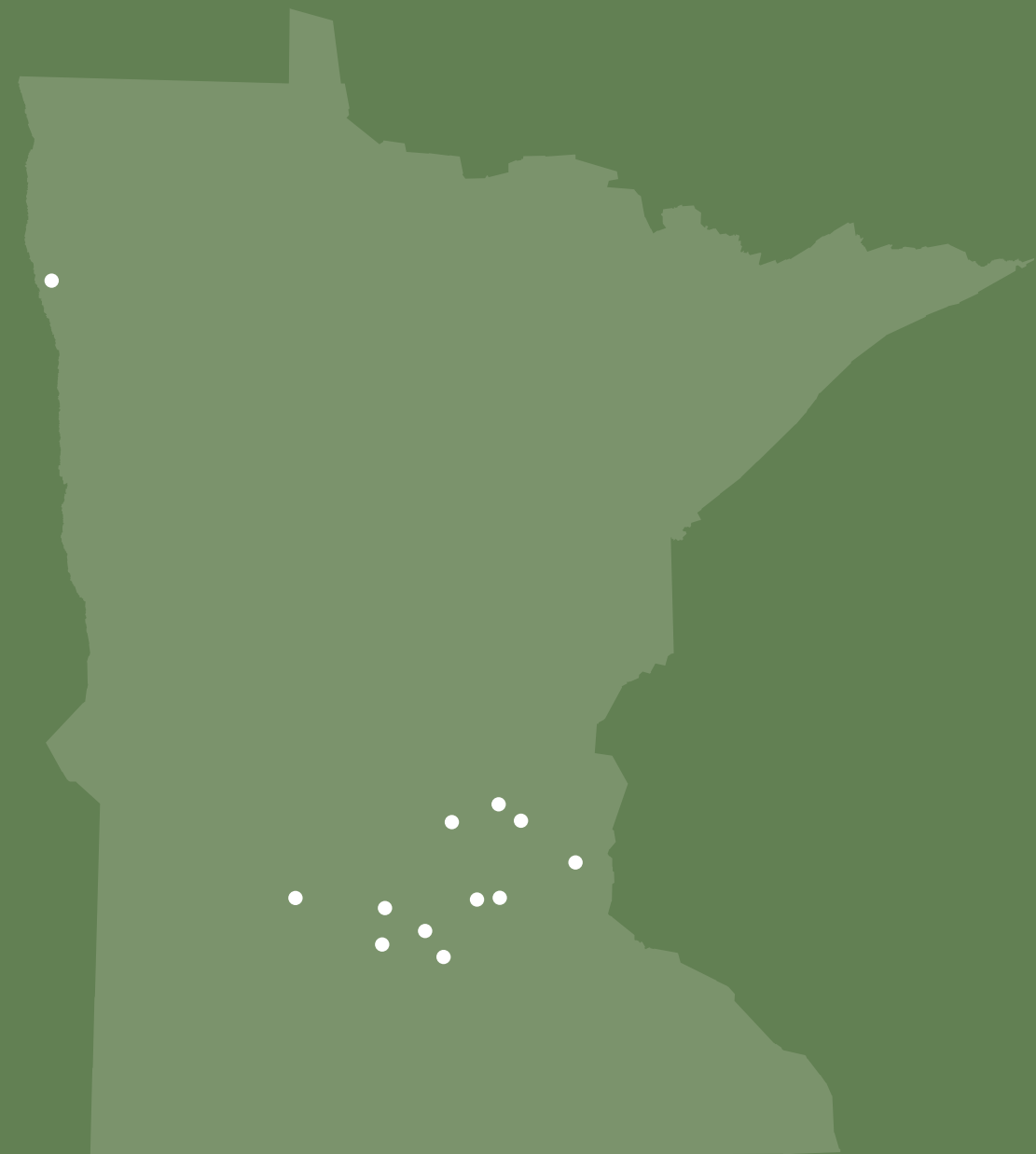




Minnesota Municipal Power Agency

ENERGY EDUCATION WORKBOOK

ELEMENTARY
SCHOOL EDITION



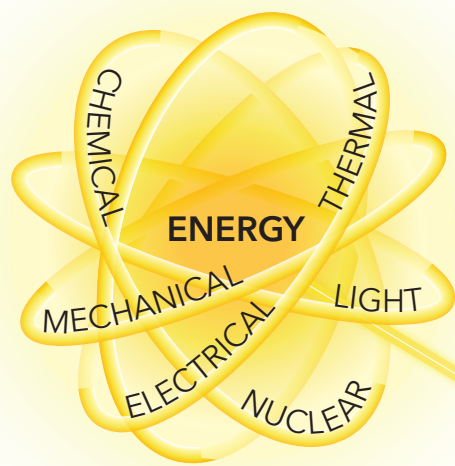
Anoka | Arlington | Brownton | Buffalo | Chaska | East Grand Forks
Elk River | Le Sueur | North St. Paul | Olivia | Shakopee | Winthrop

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Energy and Electricity

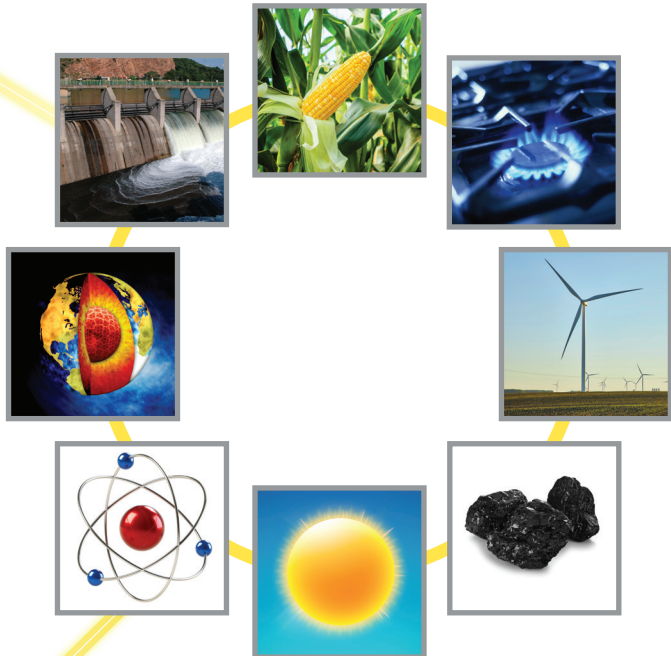
Overview: Energy and Electricity



Energy is the ability to do work and can take a number of forms including: electrical, chemical, mechanical, thermal, light, and nuclear.

Energy cannot be created or destroyed; it can only be transformed from one form of energy to another.

Electricity is a secondary energy source because it is produced by converting primary energy sources such as: natural gas, wind, coal, solar, nuclear, geothermal, hydropower, and biomass into electrical power.





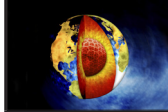


Once electricity is produced, it is transported over electric power lines to homes and businesses.







Renewable and Nonrenewable Energy Sources


Primary energy sources are divided into two categories: renewable and nonrenewable. These energy sources can be converted to produce electricity which is a secondary energy source.

Renewable energy sources are naturally replenished which means they build up again so they won't run out. Many countries in the world are trying to use more renewable energy.

	Solar energy uses heat and light from the sun collected by panels to produce electricity.
	Wind energy uses blowing wind that turns large blades to produce electricity.
	Geothermal energy uses heat from deep inside the Earth to produce electricity.
	Hydropower uses energy from moving water to produce electricity.
	Biomass is organic material from plants and animals used to produce electricity.

Nonrenewable energy sources cannot be easily replenished and will eventually run out. Currently, most of the energy used in the United States is nonrenewable.

	Natural Gas contains methane and is removed from the Earth by drilling wells and burned to produce electricity.
	Coal is a black or brownish-black sedimentary rock that is removed from the Earth by mining and then burned to produce electricity.
	Oil exists in liquid form and is removed from the Earth by drilling, refined, and burned to produce electricity.
	Nuclear energy uses nuclear fission to split uranium atoms to produce electricity.

 **Natural gas, coal, and oil** are fossil fuels formed millions of years ago. Heat from the Earth's core and pressure from rock and soil turned the remains of dead organisms (fossils) into fuel.

Energy Sources Activity

Now that you've learned about different energy sources, let's use that knowledge to complete an activity. Enter the letter of the energy source in the box next to its description on the right.



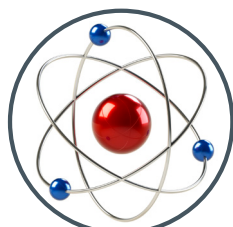
(B) Wind



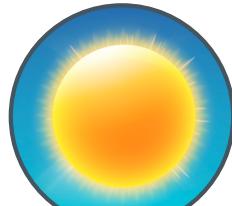
(D) Biomass



(F) Oil



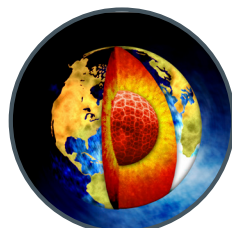
(H) Nuclear



(A) Solar



(C) Natural Gas



(E) Geothermal



(G) Coal



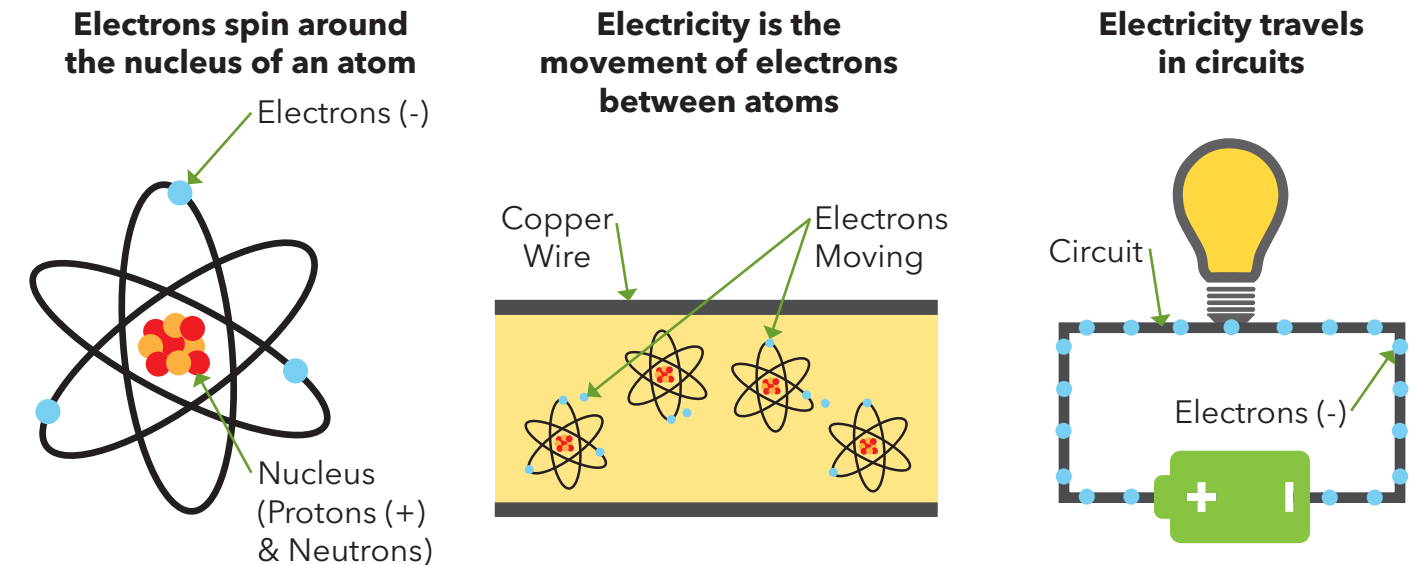
(I) Hydropower

- ☐ Energy from wind turns large blades.
- ☐ This fossil fuel is a black or brownish black rock removed from the Earth by mining.
- ☐ Organic material that comes from plants and animals.
- ☐ This fossil fuel contains methane and is removed from the Earth by drilling wells.
- ☐ Energy from the sun is collected using panels.
- ☐ Uranium atoms are split in a process called fission.
- ☐ Energy from moving water.
- ☐ Energy from heat deep inside the Earth.
- ☐ This fossil fuel exists in liquid form and is removed from the Earth by drilling.

What is Electricity?

Electricity is one of the most common forms of energy we use. It is a secondary source of energy and is neither renewable nor nonrenewable.

Everything in the universe is made up of atoms which are made up of small particles called protons, neutrons, and electrons. Electricity is defined as the movement of electrons between atoms. For electrons to move, they need a complete path known as a circuit.



Measuring Electricity

Electricity is measured in watts, a unit of power named after James Watt (the inventor of the steam engine). A watt is abbreviated by the letter W. A watt-hour is the energy of 1 watt used for 1 hour and is abbreviated by the letters Wh. For example, a 10 watt LED light bulb left on for one hour would use 10 Wh of electricity.

To measure large amounts of electricity like power generated by a power plant, we use kilowatts (kW), megawatts (MW), gigawatts (GW), and terawatts (TW). Kilo means thousand, mega means million, giga means billion, and tera mean trillion.

1,000 W	= 1 kW			
1,000,000 W	= 1,000 kW	= 1 MW		
1,000,000,000 W	= 1,000,000 kW	= 1,000 MW	= 1 GW	
1,000,000,000,000 W	= 1,000,000,000 kW	= 1,000,000 MW	= 1,000 GW	= 1 TW



In 2021, electricity consumption in the U.S. was nearly 3.8 trillion kWh (or 3,800 TWh). That's 13 times higher than in 1950 when total electricity consumption was 291,443 million kWh (or 291 TWh).

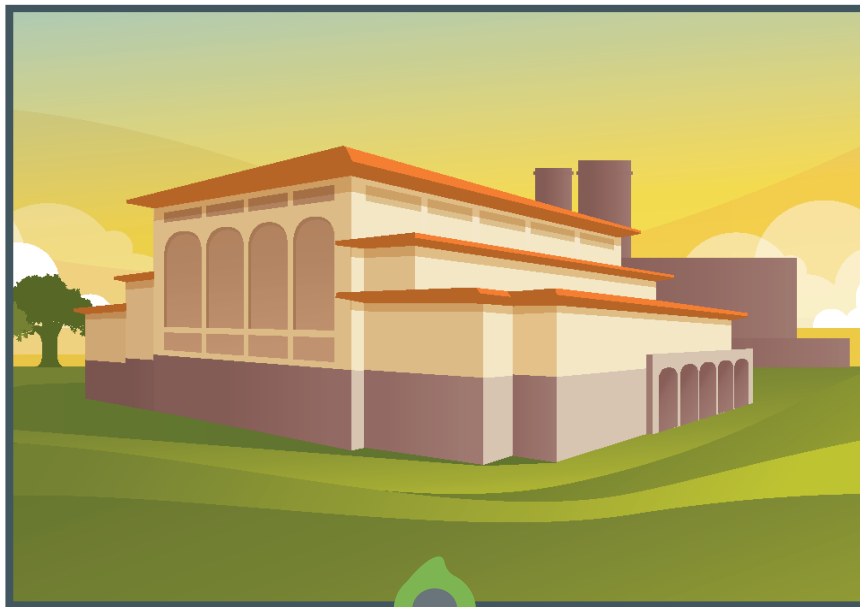
Source: U.S. Energy Information Administration

Delivering Energy

Electricity is produced at power plants and then delivered over electric power lines to customers.

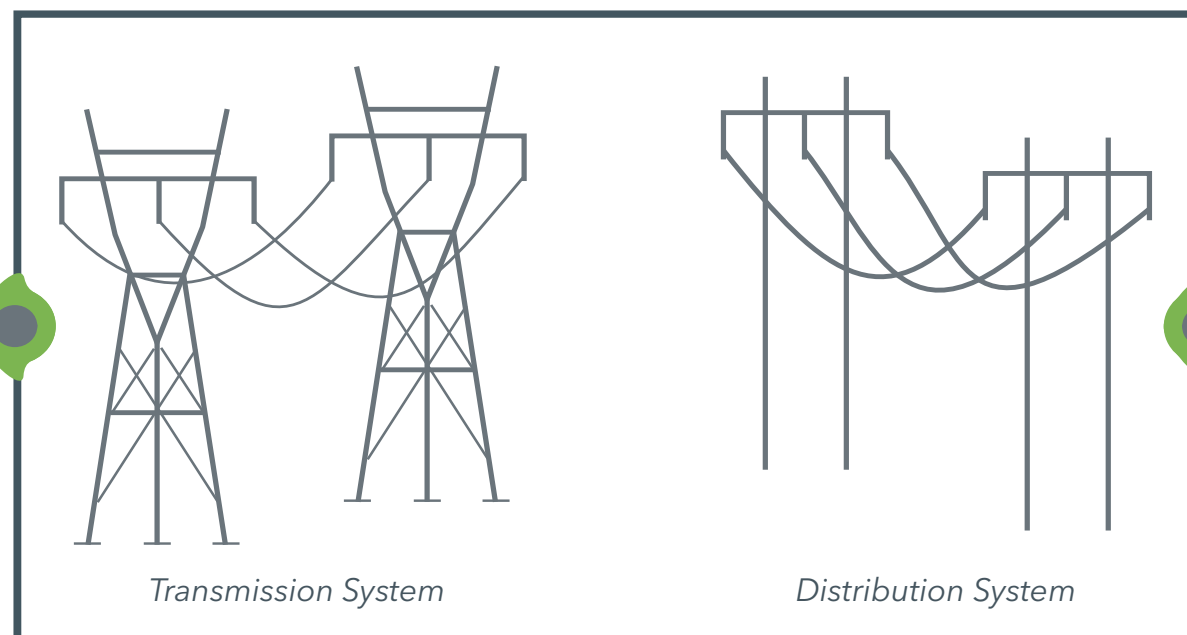
1. Power Plant

Electricity is generated at power plants using renewable and nonrenewable energy sources.



2. Power Lines

Electricity travels from power plants to customers through electric power lines. First, it travels through high voltage transmission lines that can carry electricity for many miles. Next, the voltage is lowered and it flows through distribution lines which deliver the electricity to customers.



3. Customers

Electricity is wired directly into homes and businesses and used to power things such as lights, refrigerators, computers, and air-conditioning.



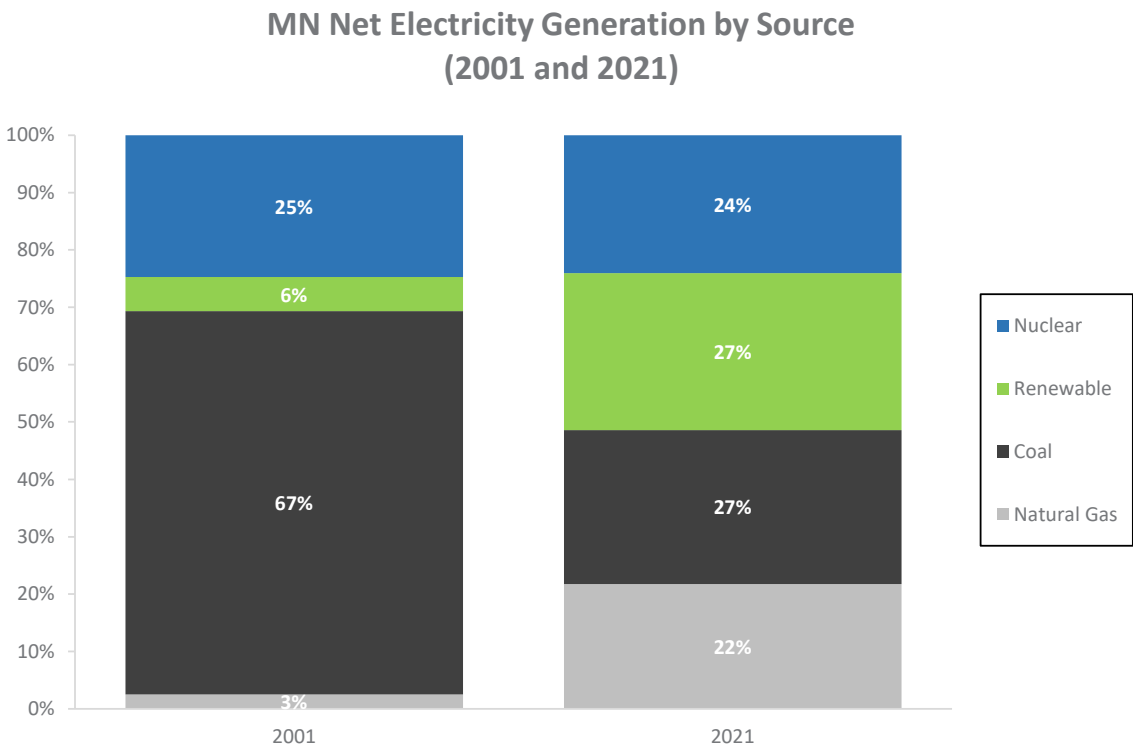
Minnesota's Energy Profile

Electricity Generation in Minnesota


What about the electricity generated in Minnesota? Let's take a look at how energy sources used to generate electricity in Minnesota have changed over the years.

Where Electricity Generated in Minnesota Comes From

Electricity generated in Minnesota comes from a variety of sources. The bar chart below compares the percentage of energy sources used to generate electricity in Minnesota in 2001 and 2021. Notice how the percentages have changed.



	ENERGY WHIZ QUIZ
	1. Which energy source(s) generated the largest share of Minnesota's electricity in 2001?
	<input type="checkbox"/> Nuclear <input type="checkbox"/> Renewable <input type="checkbox"/> Coal <input type="checkbox"/> Natural Gas
	2. Which energy source generated the largest share of Minnesota's electricity in 2021?
	<input type="checkbox"/> Nuclear <input type="checkbox"/> Renewable <input type="checkbox"/> Coal <input type="checkbox"/> Natural Gas



While 27% of Minnesota's electricity was generated from renewable energy in 2021, 73% came from nonrenewable sources (natural gas 22%, coal 27%, nuclear 24%). This means we have more work to do if we want most of our electricity to come from renewable energy.

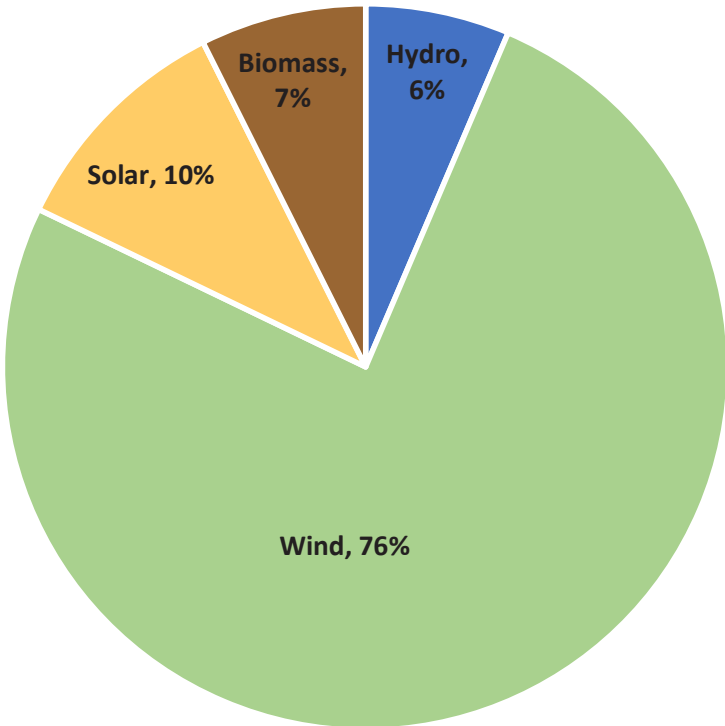
Source: U.S. Energy Information Administration

Let's take a closer look at the renewable energy sources used to generate electricity in Minnesota.

Renewable Energy Sources in Minnesota

The pie chart below shows the percentages of different renewable energy sources used to generate electricity in Minnesota in 2021.

MN Renewable Electricity Generation in 2021



Wind: Open prairies in the southern part of Minnesota are ideal for wind power.

Solar: While you may think of snow before you think of sunshine, Minnesota's solar resources are comparable to parts of Texas and Florida.

Biomass: Rolling plains, farmland, and 17 million acres of forest provide Minnesota with many sources of biomass.

Hydropower: Minnesota has nearly 70,000 miles of natural streams and rivers which are a source of hydropower.

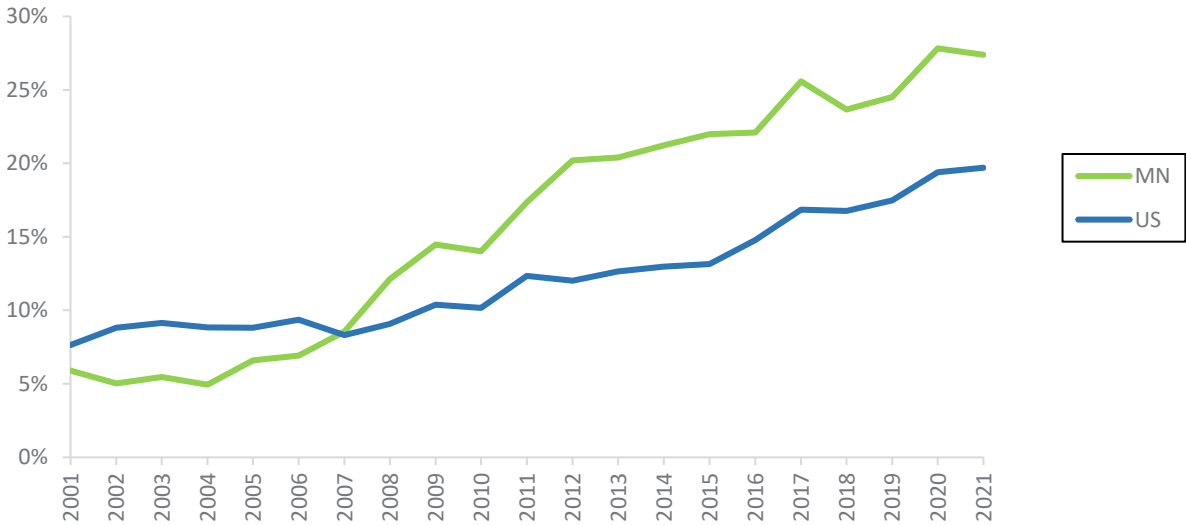
ENERGY WHIZ QUIZ	
1. Which renewable energy source generated the largest share of Minnesota's electricity in 2021?	
	<input type="checkbox"/> Solar <input type="checkbox"/> Biomass <input type="checkbox"/> Hydro <input type="checkbox"/> Wind
2. Which renewable energy source generated the smallest share of Minnesota's electricity in 2021?	
	<input type="checkbox"/> Solar <input type="checkbox"/> Biomass <input type="checkbox"/> Hydro <input type="checkbox"/> Wind

Now that you've learned about the different types of renewable energy sources we have in Minnesota, how does Minnesota compare to the rest of the United States?

How Minnesota Compares to the U.S. Average

In the chart below, the green line shows the percentage of Minnesota's electricity that came from renewable energy sources and the blue line shows the average United States' percentage. Notice how the percentages have changed over the years.

Percentage Renewable Electricity Generation (2001-2021)



ENERGY WHIZ QUIZ	
1. Who had the larger percentage of renewable energy in 2001?	
	<input type="checkbox"/> Minnesota <input type="checkbox"/> United States
2. Who had the larger percentage of renewable energy in 2021?	
	<input type="checkbox"/> Minnesota <input type="checkbox"/> United States
3. What year did Minnesota and the United States have the same percentage?	
	<input type="checkbox"/> 2001 <input type="checkbox"/> 2007 <input type="checkbox"/> 2014 <input type="checkbox"/> 2020

Spotlight: Wind Energy

Wind turbines turn wind energy into electricity. On this page, you will learn about the different parts of a wind turbine and how electricity is generated from wind.

Parts of a Wind Turbine

Tower:

Made from tubular steel, the tower supports the wind turbine. The taller the tower is, the more electricity can be generated because wind speed increases with height.

Blades:

Most turbines have three blades. The longer the blade, the more electricity that can be generated.

Hub:

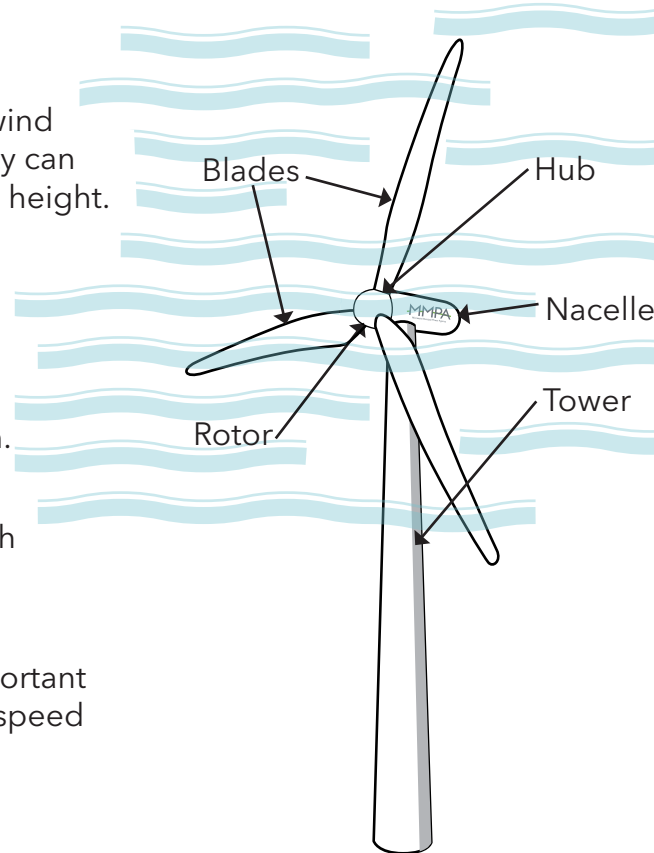
The hub holds the blades and allows them to spin.

Rotor:

Together, the blades and hub form the rotor which connects to the generator.

Nacelle:

The nacelle contains the generator and other important equipment including the gear box, low and high-speed shafts, controller, and brake.



Generating Electricity from Wind

1. Uneven heating of the Earth by the sun causes wind.

The Earth's surface is made up of land and water which absorb the sun's heat differently. This uneven heating causes wind.

2. Turbine blades rotate to create energy.

When wind blows across the blades of a wind turbine, it makes them spin. The blades are part of the rotor, which is connected to the main shaft that spins a generator.

3. A generator creates electricity.

The gear box inside the nacelle uses a large and small gear. The larger gear powers the smaller gear to turn at a faster pace, which rotates the generator to create electricity.

4. Electricity is sent over electric power lines and delivered to homes and businesses.

Power lines deliver electricity from the wind turbine to customers.



Wind turbines are not large fans. Fans use electricity to make wind. Wind turbines use wind to make electricity.

Spotlight: Solar Energy

Solar cells turn energy from the sun into electricity. On this page, you will learn about the different parts of a solar power system and how electricity is generated from the sun.

Parts of a Solar PV System

Photovoltaic (PV) Panels:

PV panels are also called solar panels. These panels are made up of PV cells (also called solar cells) that convert sunlight directly into electricity.

Array:

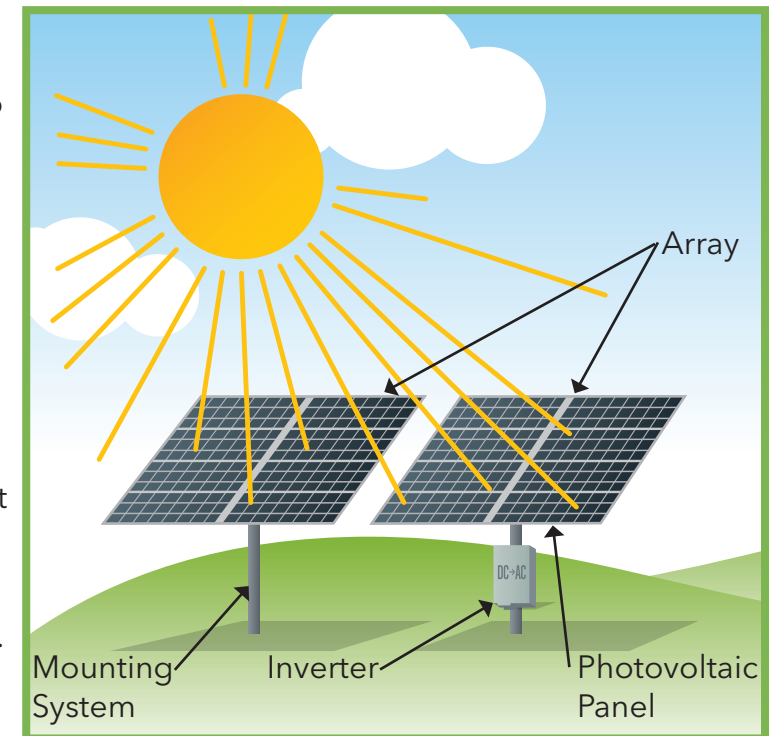
Multiple solar panels connected together are called an array. The size of the array determines how much electricity can be generated.

Inverter:

The inverter converts electricity from direct current (DC) to alternating current (AC).

Mounting System:

Solar arrays are mounted on a stable base. Some mounting systems allow PV panels to tilt and turn so they're always pointed toward the sun during the day.



Generating Electricity from the Sun

1. The sun produces solar energy.

Heat and light from the sun produce solar energy.

2. Solar panels convert solar energy into electricity.

PV panels collect light from the sun and convert it into electricity. The type of electricity produced is DC which only flows in one direction.

3. An inverter converts the electricity from DC to AC.

Most buildings use AC which is electricity that changes direction. An inverter takes the DC electricity generated by the solar panels and converts it into AC so that it can be used.

4. Electricity is sent over electric power lines and delivered to homes and businesses.

Power lines deliver electricity from solar power systems to customers.



The sun has produced energy for billions of years. It is essential for all of the energy sources and fuels that we use today.



The Power of Your Hometown

Where Your Electricity Comes From

In the previous sections of this workbook, you learned about different energy sources, how they're used to produce electricity, and how electricity is delivered from power plants to the people who use it. On this page, you can see the types of energy sources MMPA uses to produce electricity and how power gets from MMPA to your local utility and then to your home.

1. MMPA'S POWER SUPPLY



Faribault Energy Park
300 MW, Natural Gas



Black Oak Getty Wind Farm
78 MW, Wind



Minnesota River Station
49 MW, Natural Gas



Shakopee Energy Park
46 MW, Natural Gas



Oak Glen Wind Farm
44 MW, Wind



Hometown BioEnergy
8 MW, Biomass



Buffalo Solar
7 MW, Solar



Hometown WindPower
1.9 MW, Wind



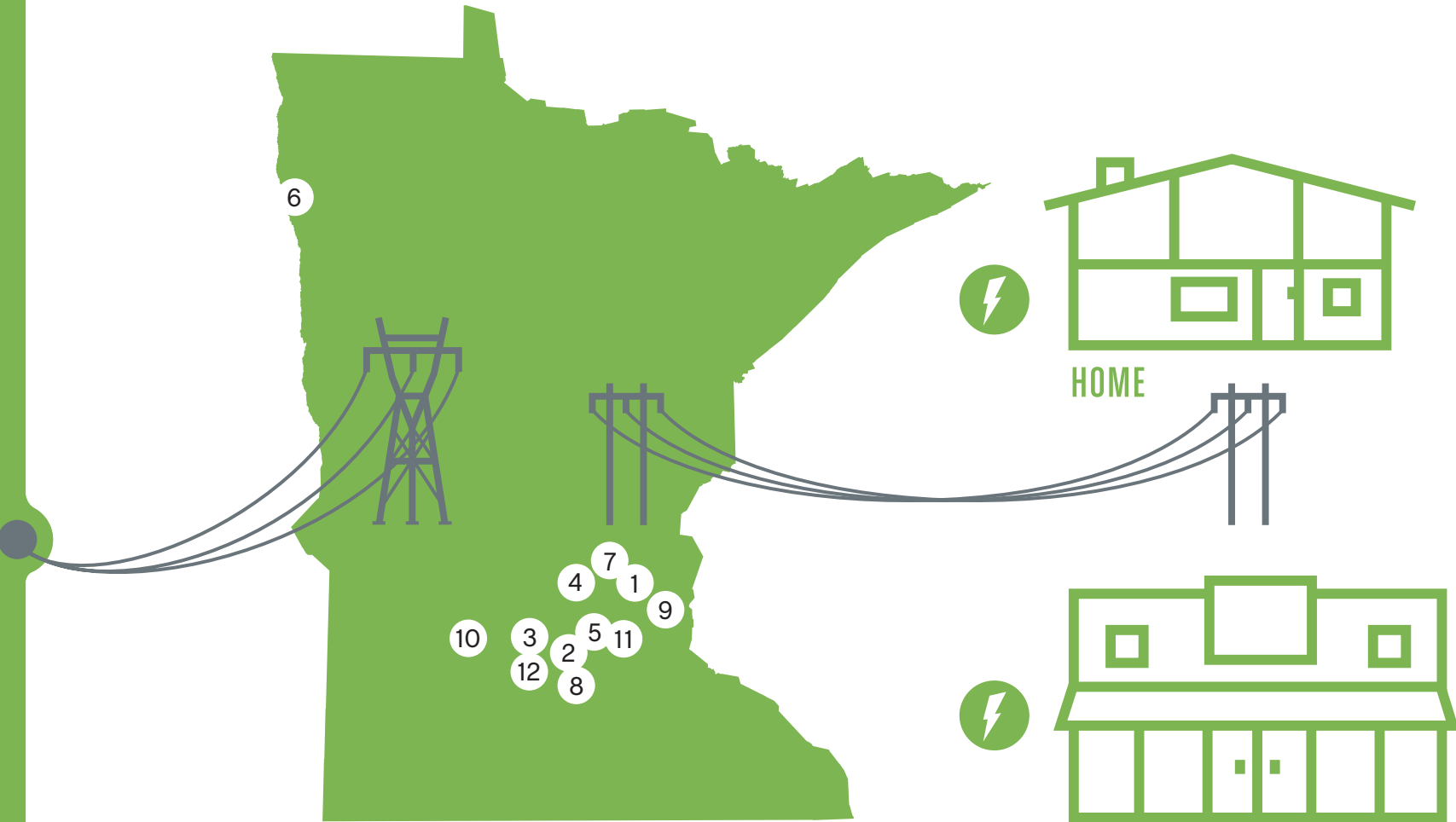
Walleye Wind Farm
110 MW, Wind

2. TWELVE MEMBER UTILITIES

MMPA provides electricity to its 12 member utilities.

3. YOUR HOMETOWN

Your local utility delivers and sells the electricity it buys from MMPA to your hometown.



- | | |
|---------------------|-------------------|
| 1. Anoka | 7. Elk River |
| 2. Arlington | 8. Le Sueur |
| 3. Brownton | 9. North St. Paul |
| 4. Buffalo | 10. Olivia |
| 5. Chaska | 11. Shakopee |
| 6. East Grand Forks | 12. Winthrop |

Spotlight: Faribault Energy Park

Faribault Energy Park (FEP) is MMPA's largest power plant. FEP runs during periods of higher demand for electricity, when other sources of energy are more expensive.



FEP Features and Facts

- 300 MW combined-cycle power plant using natural gas and steam to produce electricity
- 185 MW is generated from the gas turbine and 115 MW is generated from the steam turbine
- Operates efficiently with low emissions

Not Just a Plant but a Park

FEP began operation in 2007, but it's not just a power plant. People are welcome to visit the facility's 35 acres and explore walking trails where you'll see a wind turbine and solar array. You can even drop a fishing line into one of the ponds! Scheduled tours are also available and provide views of the control room and steam turbine.



The average home in Minnesota used 9,312 kWh in 2021. If FEP produced electricity at maximum capacity (300 MW) for a whole year, it would be enough to power over 282,000 homes, with over 108,000 powered by the steam turbine alone.

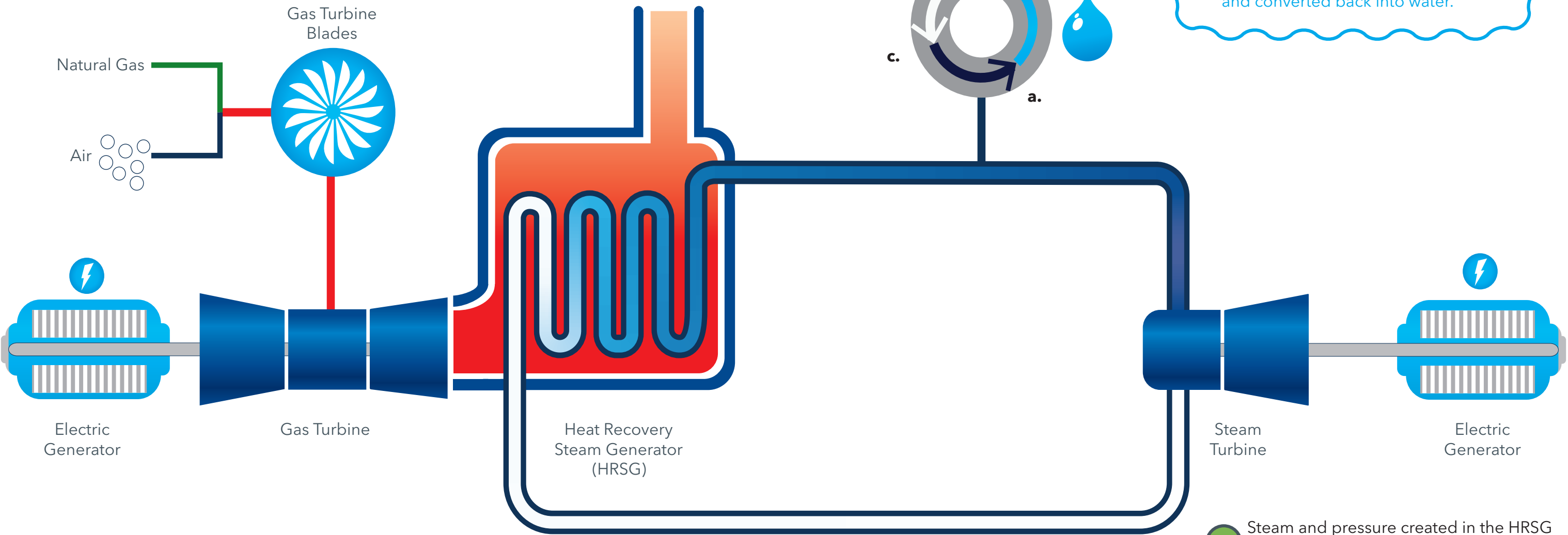
Source: U.S. Energy Information Administration



How FEP Generates Electricity

FEP is a combined-cycle power plant. A combined-cycle power plant uses both gas and steam turbines to produce electricity. At FEP, excess heat from the gas turbine is used to power a steam turbine, generating more electricity without any additional fuel.

1. Air and natural gas are burned, creating heat and pressure which makes the gas turbine blades turn.



How Water is Used in a Steam Turbine

- a. Water travels through tubes.
- b. Using excess heat from the gas turbine water is heated and converted to steam.
- c. After steam is used to power the steam turbine, it's condensed, cooled, and converted back into water.

2. Turbine blades are connected to a drive shaft that spins the electric generator and produces electricity.

3. Instead of just releasing heat up an exhaust stack, the heat is used to make steam in the Heat Recovery Steam Generator (HRSG).

4. Steam and pressure created in the HRSG are then used to turn the steam turbine blades and its electric generator.



Water exists in three different forms: solid, liquid, and gas. To convert water from one form to another, all you have to do is change its temperature or pressure.

Energy Conservation

How We Use Electricity at Home

Energy conservation means taking actions to reduce your energy use. To understand how to conserve (not waste) energy, we must first pay attention to how we use electricity.

Below is a list of some common household items that use electricity. Place a check next to the 3 items you think use the most electricity.

- ☐ lighting
- ☐ space heater
- ☐ television
- ☐ air conditioner
- ☐ toaster
- ☐ fan
- ☐ microwave
- ☐ video game console
- ☐ refrigerator

Devices Use Electricity Differently

Anything plugged in uses electricity. However, devices use electricity differently. Think about a toaster and a refrigerator.

	A toaster uses electricity while you're using it. Most toasters are used less than 15 minutes a day.		A refrigerator uses electricity when it needs. Most refrigerators actively run about 8 hours a day.
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As a result, a refrigerator uses more electricity over the course of a year than a toaster. Similarly, ovens and stoves use more electricity than microwaves (because microwaves cook foods faster).

Is It Really Off?

What if a device is plugged in, but turned off? Even if they're turned off, devices with an illuminated display (digital clock, status light) continuously use electricity if they're plugged in. Electricity used by devices that are turned off but still plugged in is called phantom load and the Department of Energy estimates it can account for as much as 10% of the electricity we use!¹

	ENERGY WHIZ QUIZ
	What are 3 items you can think of in your home that use electricity even when they're turned off? Hint think of things that have a digital clock display or small light that stays on.
	1.
	2.
	3.

Source¹: Lawrence Berkeley National Laboratory, <https://standby.lbl.gov/>

How We Can Save Energy at Home

In the previous section, you learned about things that use electricity in our homes. In this section, we'll look at things we can do to save energy.





Energy Conservation and Energy Efficiency

Energy conservation and energy efficiency are both ways we can reduce our energy use. Energy conservation involves us and the actions we take to reduce the amount of energy we use. Energy efficiency involves devices and how they work. If you replace an old light bulb with a new LED light bulb that uses less electricity, you are conserving energy by using an energy efficient device.

By conserving energy, we help the environment by reducing greenhouse gas emissions and eliminating the need to build additional power plants. Saving energy also saves money. By using less electricity, your monthly electric bill will be less.

Tips for Saving Energy

We save energy by not wasting energy. Here are some ways you can save energy.

	Unplug It	<ul style="list-style-type: none">Unplug cell phones, gaming systems, and tablets after they are charged.Unplug charging cables not being used.Unplug devices that you don't regularly use.
	Turn It Off	<ul style="list-style-type: none">Turn off fans and lights in unoccupied rooms.Plug things like TVs and gaming systems into power strips and switch them off when you're not using them.
	Turn It On	<ul style="list-style-type: none">Use energy efficient LED light bulbs.Set the thermostat to 78 degrees or higher in the summer.Purchase ENERGY STAR® appliances that use less energy.Install smart, programmable thermostats.
	Cool It Down	<ul style="list-style-type: none">Run ovens, dishwashers, and clothes dryers during the cooler part of the day since they give off heat.Use fans to help make rooms feel cooler.Close window blinds and curtains during hot days.




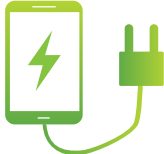





If a large number of people make small changes in their daily lives to not waste electricity, then large amounts of electricity can be saved.

Home Energy Audit

By conducting a home energy audit, you learn how you use energy now and find ways to save energy in the future. This exercise is to be completed with a grown up.

INSTRUCTIONS: Read through the questions below and enter the number that best matches your answer in the box on the right. Then calculate your score by adding up the numbers.

	How often are lights left on in rooms that aren't being used? Rarely: enter 1 Sometimes: enter 2 Almost Always: enter 3	
	How often is the TV left on when no one is watching it? Rarely: enter 1 Sometimes: enter 2 Almost Always: enter 3	
	Are most of the light bulbs used in your home LED? Yes: enter 1 Unsure: enter 2 No: enter 3	
	How often are devices left plugged in overnight to charge? Rarely: enter 1 Sometimes: enter 2 Almost Always: enter 3	
	Count the number of chargers plugged into an outlet but not being used. How many are there? None: enter 1 One or Two: enter 2 Three or More: enter 3	
	Count the refrigerators in your home. How many are there? One: enter 1 Two: enter 2 Three or More: enter 3	
Add Up Your Score Here		

If your total was 12-18 Points, you're an **ENERGY USER**

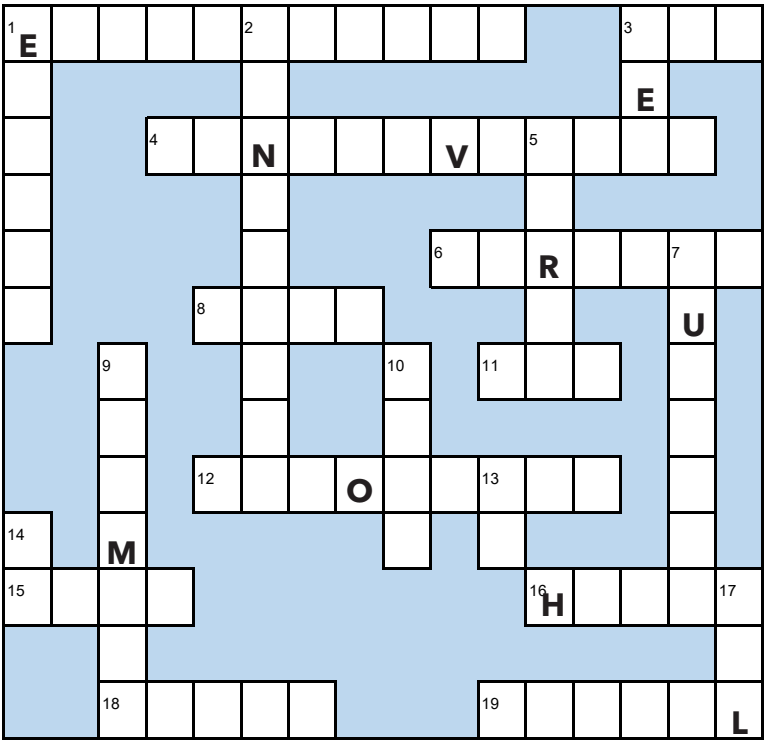
Now that you've learned ways to save energy, you can start changing the way you use it.

If your total was 6-11 Points, you're an **ENERGY SAVER**

Great job saving energy! Continue to look for new ways to save energy.

Energy Whiz Crossword Puzzle

Energy Whiz Crossword Puzzle



ACROSS:

- _____ is the movement of electrons between atoms and one of the most common forms of energy that we use.
- Natural _____ is a nonrenewable energy source that contains methane and is removed from the Earth by drilling wells and burned to produce electricity.
- Energy _____ involves doing things to reduce the amount of energy we use.
- At FEP, excess heat from the gas _____ is used to power a steam turbine.
- A _____ is a unit used to measure electricity that is abbreviated with the letter W.
- _____ is the abbreviation for light-emitting diode. These light bulbs use less electricity than incandescent light bulbs.
- Primary energy sources can be converted into electricity which is a _____ energy source.
- _____ is a nonrenewable energy source that is a black or brownish-black sedimentary rock extracted from the Earth and burned to produce electricity.
- _____ power is a renewable energy source using energy from moving water to produce electricity.
- _____ energy is a renewable energy source that uses heat and light from the sun to produce electricity.
- _____ fuels were formed millions of years ago. Examples include natural gas, coal, and oil.

DOWN:

- _____ cannot be created or destroyed and can only be transformed from one form to another.
- _____ energy sources are naturally replenished which means they build up again so they won't run out.
- _____ thermal energy is a renewable energy source that uses heat from deep inside the Earth to produce electricity.
- Number of blades most wind turbines have.
- _____ energy is a nonrenewable energy source that uses uranium to produce electricity by splitting atoms (a process called fission).
- _____ is an organic material that comes from plants and animals that is used to produce electricity.
- _____ energy is a renewable energy source that uses blowing wind that turns large blades to produce electricity.
- The abbreviation for alternating current.
- The abbreviation for direct current.
- _____ is a nonrenewable energy source that exists in liquid form and is removed from the Earth by drilling, refined, and burned to produce electricity.



220 S. 6th Street, Suite 1300, Minneapolis, MN 55402
Phone 612.349.6868 Fax 612.349.6108