PGE Brain POWER

Science Classroom Alignment – 2009 Oregon Standards

Wind Power Lesson Plan

How does Wind Power Work?

Where does energy come from?

Objectives

Curriculum Goal	Content Standard	Oregon Benchmark	PGE Content
Energy – Non-Living systems are organized groups of related parts that function together	**6.2** Interaction and Change, **7.2** Interaction and Change, **8.2** Interaction and Change	**6.2P.2** – Describe relationships between electricity and magnetism **7.2P.1 –** Describe motion and forces and relate to laws of motion **8.2P.2 –** Explain how energy is transformed, transferred and conserved	Describes how mechanical energy is converted to the electromagnetic force in the generator using a rotor and generator
Energy – Systems interact with other systems	**8.2** Interaction and Change	**8.2E.3 -** Explain the causes of patterns of atmospheric and oceanic movement and the effects on weather and climate	Describes the flow of energy in the earth's system resulting in wind and wind energy
Energy – Engineering design is a process of identifying needs and developing solutions	**6.4** Engineering Design	**6.4D.3** - Describe examples of how engineers have created inventions that address human needs and aspirations.	Explores the relationship between the natural habitat and a wind power plant, how we as a species have used engineering to meet our needs using natural resources

At the end of this lesson, students will have an understanding of the concepts and vocabulary linking energy systems and power plants, including potential and mechanical energy. Students will be prepared to derive benefit from a field trip to a power plant and further understand the relationships between technological systems required to generate electricity.

Making Connections

What is energy? Students may name things used in everyday life that need energy…make a connection to how these items are powered. How do you think this power is made? What do you think is the best source of energy?

Do you think one form of energy can be converted into another? Ask students to give some examples…make a connection to how energy is converted around them every day: electricity into light, sunlight into heat, battery electricity into noise (iPods), cell phone battery electricity into signals (texting). Learning about energy changing forms is a great opportunity to consider how different types of energy are used to **create electricity**. Students may not recognize that electricity as a form of energy is derived only from other sources of energy. Learning about power from a wind power plant gives students the opportunity to explore forms of energy, and better understand the behavior of matter.

Background

We think of energy in many different ways. You need energy to go to school, play games, or do chores. People need energy to drive cars and fly planes. But whatever you think of when you think of energy, it is really just the ability to do work.

Energy can change from one form to another. It can be used to create motion, heat, or changed into electromagnetic energy (electricity). One way to convert energy from the environment into electromagnetic energy is to use the wind.

Wind Power!

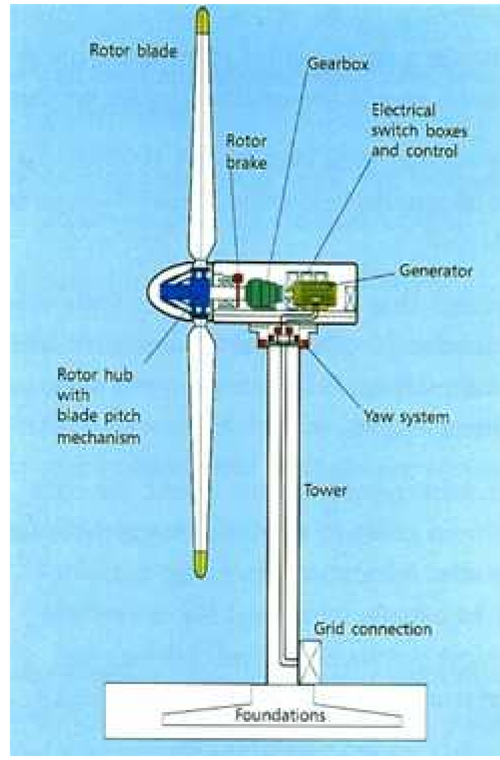
In an engine, we know that we need **fuel** to make the engine work (gasoline and a car). In a wind turbine, we don't need fuel to supply energy, because the energy comes from a natural source – the **wind**.

Thinking about wind: Simply put, the wind blows because of differences in temperature: between the ocean and the land, the air and the ocean, and the air and the land. When the sun shines on the earth, the air is heated up, and the air molecules are excited enough that they begin to move faster. This is the beginning of wind. We can say that the air molecules have absorbed the **potential energy** from the sun's rays and started to move. Kinetic energy is the energy of motion.

If the fast-moving excited air molecules are directed to hit objects (like a wind turbine), it causes a lot of pressure against whatever they hit. Think about it: when the wind blows hard, it can turn a propeller. Fast moving wind can even knock down buildings in a hurricane! This wind pressure can be used to do **work**. Work can be described as using energy to make something move.

Wind power plants have big **wind turbines** that change the energy from the wind into electricity. A wind turbine is just like a giant fan. In your house, when a fan turns, air blows out from the fan because we are changing electricity energy into the energy of motion, kinetic energy. In a power plant, the relationship is reversed! The wind turns the giant fan, which turns a **generator**, which makes electricity.

The wind turbine has fan blades that are very big – more than 100 feet long! These are called **rotor blades**. As the wind moves over the rotor blades, they begin to turn. We can say that the energy in the wind has been converted to kinetic energy in the wind turbine because *it is in motion*.



The generator is directly connected to the rotor. As the turbine turns, the generator is turned. The **generator** then changes the energy into electromagnetic energy, or electricity!

Key Concept: energy from wind is transferred to the rotor, making it turn. A generator connected to the rotor changes mechanical energy into electrical energy.

Vocabulary:

fuel – fuel is something produced by natural systems that is essential for the production of heat energy

wind – air in motion

kinetic energy – energy stored in a system or object in motion

potential energy – the energy stored in a physical system as a result of position or composition

work –making something move by using energy

wind turbine – a rotary device that uses wind to operate

rotor blades – the blades of a wind turbine. Collects energy from wind and converts it to mechanical energy.

generator – a device used to make electricity. In a power plant, the generator is connected to a turbine.

Main Activity

Wind Power

Make a machine that uses wind to do work.

One challenge engineers face when designing a machine is how to transfer one kind of energy to another. In a wind power plant, energy from wind is transferred to kinetic energy in a turbine, which turns a generator, making electricity. In this activity, we will explore wind power by making a small wind powered turbine. **This is a teacher led activity**.

Materials

- clear scotch tape (one per team of students)
- aluminum pie tins (one per team of students)
- permanent markers (one per team of students)
- scissors (one per team of students)
- 3ft ¼" dowel rods (one per team of students)
- 8 x 8" pieces of cardboard (one per team of students)
- 2 large paper cups (don't use styrofoam, it makes too much friction)
- 4 push pins
- 1 large heavy text book
- 1 very long thin rubber band, at least 6 inches long un-stretched
- A stopwatch or clock
- A fan or powerful hair dryer

Procedure

1. Your task is to create wind "turbines" that will turn cardboard "generators". You will power the turbine using wind from a fan or hair dryer.

2. Break the students into teams of two students. Each team will make a steam "turbine". The students will compete to see who designs the best turbine (which one gets more energy from the wind).

3. Under close supervision, have the students cut the pie tin into a wind turbine rotor blade shape. Use a permanent marker to draw the shape of the fan blades on the pie tin. Have the students discuss what shapes they want to use. Don't tell the students what design might be best, they should be encouraged to come up with their own designs. Help the students bend the blades as shown in the illustration below. **This is important for the blades to work – the blades must share a common "curve", and all be bent in the same direction.** *You are trying to make a pin wheel like shape.* Note: use caution with the edges of the pie tin, they may be sharp.

4. Ask the students to color designs on the cardboard generator. They can make a design of their choice.

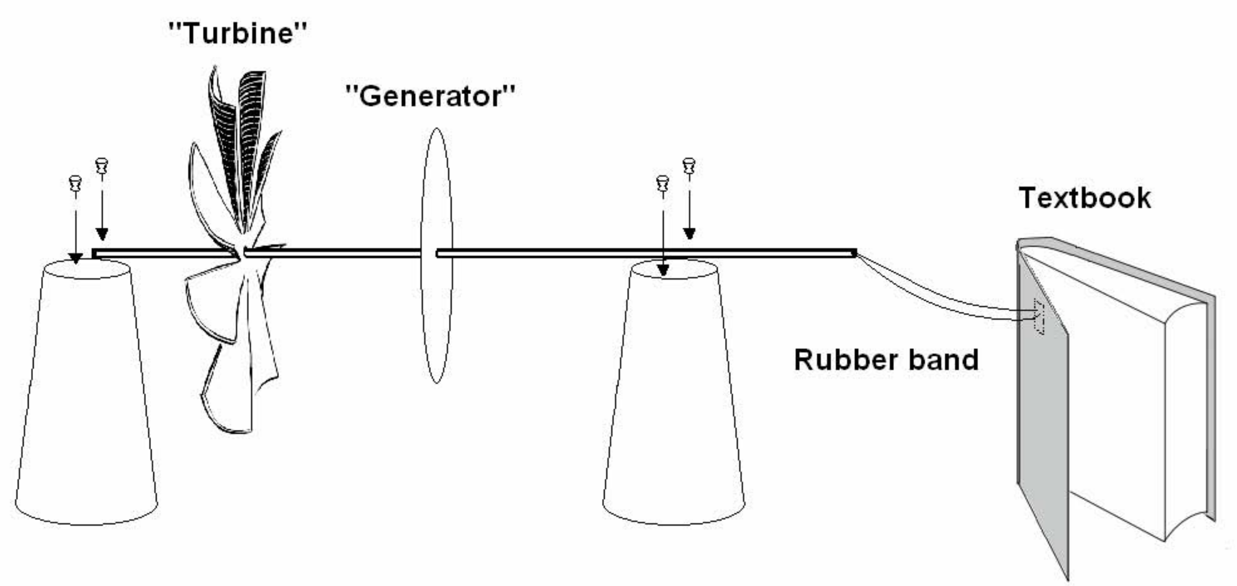
5. **Help the students** punch a hole through the middle of each “turbine rotor” (try to be accurate) using a sharp pencil. Don’t make the hole too big. Push the dowel rod through the end leaving 5 or 6 inches of dowel at the end. Fasten the turbine to the dowel rod securely using several pieces of scotch tape.

6. Punch a hole through the middle of the cardboard using a sharp pencil, and push the dowel rod through. Leave 8 to 10 inches at the other end. Fasten the “generator” to the dowel rod using scotch tape.

7. Using push pins, fix the dowel rod in place on top of the two large cups. Place one pin on each side of the dowel rod – it must be able to turn freely! If the cups are not tall enough for the blades to spin freely, set the cups on top of text books.

8. Tape the rubber band to one end of the dowel rod. Tape the other end of the rubber band to the cover of a heavy text book.

9. When completed, the turbine and generator setup will look like this:



10. Ready the fan or hair dryer. You will want to approach the turbine with the wind slowly. Using a hair dryer, a distance of 3 or 4 inches from the blades should be sufficient to get it to turn. Aim the wind directly at the rotor, head on. IF you are using a large fan, you will want to increase this distance. Use your judgment. You may need to hold the front cup in place by hand, the wind may create enough force to move the assembly across the table!

You will test each turbine setup and count the amount of time it takes before the turbine stops turning. The rubber band will slow down the turbine as it winds up. Eventually, the pressure from the wind will not be strong enough to turn the turbine against the potential energy being stored in the rubber band. The less time it takes for the turbine to stop, the better the design of the blades (if the blades catch more energy, it will wind the rubber band faster!!)

11. Have the students count the time until the rubber band stops the blades from turning more. Write the results on the board by team.

Additional activity: You might also want to count the amount of time each turbine spins from the potential energy stored in the rubber band. The difference between the time spent putting energy in (spinning the turbine using steam power), and the amount of time for the energy to come out (the rubber band unwinding) will be different. Challenge the students to figure out why this happens!

Repeat #11 above for each blade design. You will need to take each students assembly off the cups, and re-attach the rubber band to the end of each dowel rod before continuing.

Discussion

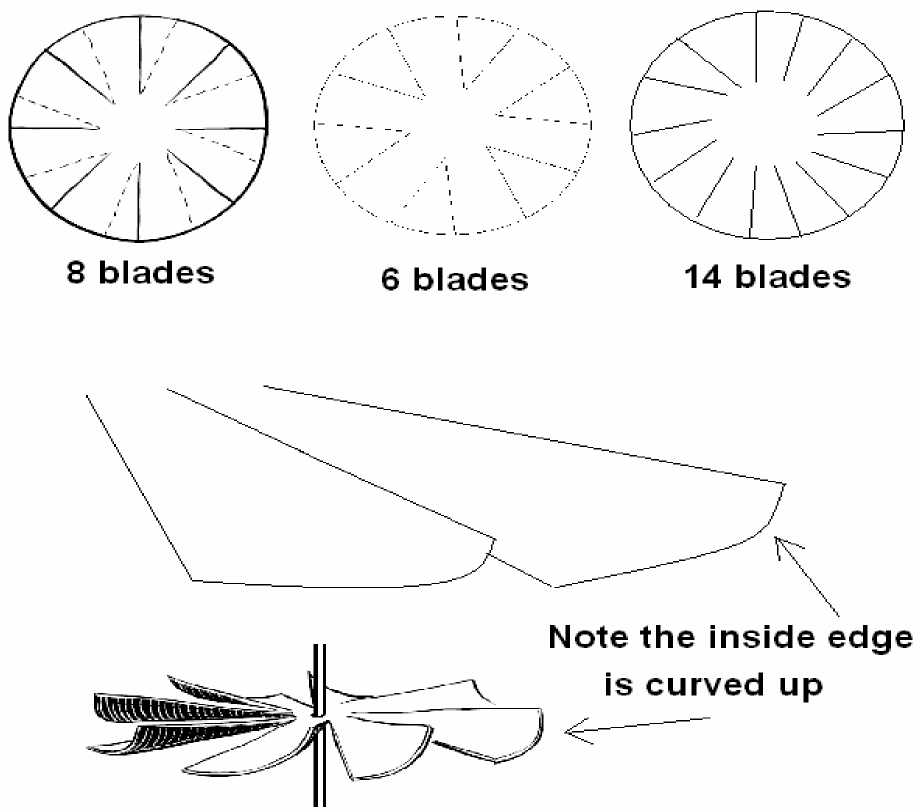
1. Point out that wind doesn't always blow at the same speed. How would this affect the generation of power? What if the wind is not blowing?

2. Why did some rotor blade designs work better than others? If there are more blades, did it matter? What if the blades were bigger? Different shapes? Different shapes of blades, and especially the curve of the blades, will make a big difference. The closer together the blades are, the more energy they can gather from the wind. Thinking about design: If the blades are too close, the wind could knock over the turbine!

Supplemental Activity

Heating, Cooling and Wind Pressure: Fill a 2-liter plastic soda bottle one-quarter full of hot (not boiling) water. Screw the cap on tightly. Submerge the bottle in ice-cold water. Watch the bottle. What happens? Why? Now submerge the bottle in a bath of very warm water. What happens now? Why? Discuss pressure with the students, and how moving from hot to cold / cold to hot can make pressure. "Pressure" on the surface of the Earth is wind! Heating happens during the day because of the Sun! Cooling happens at night because the Sun is behind our planet. These daily pressures create the trade winds, and are the source of weather patterns across our planet.

Wind Turbine Rotor Blade Shapes



PGE Brain POWER
Science Classroom Alignment –2009 Oregon Standards
Hydro Power Lesson Plan

How does Hydro Power Work?

Where does energy come from?

Objectives

Curriculum Goal	Content Standard	Oregon Benchmark	PGE Content
Energy – Non-Living systems are organized groups of related parts that function together	**6.2** Interaction and Change, **7.2** Interaction and Change, **8.2** Interaction and Change	**6.2P.2** – Describe relationships between electricity and magnetism **7.2P.1 –** Describe motion and forces and relate to laws of motion **8.2P.2 –** Explain how energy is transformed, transferred and conserved	Describes how mechanical energy is converted to the electromagnetic force in the generator using a rotor and generator
Energy – Systems interact with other systems	**8.2** Interaction and Change	**8.2E.3 -** Explain the causes of patterns of atmospheric and oceanic movement and the effects on weather and climate	Describes the flow of energy in the earth's system and the effects of using a watershed to store energy
Energy – Engineering design is a process of identifying needs and developing solutions	**6.4** Engineering Design	**6.4D.3** - Describe examples of how engineers have created inventions that address human needs and aspirations.	Explores the relationship between the natural habitat and a hydro power plant, how we as a species have used engineering to meet our needs using natural resources

At the end of this lesson, students will have an understanding of the concepts and vocabulary linking energy systems and power plants, including potential and mechanical energy. Students will be prepared to derive benefit from a field trip to a power plant and further understand the relationships between technological systems required to generate electricity.

Making Connections

What is energy? Students may name things used in everyday life that need energy…make a connection to how these items are powered. How do you think this power is made? What do you think is the best source of energy?

Do you think one form of energy can be converted into another? Ask students to give some examples…make a connection to how energy is converted around them every day: electricity into light, sunlight into heat, battery electricity into noise (iPods), cell phone battery electricity into signals (texting). Learning about energy changing forms is a great opportunity to consider how different types of energy are used to **create electricity**. Students may not recognize that electricity as a form of energy is derived only from other sources of energy. Learning about power from a hydro power plant gives students the opportunity to explore forms of energy, and better understand the behavior of matter.

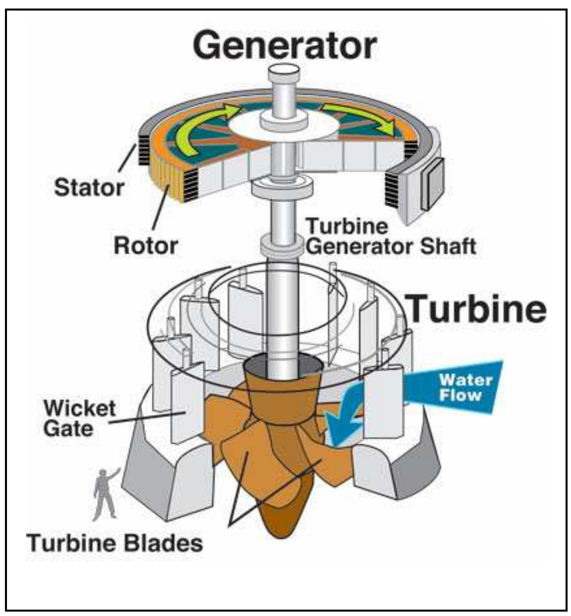
Background

We think of energy in many different ways. You need energy to go to school, play games, or do chores. People need energy to drive cars and fly planes. But whatever you think of when you think of energy, it is really just the ability to do work.

Energy can change from one form to another. It can be used to create motion, heat, or changed into electromagnetic energy (electricity). One way to convert energy from the environment into electromagnetic energy is to use the force of water.

Water Power!

In an engine, we know that we need **fuel** to make the engine work (gasoline and a car). In a hydroelectric power plant, we don't need fuel to supply energy, because the energy comes from a natural source – the **water**.



Thinking about water: Simply put, water flows downhill because of the force of gravity. By making a dam across a river, we can store the water behind the dam and let it out into the river at a much slower rate, and create electricity at the same time. We can say that the water molecules have **potential energy** stored up because they are held back from flowing down the river by the dam. By allowing the water to escape the dam through the power plant, we can change the potential energy into kinetic energy - the energy of motion.

If the fast-moving water molecules are directed to hit objects (like a turbine), they cause a lot of pressure against whatever they hit. Think about it: when the wind blows hard, it can turn a propeller. Moving water has even more force! This water pressure can be used to do **work**. Work can be described as using energy to make something move.

Hydro power plants have big **hydro turbines** that change the energy from the moving water into electricity. Hydro is a word from ancient Greek which means “water”. A hydro turbine is just like a giant fan under water. In a hydro power plant, the water flows from behind the dam, moves over and turns the turbine, which turns a **generator**, which makes electricity.

The hydro turbine has fan blades that are very big – some as big as 25 feet across! These are called **turbine blades**. As the water moves over the blades, they begin to turn. We can say that the energy in the water has been converted to kinetic energy in the turbine because *it is in motion*. Energy used in motion is called kinetic energy. Energy waiting to be used, in an object at rest, is called potential energy.

A generator is directly connected to the turbine…. as the turbine turns, the generator is turned. The generator then changes the energy into electromagnetic energy, or electricity!

Key Concept: water moves through a dam and kinetic energy is transferred to the turbine, making it turn. A generator connected to the turbine turns at the same time, and changes mechanical energy into electrical energy.

Vocabulary:

fuel – fuel is something produced by natural systems that is essential for the production of heat energy

water – a renewable resource used to make electricity inside a dam

kinetic energy – energy stored in a system or object in motion

potential energy – the energy stored in a physical system as a result of position or composition

work –making something move by using energy

hydro turbine – a device that uses water to turn like a water wheel

generator – a device used to make electricity. In a power plant, the generator is connected to a turbine.

turbine blades – the blades of a hydro turbine. Collects energy from moving water and converts it to mechanical energy.

Main Activity

Hydro Power

Make a machine that uses water to do work.

One challenge engineers face when designing a machine is how to transfer one kind of energy to another. In a hydro power plant, energy from water is transferred to kinetic energy in a turbine, which turns a generator, making electricity. In this activity, we will explore hydro power by making a small hydro powered turbine. **This is a teacher led activity**.

Materials

- clear scotch tape (one per team of students)
- aluminum pie tins (one per team of students)
- permanent markers (one per team of students)
- scissors (one per team of students)
- 3ft ¼" dowel rods (one per team of students)
- 8 x 8" pieces of cardboard (one per team of students)
- 2 large paper cups (don't use styrofoam, it makes too much friction)
- 4 push pins
- 1 large heavy text book
- 1 very long thin rubber band, at least 6 inches long un-stretched
- A stopwatch or clock
- A 1 gallon jug of water
- A pan or container to catch water

Procedure

1. Your task is to create hydro "turbines" that will turn cardboard "generators". You will power the turbine using water from a 1 gallon jug.

2. Break the students into teams of two students. Each team will make a water "turbine". The students will compete to see who designs the best turbine (which one gets more energy from the wind).

3. Under close supervision, have the students cut the pie tin into a turbine rotor blade shape. Use a permanent marker to draw the shape of the fan blades on the pie tin. Have the students discuss what shapes they want to use. Don't tell the students what design might be best, they should be encouraged to come up with their own designs. Help the students bend the blades as shown in the illustration below. **This is important for the blades to work – the blades must all be bent in the same direction.** *You are trying to make a pin wheel like shape*. Note: use caution with the edges of the pie tin, they may be sharp.

4. Ask the students to color designs on the cardboard generator. They can make a design of their choice.

5. **Help the students** punch a hole through the **middle** of each “turbine” (try to be accurate, use a ruler) using a sharp pencil. Don’t make the hole too big. Push the dowel rod through the end leaving 5 or 6 inches of dowel at the end. Fasten the turbine to the dowel rod securely using several pieces of scotch tape.

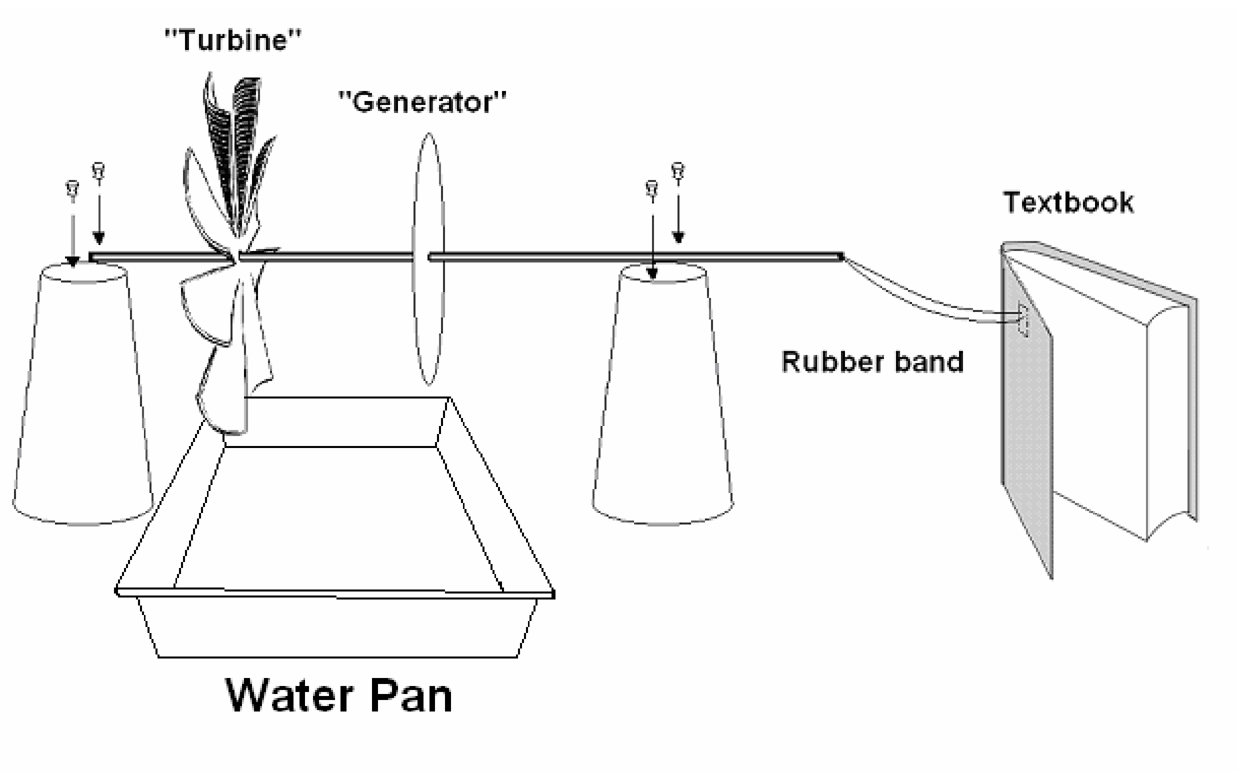
6. Punch a hole through the middle of the cardboard using a sharp pencil, and push the dowel rod through. Leave 8 to 10 inches at the other end. Fasten the “generator” to the dowel rod using scotch tape.

7. Using push pins, fix the dowel rod in place on top of the two large cups. Place one pin on each side of the dowel rod – it must be able to turn freely! It is best to let the dowel rod sit on top of the push pins to reduce friction. If the cups are not tall enough for the blades to spin freely, set the cups on top of text books.

8. Tape the rubber band to one end of the dowel rod. Tape the other end of the rubber band to the cover of a heavy text book.

9. Place a pan to catch water under the “turbine”.

10. When completed, the turbine and generator setup will look like this:



11. Ready the jug of water. You will want to pour water onto the turbine slowly. A distance of 3 or 4 inches from the blades should be sufficient to get it to turn. Aim the water directly at the edge of the turbine where the edges are turned up. Use your judgment and try to pour the water evenly.

You will test each turbine setup. The rubber band will slow down the turbine as it winds up. Eventually, the pressure from the water will not be strong enough to turn the turbine against the potential energy being stored in the rubber band. The less time it takes for the turbine to stop, the better the design of the blades (if the blades catch more energy, it will wind the rubber band faster!!)

12. Have the students count the time until the rubber band stops the blades from turning more. Write the results on the board by team.

Additional activity: You might also want to count the amount of time each turbine spins from the potential energy stored in the rubber band. The difference between the time spent putting energy in (spinning the turbine using water power), and the amount of time for the energy to come out (the rubber band unwinding) will be different. Challenge the students to figure out why this happens!

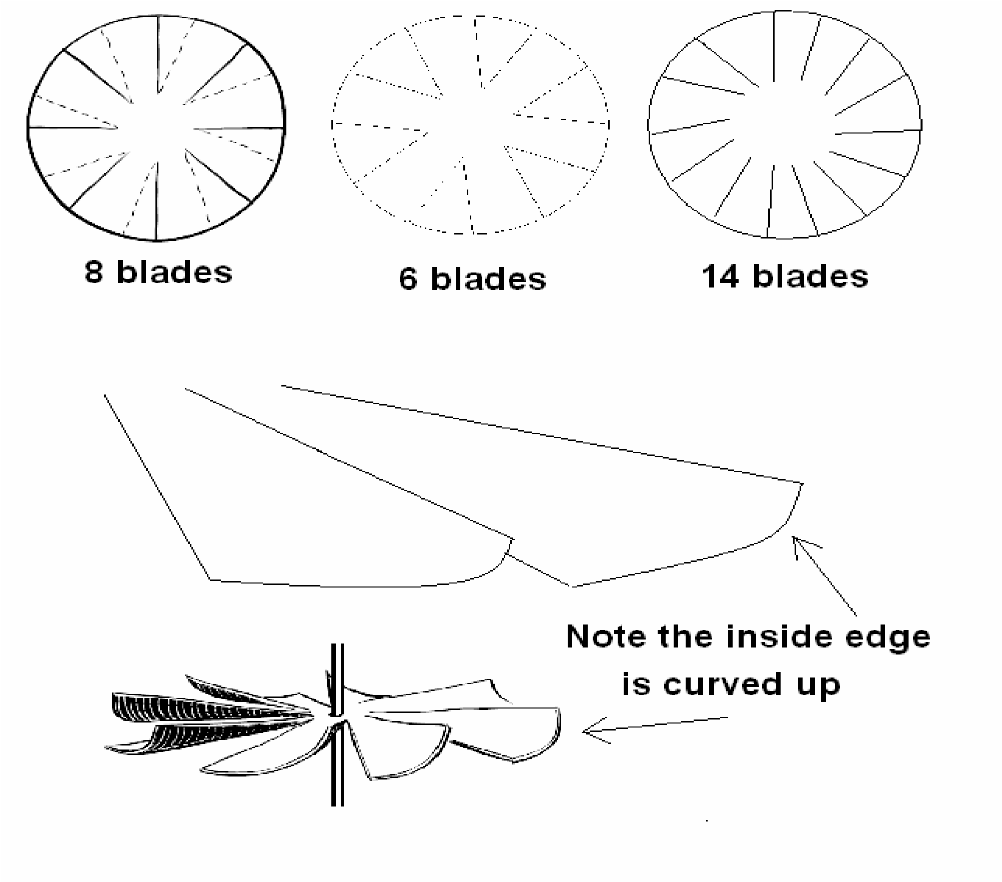
Repeat #11 above for each blade design. You will need to take each students assembly off the cups, and re-attach the rubber band to the end of each dowel rod before continuing.

Discussion

1. Point out that water doesn't always move at the same speed depending on how fast you pour it. How do utility companies change how fast the water moves through the dam? Are there important issues at work? (Fish, river flow rate and height of the water downstream)

2. Why did some rotor blade designs work better than others? If there are more blades, did it matter? What if the blades were bigger? Different shapes? Different shapes of blades, and especially the curve of the blades, will make a big difference. The closer together the blades are, the more energy they can gather from the water.

Hydro Turbine Rotor Blade Shapes



** The more the edges are curved, the better they will catch the water!

PGE Brain POWER
Science Classroom Alignment – 2009 Oregon Standards
Steam Power Lesson Plan

How does Steam Power Work?

Where does energy come from?

Objectives

Curriculum Goal	Content Standard	Oregon Benchmark	PGE Content
Energy – Non-Living systems are organized groups of related parts that function together	**6.2** Interaction and Change, **7.2** Interaction and Change, **8.2** Interaction and Change	**6.2P.2** – Describe relationships between electricity and magnetism **7.2P.1 –** Describe motion and forces and relate to laws of motion **8.2P.2 –** Explain how energy is transformed, transferred and conserved	Describes how mechanical energy is converted to the electromagnetic force in the generator using a rotor and generator
Energy – Systems interact with other systems	**8.1** Structure and Function	**8.1P.3 -** Explain how the motion and spacing of particles determines states of matter.	Describes the flow of energy in the power plant system and the use of steam to move energy between systems
Energy – Engineering design is a process of identifying needs and developing solutions	**6.4** Engineering Design, **8.4** Engineering Design	**6.4D.3** - Describe examples of how engineers have created inventions that address human needs and aspirations.	Explores the relationship between the natural habitat and a power plant, how we as a species have used engineering to meet our needs using natural resources

At the end of this lesson, students will have an understanding of the concepts and vocabulary linking energy systems and power plants, including potential and mechanical energy. Students will be prepared to derive benefit from a field trip to a power plant and further understand the relationships between technological systems required to generate electricity.

Making Connections

What is energy? Students may name things used in everyday life that need energy…make a connection to how these items are powered. How do you think this power is made? What do you think is the best source of energy?

Do you think one form of energy can be converted into another? Ask students to give some examples…make a connection to how energy is converted around them every day: electricity into light, sunlight into heat, battery electricity into noise (iPods), cell phone battery electricity into signals (texting). Learning about energy changing forms is a great opportunity to consider how different types of energy are used to **create electricity**. Students may not recognize that electricity as a form of energy is derived only from other sources of energy. Learning about steam power in a power plant gives students the opportunity to explore forms of energy, and better understand the behavior of matter.

Background

We think of energy in many different ways. You need energy to go to school, play games, or do chores. People need energy to drive cars and fly planes. But whatever you think of when you think of energy, it is really just the ability to do work.

Energy can change from one form to another. It can be used to create motion, heat, or changed into electromagnetic energy (electricity). One way to convert heat energy into electromagnetic energy is to use steam.

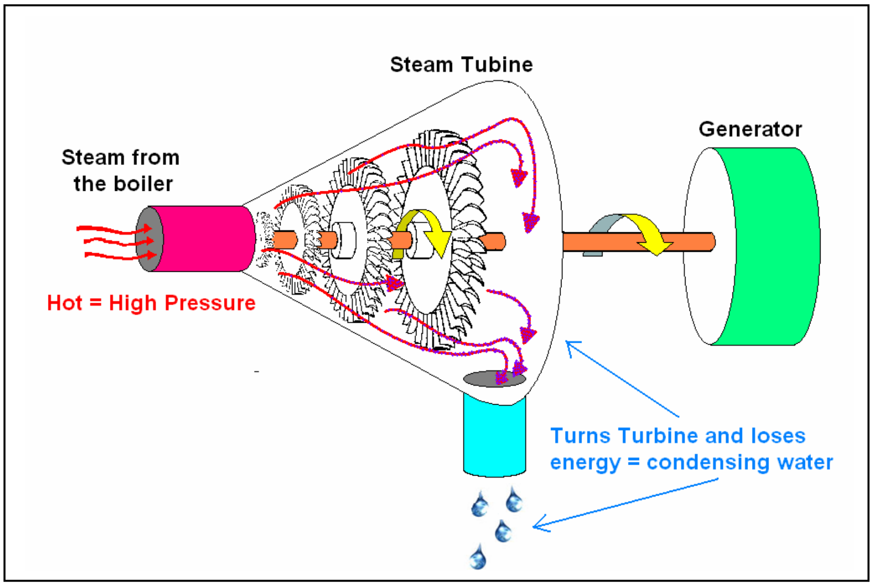
Steam Power!

In an engine, we know that we need **fuel** to make the engine work (gasoline and a car). In a steam engine, the fuel (such as oil, gas, coal, or wood) is burned to heat water into steam. When fuel burns, the fuel's energy is changed to thermal energy, or **heat**.

Thermal power plants have big **boilers** that heat water into steam. A boiler is just like a teapot on a stove. When the water boils, the steam comes through the hole at the top of the spout. As the steam comes out of the teapot, the steam makes a whistle that tells you the water has boiled. In a power plant, the water is brought to a boil inside a boiler, which makes steam.

Thinking about steam: the heat from burning fuel is *absorbed* by the liquid molecules in the water, exciting them. When enough heat is applied, the water molecules are excited enough that they begin to move faster, and can “break away” from the liquid surface, shooting up into the space above the liquid. When this happens, we say that the liquid **vaporized**, or **changed state**, turning into **steam**. Steam is the vapor state of water. We can say that steam has **thermal energy**, because the water molecules have absorbed the **potential energy** from the fuel when it was burned.

If the fast-moving excited water molecules are directed to hit objects, it causes a lot of pressure against whatever they hit. Think about it: when the wind blows hard, it can turn a propeller. Steam is similar to wind, it has pressure and when it hits something, it can make it move. This pressure can be used to do **work**. Work can be described as using energy to make something move.



In a thermal power plant, the energy in steam is used to turn a **turbine**. A turbine is a like a windmill inside a box with openings on both sides, so that that steam can move through it. A windmill has fan **blades**, and so does a turbine. A turbine has many more blades on it. As the steam moves through the box, the stream pushes on the blades of the turbine, just like wind pushes on a windmill. As the steam pressure hits the blades, the turbine starts to turn. We can say that the thermal energy in the steam has been transferred to **kinetic energy** in the turbine because *it is in motion*. After the steam hits the blades, the steam gives up some its energy, and cools off. As the steam cools, it condenses, and changes state back to liquid. When water changes state from steam back to a liquid, it is called **condensing**. Finally, the liquid water is pumped back to the boiler to do it all again!

In a power plant, the turbine is connected to a generator. As the turbine turns, the generator is turned. The **generator** then changes the energy into electromagnetic energy, or electricity!

Key Concept: Heat energy from fuel is transferred to water in a boiler, making steam. Steam pressure can be converted to **mechanical energy** inside a turbine. A generator connected to a turbine changes mechanical energy into electrical energy.

Vocabulary:

change of state – to change from one physical form of matter into another, like ice into water, or water into steam.

potential energy – the energy stored in a physical system as a result of position or composition

vaporize – changing matter from a liquid state to a vapor state by using heat

fuel – fuel is something produced by natural systems that is essential for the production of heat energy heat – thermal energy

boiler – a large container filled with water which is heated to make steam

steam – a physical state of water with high energy

work –making something move by using energy

steam turbine – a type of rotary engine that uses steam to operate

kinetic energy – energy stored in a system or object in motion

condensing – changing from a vapor state to a liquid state

generator – a device used to make electricity. In a power plant, the generator is connected to a steam turbine.

rotary – refers to something mechanical that rotates, like the motion of a turbine

Main Activity

Steam Power

Make a machine that uses steam to do work.

One challenge engineers face when designing a machine is how to transfer one kind of energy to another. In a power plant, heat energy from steam is transferred to kinetic energy in a turbine, which turns a generator, making electricity. In this activity, we will explore steam power by making a small steam powered turbine. **This is a teacher led activity**. Note: safety precautions should be taken using steam with the students.

Materials

- 1 electric teapot
- 4 feet of ½ inch vinyl fish tank / aquarium hose
- 1 roll of duct tape
- clear scotch tape (one per team of students)
- aluminum pie tins (one per team of students)
- permanent markers (one per team of students)
- scissors (one per team of students)
- 3ft ¼” dowel rods (one per team of students)
- 8 x 8” pieces of cardboard (one per team of students)
- 2 large paper cups (don’t use styrofoam, it makes too much friction)
- 4 push pins
- 1 large heavy text book

- 1 very long thin rubber band, at least 6 inches long un-stretched
- 1 oven mitt
- paper towels
- A stopwatch or clock

Procedure

1. Your task is to create steam "turbines" that will turn cardboard "generators". You will power the turbine using steam from a teapot.

2. Break the students into teams of two students. Each team will make a steam "turbine". The students will compete to see who designs the best turbine (which one gets more energy from the steam).

3. Under close supervision, have the students cut the pie tin into a turbine shape. Use a permanent marker to draw the shape of the fan blades on the pie tin. Have the students discuss what shapes they want to use. Don't tell the students what design might be best, they should be encouraged to come up with their own designs. Help the students bend the blades as shown in the illustration below. **This is important for the blades to work – the blades must share a common "curve", and all be bent in the same direction.** *You are trying to make a pin wheel like shape*. Note: use caution with the edges of the pie tin, they may be sharp.

4. Ask the students to color designs on the cardboard generator. They can make a design of their choice.

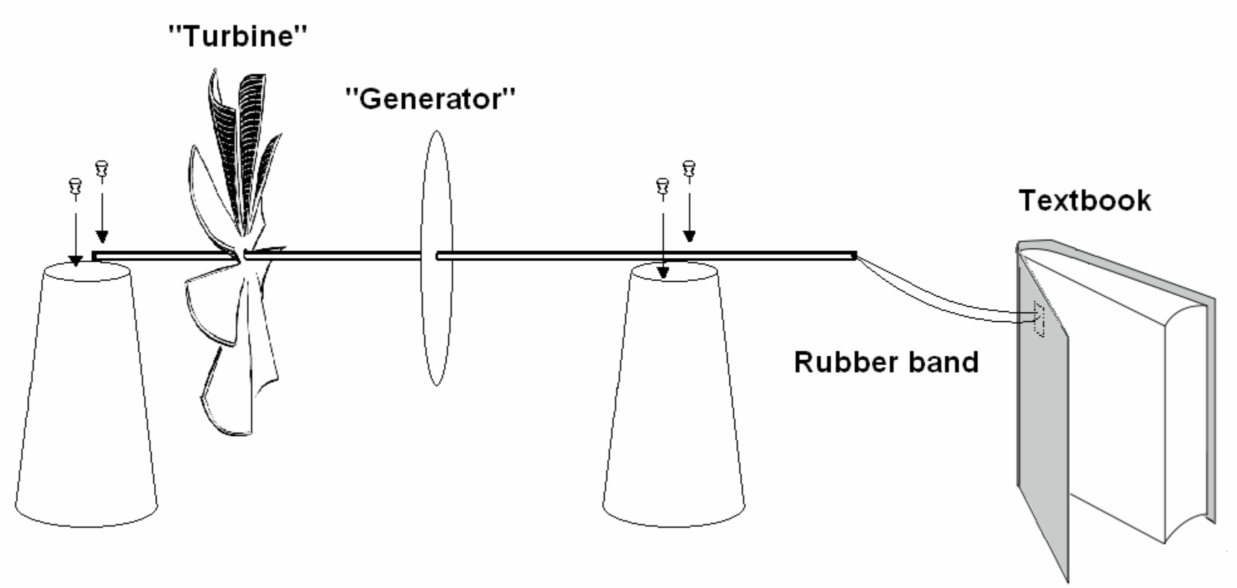
5. Help the students punch a hole through the middle of each "turbine" (try to be accurate) using a sharp pencil. Don't make the hole too big. Push the dowel rod through the end leaving 5 or 6 inches of dowel at the end. Fasten the turbine to the dowel rod using a piece scotch tape.

6. Punch a hole through the middle of the cardboard using a sharp pencil, and push the dowel rod through. Leave 8 to 10 inches at the other end. Fasten the "generator" to the dowel rod using scotch tape.

7. Using push pins, fix the dowel rod in place on top of the two large cups. Place one pin on each side of the dowel rod – it must be able to turn freely! Use an area where water can drip of the blades of the "turbine". If the cups are not tall enough for the blades to spin freely, set the cups on top of text books.

8. Tape the rubber band to one end of the dowel rod. Tape the other end of the rubber band to the cover of a heavy text book.

9. When completed, the turbine and generator setup will look like this:



10. Attach the fish tank hose to the tea kettle spout using duct tape. You may want to adjust the hose length - the shorter the hose, the better (the steam will cool inside the hose, losing energy). Three feet (3) of hose is recommended, but you can use less. It is important that there are no gaps between the hose and the spout, all of the steam must travel through the hose.

You will test each turbine setup and count the amount of time it takes before the turbine stops turning. The rubber band will slow down the turbine as it winds up. Eventually, the pressure from the steam will not be strong enough to turn the turbine against the potential energy being stored in the rubber band. The less time it takes for the turbine to stop, the better the design of the blades (if the blades catch more energy, it will wind the rubber band faster!!)

11. Boil the teapot. USE CAUTION. **Teacher only**: using the oven mitt, hold the end of the hose about 1 inch from the blades (aiming at the widest section of the blades will help). Try and hold the hose steady in the same place. Have the students count the time until the rubber band stops the blades from turning more. Write the results on the board by team.

Additional activity: You might also want to count the amount of time each turbine spins from the potential energy stored in the rubber band. The difference between the time spent putting energy in (spinning the turbine using steam power), and the amount of time for the energy to come out (the rubber band unwinding) will be different. Challenge the students to figure out why this happens!

Repeat #11 above for each blade design. You will need to take each students assembly off the cups, and re-attach the rubber band to the end of each dowel rod before continuing.

12. When completed, unplug the kettle. **Teacher**: maintain control of the hose, it will be hot for several minutes after the tests.

Discussion

1. Point out that water starts in the "boiler" in a liquid state, but turns to vapor with the addition of heat. How long did it take to boil water? Is there a way to make a teapot boil faster? (you can use distilled water, it has a lower boiling point than tap water). Things that are in the water don't absorb heat at the same rate as water. The dirtier the water, the slower it is to boil. Power plant water is very very clean (99.999%).

2. Why do some blade designs work better than others? If there are more blades, did it matter? What if the blades were bigger? Different shapes? Different shapes of blades, and especially the curve of the blades, will make a big difference. The closer together the blades are, the more energy they can gather from the steam.

3. Point out that the steam begins to condense to water on the blades of the turbine. Discuss how the steam's energy is transferred to the turbine blades, changing the state of the water from vapor back to liquid.

Supplemental Activities

1. Fill a 2-liter plastic soda bottle one-quarter full of hot (not boiling) water. Screw the cap on tightly. Submerge the bottle in ice-cold water. Watch the bottle. What happens? Why? Now submerge the bottle in a bath of very warm water. What happens now? Why? Discuss pressure with the students, and how heat energy adds pressure, while cold (removing energy) takes it away.

2. Draw a 15 or 20 foot circle of chalk on the ground (does not need to be a perfect circle). With their hands at their sides, place a group of 5 students into the circle. Tell the students in the middle they can walk around in the circle. Is it hard for the students to stay in the circle? Why? The students are like a gas (few molecules per volume). Now add 10 more students. Add music, and tell the students they can dance around. Is it harder to stay in the circle now? What happens if the music gets louder? Now fill the circle with students, so it is difficult for them to move around without bumping into one another. Turn the music back on. Tell the students if they step over the line, they have to leave the circle. The students are like a pond of water in liquid state (packed together, but free to move around), and the energy of the music is like heat. Eventually, some of the water molecules (the students in the middle) escape the surface of the water (the edge of the circle).

Turbine Shapes