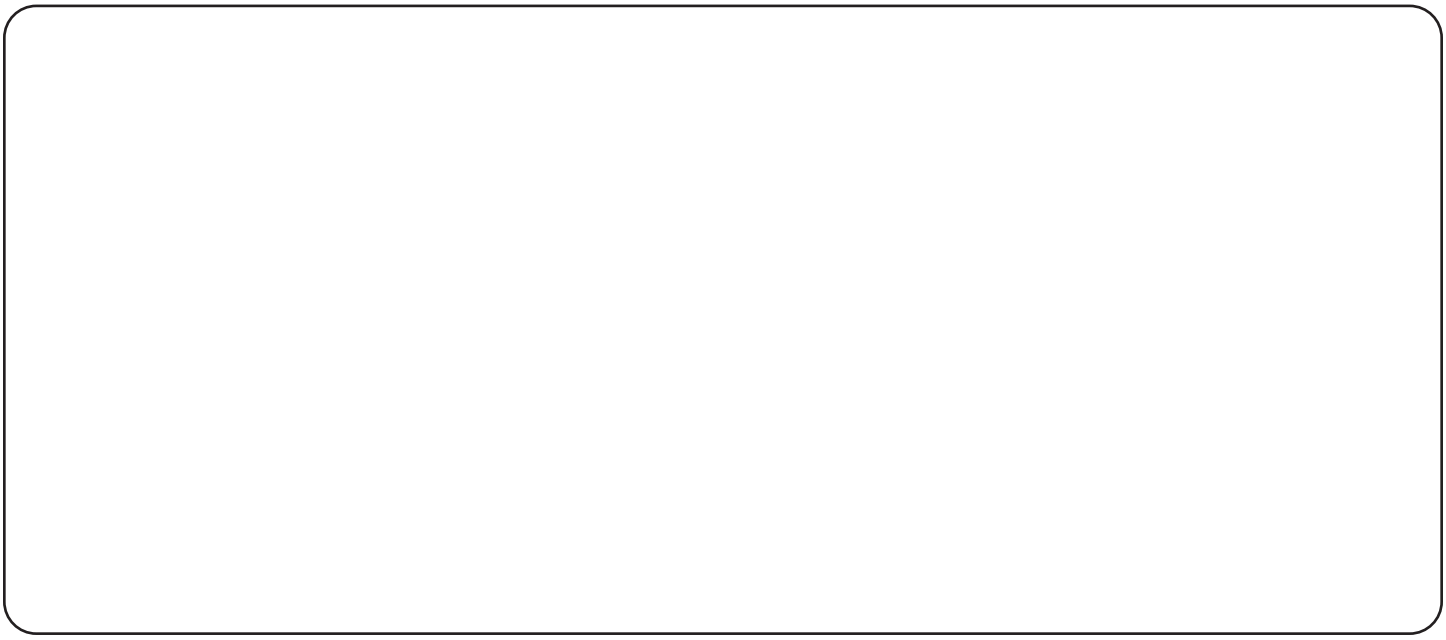
Date: _____

Wind

Question: What evidence is there that the wind is blowing?

Observe the wind. Draw pictures of evidence that the wind is blowing.



Date: _____

Wind

Question: What evidence did you find that proved the wind was blowing?

Look back at your evidence that the wind was blowing. Describe how the wind was blowing. Write about what you saw that proves the wind was blowing.

Date: _____

Wind Can Do Work, Part 1

Guiding Question: How can wind do work?

Question: What will happen when wind blows into the windmill?

I predict _____

_____

because _____

_____

Draw a picture and use words to explain what happened.

_____

_____

_____

Date: _____

1. Make your windmill.
2. Draw a diagram of the windmill below and label the parts.

Windmill Diagram

Date: _____

Wind Can Do Work, Part 2

Question: How many paper clips can the wind lift to the top of the windmill?

I predict _____

_____

because _____

_____

Trial	Number of Paper Clips	Lifted to the top? (Yes or No)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Date: _____

Question: _____

_____

_____

Weightlifter Turbine Diagram

Date: _____

Blade Design Ideas

Draw some ideas you have for what the blades could look like.

My blade design ideas...

My group's blade design will be...

Date: _____

Question: _____

_____

_____

I predict _____

_____

because _____

_____

_____

Data:

Date: _____

Data and Observations Continued:

Blade Investigation Results

Date: _____

Wind Can Do Work Conclusion

How does wind do work? What did you learn in your windmill investigations? How much work did your windmills do? Is the wind a good source of energy to do work? Why or why not?

Date: _____

Wind Measurement Tools

Draw diagrams of the wind measuring tools you will be using. Label each one and tell what it measures.

Date: _____

Measuring the Wind

Question: Will the wind blow the same speed in different locations around the school?

I predict _____

_____

because _____

_____

_____

Data and Observations: From what direction is the wind blowing?

_____

_____

_____

Date: _____

Location	Time	Revolutions in 10 Seconds	Speed

Date: _____

Wind Reflection

What did you learn about wind and energy? What is the most important thing you learned?

Date: _____

Date: _____

What are You Wondering About?

After learning something new, scientists often have even more questions to which they want to find answers.

- What questions about wind do you still have?
- How can you find the answers to your questions?

Date: _____

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National Renewable Energy Laboratory
NC Green Power
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NextEra Energy Resources
NEXTracker
Nicor Gas
Nisource Charitable Foundation
Noble Energy
North Carolina Department of Environmental Quality
North Shore Gas
Offshore Technology Conference
Ohio Energy Project
Oklahoma Gas and Electric Energy Corporation
Oxnard Union High School District
Pacific Gas and Electric Company
PECO
Pecos Valley Energy Committee
People's Electric Cooperative
Peoples Gas
Pepco
Performance Services, Inc.
Petroleum Equipment and Services Association
Permian Basin Petroleum Museum
Phillips 66
Pioneer Electric Cooperative
PNM
PowerSouth Energy Cooperative
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Quarto Publishing Group
Prince George's County (MD)
R.R. Hinkle Co
Read & Stevens, Inc.
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U.S. Department of Energy
U.S. Department of Energy–Office of Energy Efficiency and Renewable Energy
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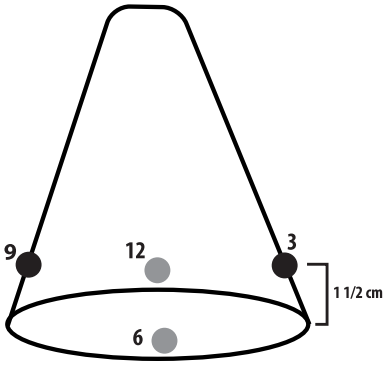
Build an Anemometer

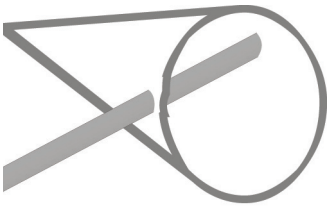
Materials

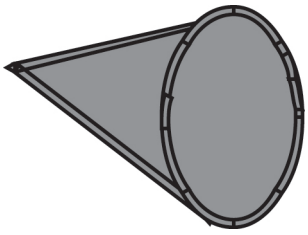
- 1 Pencil
- 5 Snow cone cups
- 2 Extra-long straws
- Masking tape
- Hole punch
- Scissors
- 1 Straight pin
- Marker
- Watch with second hand
- Ruler

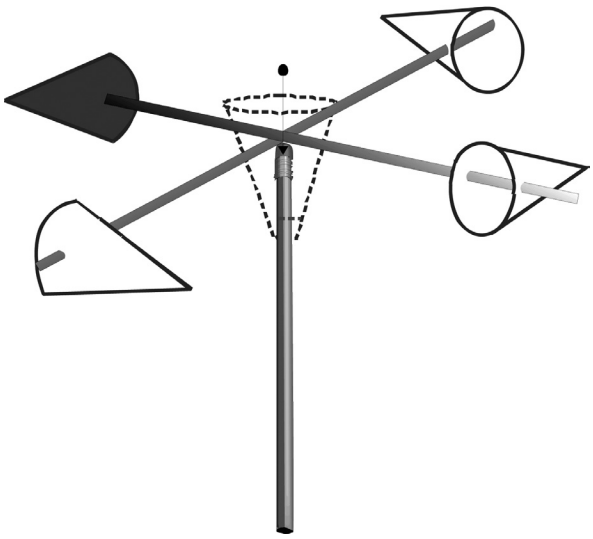
✔ Procedure

1. Take one cup and cut the tip off so it can slide onto a pencil. This is your base cup.
2. Think of the circle end of the cup like a clock. Imagine where 12, 3, 6, and 9 would be located.
3. Use the hole punch to make two holes opposite each other, very near the rim at 12 o'clock and 6 o'clock.
4. Punch two more holes opposite each other 1 1/2 cm from the rim at 3 o'clock and 9 o'clock.
5. Slide the first straw through the 12 o'clock and 6 o'clock holes. Slide the second straw through the 3 o'clock and 9 o'clock holes.
6. In the other cups, use the hole punch to make two holes opposite each other at 3 o'clock and 9 o'clock.
7. Color one of these four cups a bright color that is easy to see.
8. Slide one cup onto the end of each straw. Make sure the cups all face the same direction. Tape the cups to the straw.
9. Center the straws in the base cup.
10. Slide the base cup over the pencil as shown in the diagram.
11. Push a straight pin through the middle of each straw and into the pencil eraser. Lightly push the cups to make sure the straws spin smoothly.
12. Take your anemometer outside. Hold the anemometer so the colored cup is facing you.
13. Measure the speed of the wind by counting the number of revolutions in 10 seconds. Use the *Wind Speed Table* to find the speed in miles per hour.









Wind Speed Table

Make copies of this page and cut apart the tables so each student gets one table. Students should tape the table into their Student Guides on page 18 so they have a reference and can record wind speed during their wind speed exploration.

REVOLUTIONS PER 10 SEC.	MPH
2-4	1
5-7	2
8-9	3
10-12	4
13-15	5
16-18	6
19-21	7
22-23	8
24-26	9
27-29	10
30-32	11
33-35	12
36-37	13
38-40	14
41-43	15
44-46	16
47-49	17
50-51	18
52-54	19
55-57	20

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50-51	18
52-54	19
55-57	20

Wind

You cannot see air, but it is all around us.

You cannot see the **wind**, but you know it is there. You hear leaves rustling in the trees. You see clouds moving across the sky. You feel cool breezes on your skin. Wind is moving air.

Seed pods in a tree

Wind is important. Wind helps plants survive. Some small plant seeds are very light. The wind carries them to new places. This is an important part of nature. The plant seeds spread out across the land. They land in new areas and start to grow. Many plant seeds use the wind to survive.

Thistle seeds

A flock of geese soars with the wind.

Birds soar in the sky and **migrate** with the help of the wind. Some tiny animals use the wind to carry them from one living area to another.

Animals also depend on wind. Many animals use smell to warn them of danger. Wind can carry smells a long way. Animals can stay away from **predators** and catch **prey** with help from the wind.

People all over the world use the wind every day. Like the early Egyptians, many people still use the wind to power their sailboats. In some countries, **windmills** are still used to pump water from below the ground to the surface for people and animals to drink.

Sailboats use the wind to move them.

A hang glider uses the wind to fly.

The wind can be fun, too. Windsurfers use wind to move them along the water. Many people like to fly kites in the wind. Hang gliders use wind to carry them through the air like birds.

Wind Causes Change

Wind makes waves for surfers.

Wind moves across water and makes **waves** on **lakes** and **oceans**. Wind pushes desert sand into dunes and creates sandstorms. The wind can start rocks and boulders moving down mountains.

A tornado has very strong winds.

Sometimes, the wind is very strong and can create storms. A strong storm over the ocean is called a **hurricane**. A powerful storm on land can produce a column of rotating air called a **tornado**. These windstorms can change the shape of the land.

Wind is **energy**.

Energy

Wind is energy, but what is energy? Energy is many things. Energy is the power to change things. Energy is the ability to do work.

Energy is light.

Energy is sound.

Energy is heat.

Energy makes things move and grow.

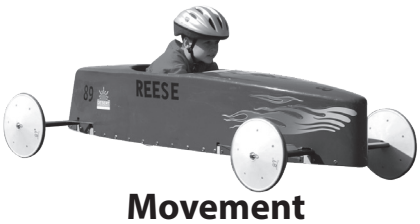
Energy runs machines.

Anytime you see light, hear sound, feel warmth or cold, anytime you move and grow, anytime you use a machine, energy is involved!

Light

Sound

Heat



Movement

Runs Machines

The Conservation of Energy

All of the energy we use is already in our universe. When we use energy it does not disappear, it simply changes into another form of energy. This is called the **Law of Conservation of Energy**.

Food gives us energy.

Food provides your body with energy. When you eat, that energy does not disappear, it changes. Your body changes the energy in your food to motion, heat, sound, and growth.

Energy Changes Forms

Gasoline provides energy for our cars. When we drive, the energy in gasoline changes into motion, heat, and sound.

Energy Transformations

The Law of Conservation of Energy states that energy does not disappear, it just changes forms.

The sun has energy. The sun's energy travels to Earth as light.

Plants, like apple trees, corn, and wheat, change the sun's energy into **sugars** that are stored in their fruits and leaves. This process is called **photosynthesis**. Plant sugars are full of energy.

People cannot change light into sugars. We have to eat food to get energy. Eating lets our bodies use the energy stored in plants.

Energy in our bodies is changed to motion, heat, sound, and growth.

Energy is Work

The word **work** means many things. Many adults leave their homes every morning to go to their jobs. They go to work. Exercise is often called "working out." Your teacher gives you homework to do.

Many adults go to work.

Playing soccer is doing work.

In science, work has a special meaning. Work is using a **force** to move an object across a **distance**. A force is a push or a pull. A force uses energy. To do work, there must be energy.

Think about playing soccer. A soccer ball cannot move by itself. You must kick it. You use the energy you got from food to kick the ball. The soccer ball rolls across the field to score a goal. You have just done work!

Wind Can Do Work

For many years people have used the energy in wind to do work.

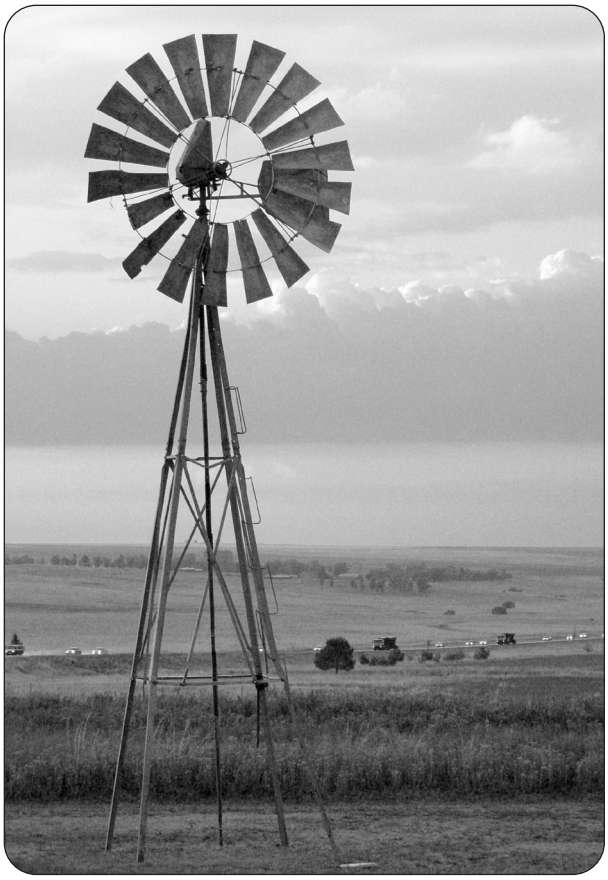
People in Egypt wanted a way to travel on water easier and faster, so they invented the sailboat.

To make bread, people have to grind the grain into fine pieces. This is hard work! A long time ago people in Persia invented the first windmill to grind the grain for them. This technology spread and people in Holland became famous for their use of windmills.

A windmill ground grain.

When Pilgrims came to America, they used windmills to grind corn, pump water, and run sawmills.

Today, we use energy from the wind to make electricity that powers our lights and runs our machines.

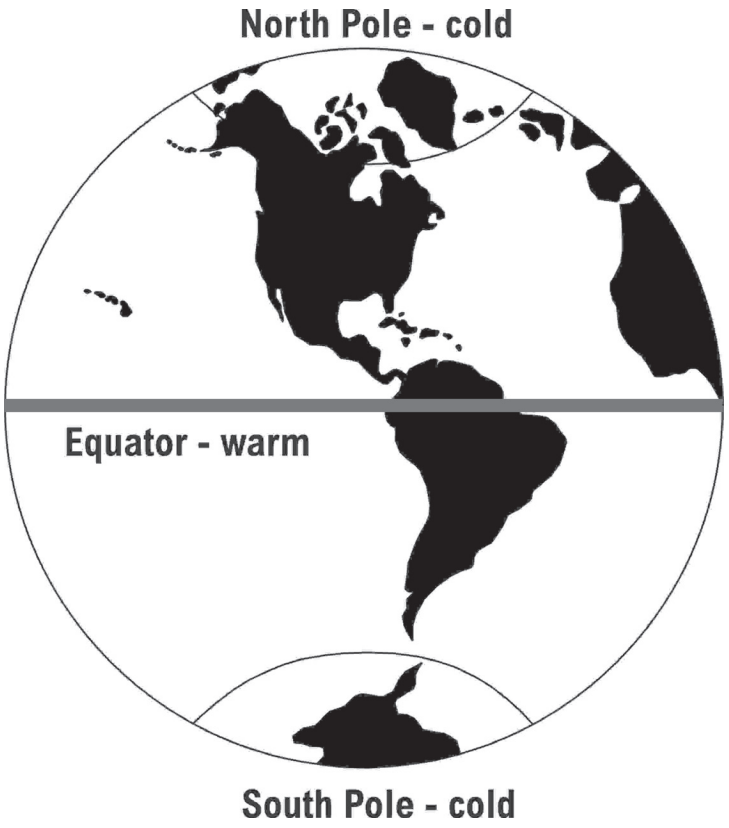


An early American windmill.

Modern wind turbines can generate electricity.

The Wind's Energy

The energy in wind comes from the sun. Energy from the sun is called **solar energy**.

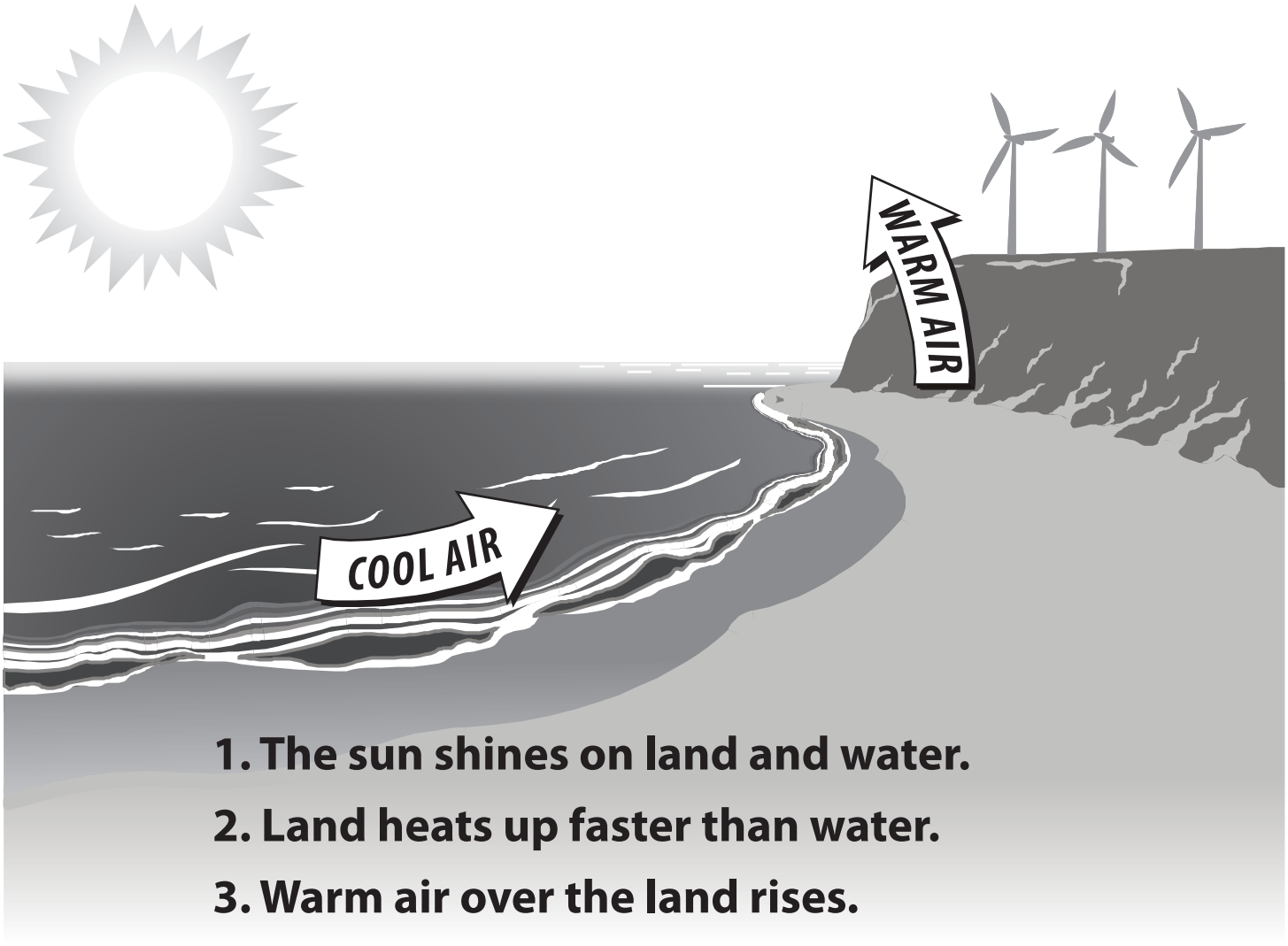


The sun shines on the Earth. The area around the middle of the Earth, the **Equator**, gets more solar energy than the **poles**. The solar energy heats the air over the Equator more than the air over the poles. The warm air around the Equator moves toward the cold air around the poles. This is wind.

Solar energy heats the land and water. The air over land warms up faster than the air over water. Warm air rises and cool air rushes in to take its place. The air is moving. This is wind.

Wind forms when some air is hotter than other air over the Earth.

How Wind is Formed



1. The sun shines on land and water.

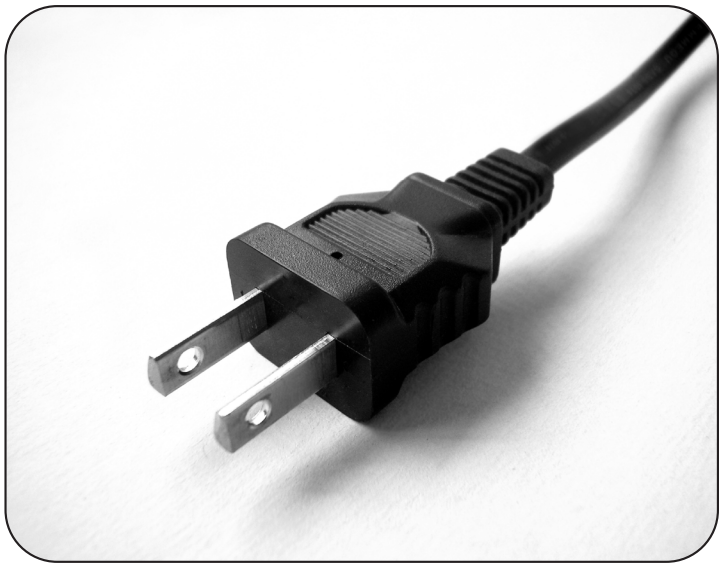
2. Land heats up faster than water.

3. Warm air over the land rises.

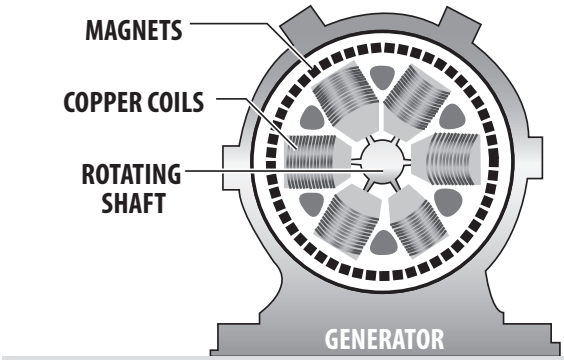
4. Cool air over the water moves in.

Wind Can Make Electricity

Electricity is moving **electrons**. It gives us the power we use to run our lights, video games, televisions—anything you plug into an outlet uses electricity. Electricity does not magically come out of the walls in your house.

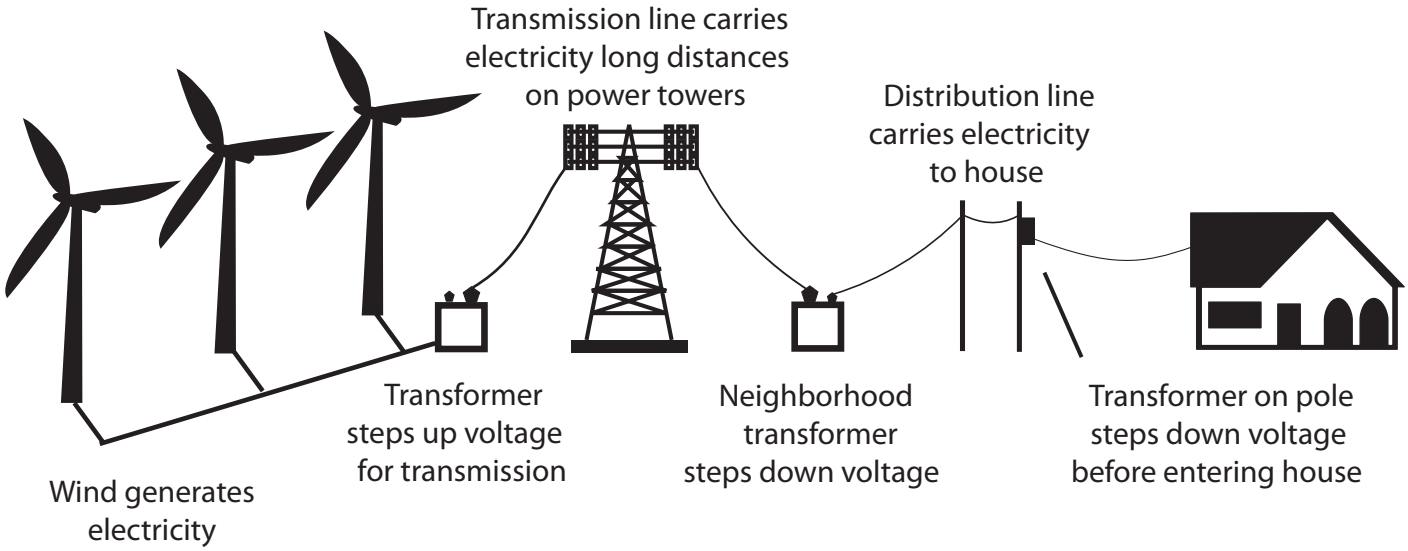


Inside a Generator



The copper coils spin inside a ring of magnets. This creates an electric field, producing electricity.

Electricity is made in a **generator**, where **magnets** spin around coils of copper wire. Today we use wind **turbines** to capture the energy in the wind to make electricity.



The wind pushes against the blades of the turbine. The blades spin the hub. The hub turns a long rod, or **shaft**, that goes from the hub into the nacelle. The turning shaft spins the generator. The generator changes the motion from the wind into electricity.

The electricity then travels through wires to get from the wind turbine to your house.

A wind turbine can only make electricity when the wind is blowing. Sometimes the wind does not blow at all, sometimes the wind is too strong. A good site for wind turbines has to have an **average** wind speed of at least 8 miles per hour. Wind turbines do not run all of the time.

The amount of electricity a turbine makes depends on its size and the speed of the wind. A small turbine may help to power one home. A large turbine may power up to 750 homes.

This comparison illustrates how tall an industrial wind turbine is. A wind turbine this size could generate 1.5 MW of electricity, which is enough power for more than 300 homes!

Wind Farms

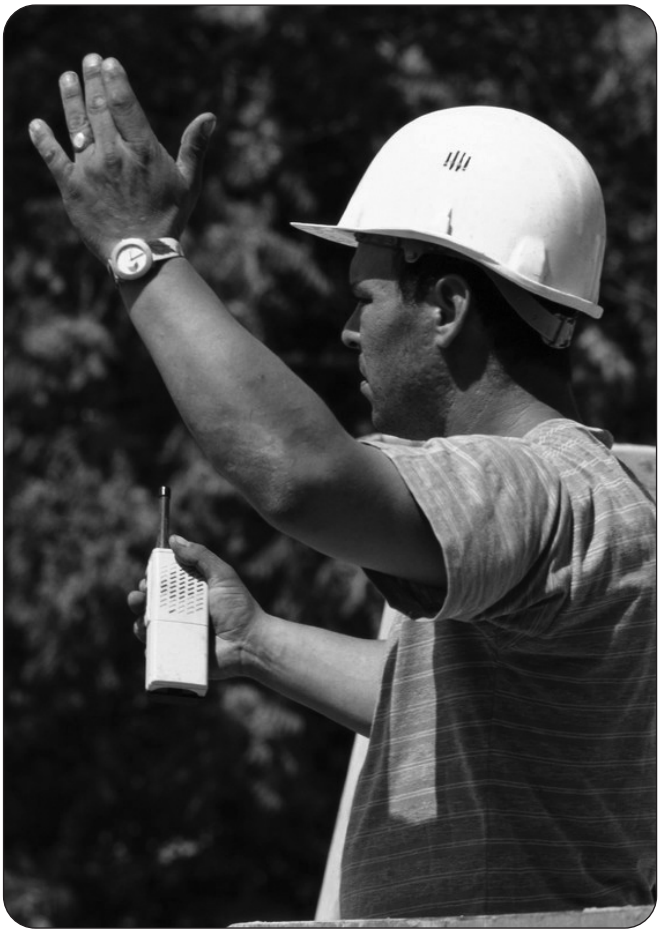
Sometimes there are a few or even hundreds of turbines in one place. This is called a **wind farm**. The turbines work together to make a lot of electricity. A wind farm takes up a large area of land but the land can still be used for animals to graze on, or to grow crops.

A Wind Farm

An anemometer and wind vane combined in one tool.

Scientists study where to put a wind farm. This is called **siting** a wind farm.

To site a wind farm, scientists study the wind. They use tools like an **anemometer**. An anemometer spins in the wind and measures how fast the wind is blowing.



These are questions the scientists need to answer before building a wind farm:

Is the wind the right speed?

Will the turbines damage animal habitats?

Can the electricity travel from the wind farm to the homes where people need the electricity?

Will the land support all of the turbines for a long time?

Are people willing to live next to a wind farm?

Scientists use a **wind vane** to study the direction that the wind blows. A wind vane points to where the wind is coming from. They also study the birds and animals that live in the area. They study the land. They talk to the people in the area.

Ocean Wind Farms

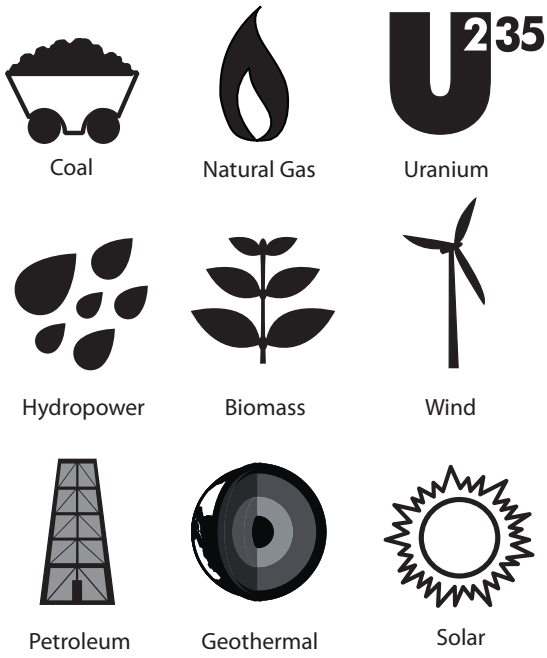
Wind is very strong over water, or offshore. On the ocean there is nothing in the way to block the wind. The wind blows more regularly. The ocean is a good place to build a wind farm. These are called **offshore wind farms**. There are several countries in the world with offshore wind farms. The United States' first offshore wind farm was built off the coast of Rhode Island in 2016.

An Ocean Wind Farm

Wind is Clean and Renewable

Wind is not the only energy source we have that can make electricity. By burning coal, natural gas, and oil we can also make large amounts of electricity. We also use energy in uranium ore to make electricity.

Sources Used to Generate Electricity



Most of the electricity in the United States comes from these sources. They are called **nonrenewable energy sources**. We find these sources in the ground. It takes a long time for the Earth to make them again.

Burning coal, natural gas, and oil also causes **pollution**. Pollution makes our air and water dirty.

As long as the sun shines there will be wind moving across the Earth. Wind is called a **renewable energy source** because solar energy makes wind all of the time. We will never run out of wind.

Wind turbines do not burn fuel, so they do not pollute the air. Wind, like other renewables, is a safe, clean energy source for making electricity.

Today wind energy makes less than ten percent of the electricity in the United States. However, wind power is growing. There are plans for many more wind farms on land and in the ocean all over the country and the world.