moving air ➔ mechanical kinetic energy of the spinning pinwheel (some energy may also be transferred to sound energy).

The **balloon** converts mechanical kinetic energy from students' muscles ➔ kinetic energy of moving air --> potential energy stored in the full balloon ➔ kinetic and sound energy as the balloon deflates and moves about the room.

The **light stick** contains potential chemical energy. This energy along with mechanical kinetic energy from students' muscles➔ radiant energy when the light stick is broken.

The **hand warmer** also contains potential chemical energy. This energy along with mechanical kinetic energy from students' muscles ➔ thermal energy when the hand warmer is broken.

The **Yo-Yo**™ converts mechanical kinetic energy from students' muscles ➔ potential gravitational energy as it is held up high ➔ mechanical kinetic energy as it moves up and down.

The **top** converts mechanical kinetic energy from students' muscles ➔ mechanical kinetic energy in the top as it spins.

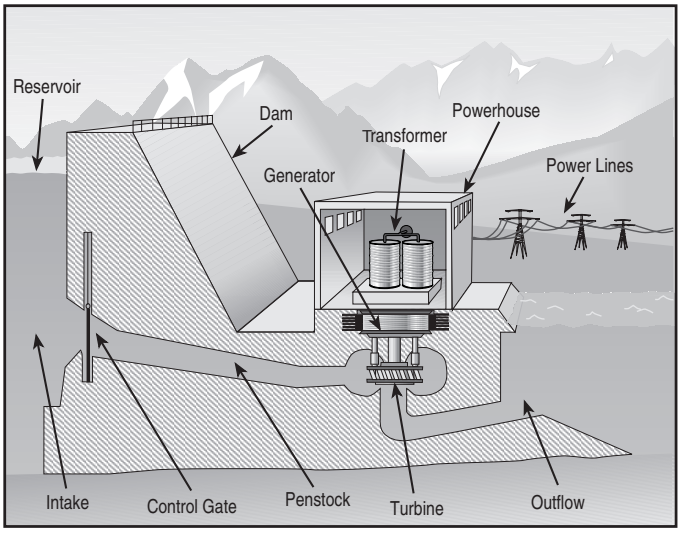
HYDROPOWER

What is Hydropower?

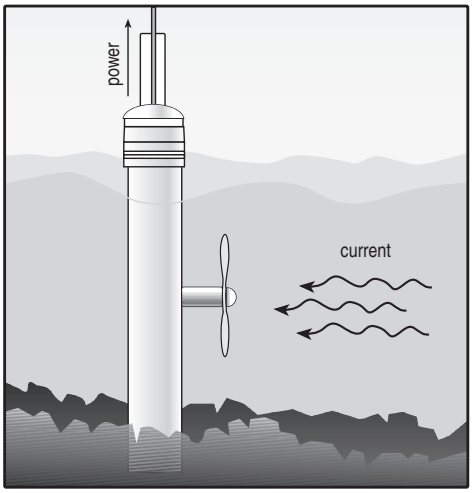
Water is constantly moving through Earth's hydrologic system. The sun's energy drives this system. Hyrdopower taps the kinetic energy of moving water to produce electricity. Water is not reduced or used up (like wood or oil) and so hydropower is considered a renewable resource. The amount of energy available in moving water is determined by its quantity (volume) and flow (velocity). Rivers, streams, lakes and oceans all have the capacity to generate electricity.

How Hydropower Plants Work

Hydropower plants convert water's energy into electricity. Many hydroelectric power plants have a dam that holds back water in a reservoir. The control gate manages how much water can flow through the intake and into the penstock. Water flowing through the penstock picks up speed and spins a turbine, which turns a generator. Generators contain a coiled wire located between two magnets. When the coiled wire spins it creates a flow of electrons in the wire (an electric current). The electric current passes through the transformer where it is converted to a higher voltage and transmitted through the power lines. Meanwhile the water is returned to river through the outflow area.



Use two different colored pencils to trace the route of water and then label the transformations of energy that occur as it moves through the hydropower plant.



Hydrokinetic River Turbines

River turbine systems are installed directly in the river. In Alaska, turbines may be placed on a pontoon or anchored on the river bottom. The current of the river turns the turbine blades that are attached to a generator by a shaft enclosed in a casing. The generator produces electricity that is sent through power lines. There are other river turbine designs as well.

Alaska's cold climate and freezing winter conditions can be challenging for these systems. Sometimes they cannot be used at all after freeze-up. Hydrokinetic systems are more likely to be used in Interior and Western Alaska where large rivers exist.

NAME: _____

HYDROPOWER WORD SEARCH

Vocabulary:

energy—the ability to do work; energy can exist in a variety of forms (potential, kinetic, thermal, radiant, electrical, gravitational, mechanical, chemical, nuclear) and can be transformed from one form to another

potential energy—the energy stored in an object as a result of its position or condition such as a raised weight, a coiled spring or a charged battery

kinetic energy—the energy possessed by a body as a result of motion; the amount of kinetic energy is dependent on mass and velocity of the object

mass—the measure of the amount of matter contained in a physical body

velocity—the rate at which an object moves in a specified direction

volume—the amount of space occupied by a three dimensional object or region of space

reservoir—a natural or artificial pond or lake used for water storage

penstock—a conduit, usually an enclosed pipe, used to control the flow of water to a turbine or power plant

turbine—a simple machine in which the kinetic energy of a moving fluid (water, steam or gas) is converted to rotary motion

generator—a machine that converts movement or mechanical energy into electrical energy; generators create an electric current by means of a coiled wire that rotates between two magnets creating an electric current

transformer—a device used to transfer electric energy from one circuit to another by means of inductively coupled, coiled wires (conductors)

Directions: Circle each word from the vocabulary list in the word search below. Words may run in any direction.

T	E	N	E	R	G	Y	R	F	K	J
R	W	M	Y	E	U	T	E	R	I	K
A	S	G	U	C	L	N	S	O	N	C
N	S	E	V	L	I	X	E	X	E	O
S	A	X	U	B	O	N	R	R	T	T
F	M	F	R	S	Y	V	V	X	I	S
O	S	U	S	Z	X	T	O	L	C	N
R	T	V	E	L	O	C	I	T	Y	E
M	N	Y	V	K	W	Z	R	E	Q	P
E	G	E	N	E	R	A	T	O	R	L
R	D	L	A	I	T	N	E	T	O	P

NAME: _____

ENERGY TRANSFORMATION

What Is Energy?

Scientists define energy as the ability to do work. Energy can also mean the rate at which molecules in a solid, liquid or gas are moving. Many of the things we do and use everyday are possible because we have learned how to transform, transport and store energy so that it is available to do work for us.

Forms of Energy

Potential energy is stored energy. **Kinetic energy** is the energy of motion (of waves, molecules or objects). Both potential and kinetic energy can be found in many forms

Chemical energy	is stored in the bonds of atoms or molecules. Examples of potential chemical energy include petroleum, coal, natural gas and wood. These are transformed to kinetic energy when we burn them.
Mechanical energy	is due to position or motion. A stretched rubber band is an example of potential mechanical energy that becomes kinetic when the tension is released and the rubber band is launched across the room.
Nuclear energy	is potential energy stored in the nucleus of an atom. A very large amount of kinetic energy can be released when a nucleus is split (as in a nuclear power plant) or fused (as in the sun).
Gravitational energy	is stored in an object due to its position above Earth. A ball or bike on top of a hill is an example of potential gravitational energy that is transformed to kinetic gravitational energy when the bike picks up speed as it rolls downhill.
Electrical energy	is the result of tiny charged particles called electrons. Potential electrical energy can be stored in a battery. Kinetic electrical energy can move through wires and power electronic devices.
Thermal energy	is heat resulting from an increase in the movement and collision of molecules. Examples include geothermal energy and body heat (i.e. rubbing your hands together).
Radiant energy	is electromagnetic energy including visible light and radio waves. Sunlight is radiant kinetic energy that fuels life on Earth.
Sound	is a typically weak kinetic energy that is produced by a vibration and transferred in a wave.

NAME: _____

ENERGY TRANSFORMATION

1. Energy is never created or lost, but it often changes (transforms) from one form to another. Energy transformations occur constantly in our lives every day. Complete the following chart that shows everyday examples of energy transfer.

Event	Original Energy Form	Transformed Energy Form
Lighting a match	Chemical	
Alarm clock going off		Sound
Using a hand warmer		Heat
Boiling water on the stove		Heat

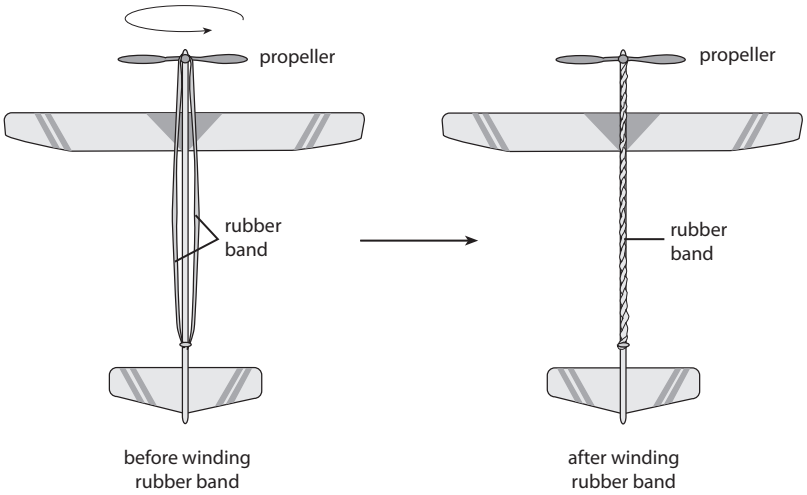
2. Look at the diagram below and circle the best answer to describe the energy transformation that occur in the rubber band powered airplane when it is flown.

   A. Thermal energy stored in the rubber band is transformed into chemical energy used by the propeller.

   B. Kinetic energy stored in the rubber band is transformed into thermal energy used by the propeller.

   C. Chemical energy stored in the rubber band is transformed into potential energy used by the propeller.

   D. Potential energy stored in the rubber band is transformed into kinetic mechanical energy used by the propeller.



3. Circle the correct response then use the lines below to explain your choice.

   A student rapidly rubs the palms of both hands together. Which sequence correctly describes the energy transformations that occur?

   A. chemical ➔ mechanical ➔ thermal

   B. mechanical ➔ thermal ➔ chemical

   C. thermal ➔ mechanical ➔ chemical

   D. mechanical ➔ nuclear ➔ thermal

_____

_____

_____

NAME: _____

ENERGY TRANSFORMATION

4. Describe the energy transfer that occurs as you talk to a friend on a cell phone.

5. Describe the energy transfer that occurs during a lightning strike.

6. Ordinary incandescent light bulbs produce a lot of heat in addition to light. Compact fluorescent light bulbs produce much less heat when operating and LED light bulbs produce almost no heat. If you wanted to conserve electricity, which type of bulb should you use? Explain your answer.

NAME: _____

HYDROPOWER IN MY COMMUNITY

1. The statements below are in the wrong order. Put them in the right order to describe the process (and transfer of energy) that produces power in a hydroelectric plant.

   _____ _____ _____ _____ _____

   A. Water flowing through the penstock spins the turbine. (The gravitational kinetic energy is transformed into mechanical kinetic energy.)
   B. The turbine spins a large shaft inside a generator creating an electric current. (The mechanical kinetic energy becomes electrical energy.)
   C. Precipitation falls into a river and flows until it is stopped at a reservoir by a dam. (The kinetic energy of moving water is transformed into potential energy that is stored in the reservoir)
   D. The sun's energy produces clouds and then precipitation. (The sun's radiant energy is transformed to kinetic energy as it moves through Earth's hydrologic cycle.)
   E. Water is released from the dam and flows through the penstock. (The potential energy stored in the reservoir becomes gravitational kinetic energy as it flows faster and faster through the penstock.)

2. The list below includes some of the impacts of hydroelectric power plants. Read each one and decide if it is an "advantage" (positive) or a "disadvantage" (negative). Place the LETTER of each item on either the "advantage" list or the "disadvantage" list.
   A. Huge amounts of energy are used in building hydroelectric plants.
   B. Energy produced by hydroelectric plants is less expensive than that produced by burning oil or coal.
   C. Reservoirs can cover important agricultural or archaeological lands.
   D. Migratory fish, including salmon, can be stopped by dams.
   E. Flowing water is a renewable energy source.
   F. Increased water temperature can affect plant and animal life.
   G. Hydroelectric plants produce very little air and water pollution.
   H. Reservoirs provide places for people to swim, boat, and fish.
   I. Dams can slow the flow of streams and rivers, increasing the amount of material deposited in them.

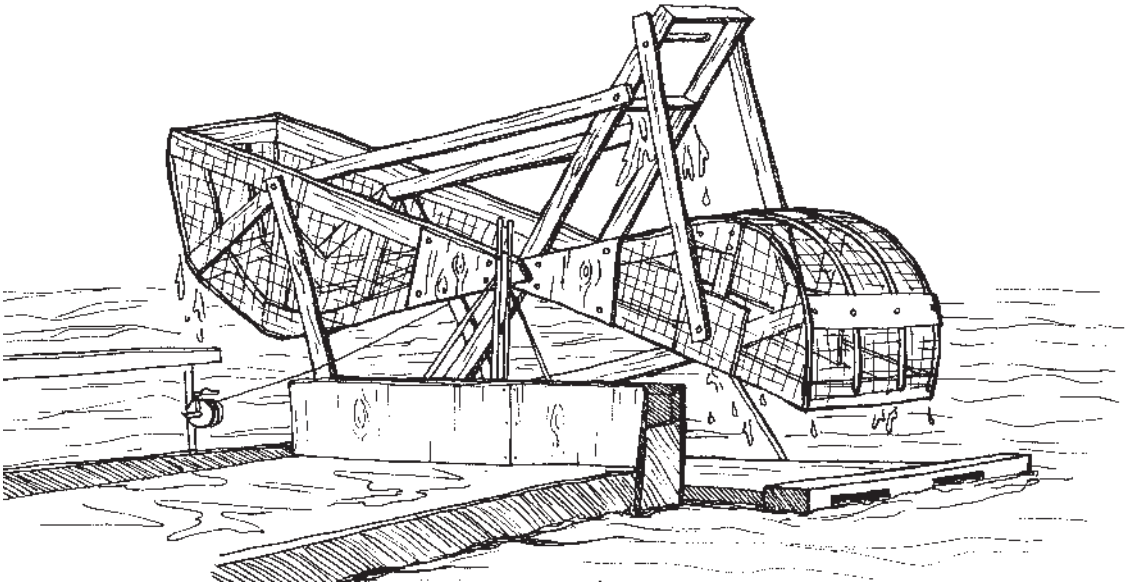
Advantage	Disadvantage

3. Many communities in Alaska are located on or near rivers.
   What is the name of the river nearest your community? _____
   How far from your community is the river? _____

NAME: _____

IS HYDROPOWER IN MY COMMUNITY

4. Many Alaskans are familiar with the use of fish wheels. Look at the drawing of the fish wheel below. Use a colored pencil to draw arrows to indicate the movement of the water. Use another color to draw arrows to show which way the fish wheel turns.



5. What type of energy powers the turning of the fish wheel?_____

6. Do you think your community could develop a hydropower system? Why or why not?

_____

_____

_____

_____

_____

_____