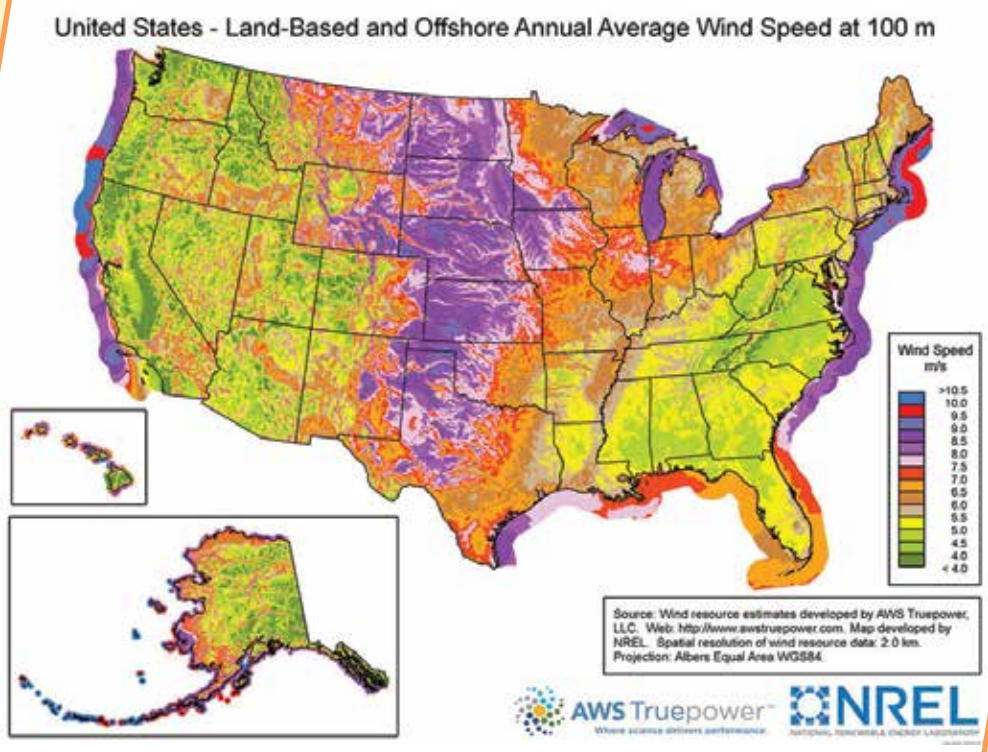
EXPLORATION

Where and Why Does the Wind Blow?

Examine
the map and the key.

Most sources say that areas with annual average wind speeds greater than 6.5 meters per second at 80 - 100 m are suitable for utility scale wind farms. Go to the U.S. Department of Energy's Wind Powering America web site to find more information. You can find wind maps for 50 m and 30 m. You can also find maps and information about projects that are specific to any state.



There are dynamic wind energy resource maps and Geographic Information Systems (GIS) data available from National Renewable Energy Laboratory (NREL) Regional maps are also available. Visit *The Power of the Wind* online at *www.4-H.org/curriculum/wind.*

For additional information in your community contact your library, science teachers, or local/regional planning district commission.

In Your Engineering Notebook

write or sketch answers to questions you find important or interesting.

Which colors on the map indicate greater wind resources?

Which areas of the U.S. have average wind speeds higher than 6.5 m/s?

Which parts of the Midwest have wind speeds greater than 7.5 m/s?

Which states have low average wind speeds?

Why does this map give annual average wind speeds at 100 meters? Why do some other maps give wind speeds at 30 m or 50 m?

Talk About It

- What do you notice about the wind resources near the coasts? Where are offshore wind farms being considered?
- What do you know about the geography of California that might explain the variety of wind speeds in that state?
- Examine the map in Appendix G to discover how the wind blows in Illinois. Find similar maps of your state.
- What is the average wind speed near your community?
- How could wind turbines transfer the energy from the sun into electricity? Draw a diagram in your engineering notebook.
- What did you learn from the turbine you built about the importance of wind speed for producing electricity? What other factors are important?

Learning from Others

- How can you share information about wind energy potential in your state with members of your community?
- Why would this information be important to share?

Thinking about Wind Power as Solar Power

Wind power is really a form of solar power. Winds are caused by uneven heating of the surface of the earth.

Land heats up more quickly than water and water keeps its heat longer.

Air expands as it warms. When this same mass of air expands, it takes up more space and becomes less dense. Cooler and denser air then pushes in below the warm air mass and pushes it up.

Wind Power Timeline

1970 — Higher oil prices spurred search for cheaper energy sources

1980 — First large U.S. wind farm at Altamont Pass, CA

1990 — More than 2,200 **megawatts** of wind energy capacity installed in California

2000 — Global wind energy capacity reached 31,000 megawatts

U.S. installed more new wind energy capacity (2,431 megawatts) than any other country in the world

In U.S. 16,596 megawatts of wind energy are produced in 36 states.

2010 — In U.S. 60, 078 megawatts of wind energy are produced in 39 states.

Iowa wind turbines produced 27.4% of the state's electricity

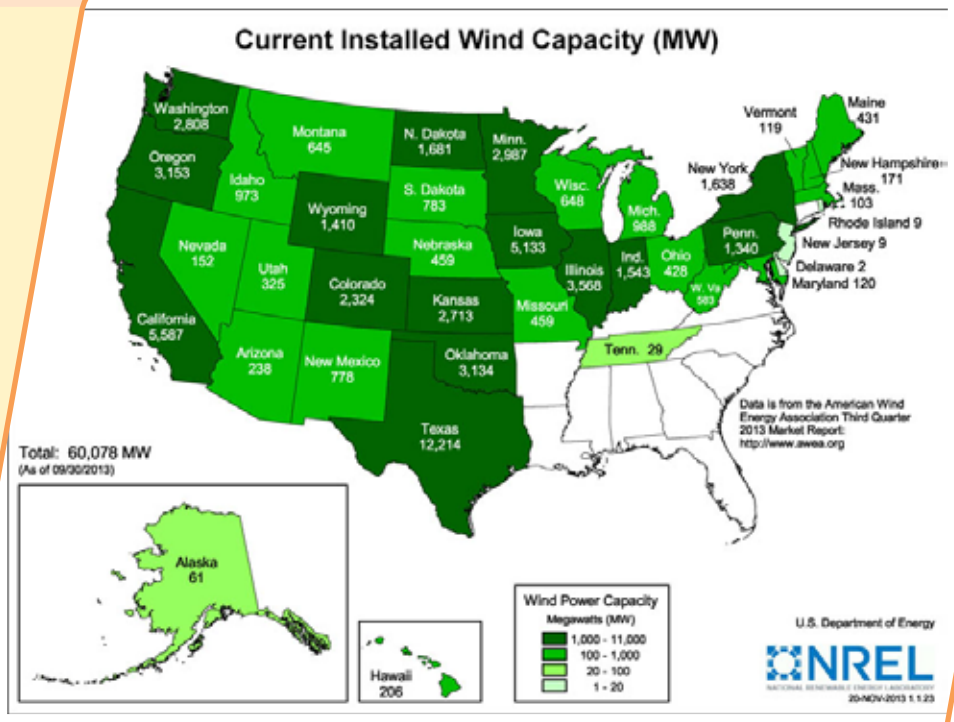
EXPLORATION

Where Are the Wind Turbines?

Examine
the map and the key.

View an animated version of this map and other maps of installed wind capacity at ***www.4-H.org/curriculum/wind***

Get information about wind energy in individual states by visiting *The Power of the Wind* online and searching for the Wind Powering America's State Wind Activities.



Wind Powering America is an initiative of the U.S. Department of Energy, Energy, Efficiency and Renewable Energy.

In Your Engineering Notebook

write or sketch answers to questions you find important or interesting.

How does this map compare with the Wind Resource Map on page 26? Compare this information with the information on the Wind Powering America web site, found at ***www.4-H.org/curriculum/wind***. Why has this information changed over time? What social, economic, and environmental factors might have influenced this data?

Which states have the most installed wind power capacity? Why do you think these states have the most wind installations? What factors, other than available wind, influence where wind turbines are built?

Nebraska has good wind resources. Why do you think there are fewer wind turbines there?

Go to the Wind Powering America State Wind Activities web site and view the information for your state or another state. Write about wind-related news.

Talk About It

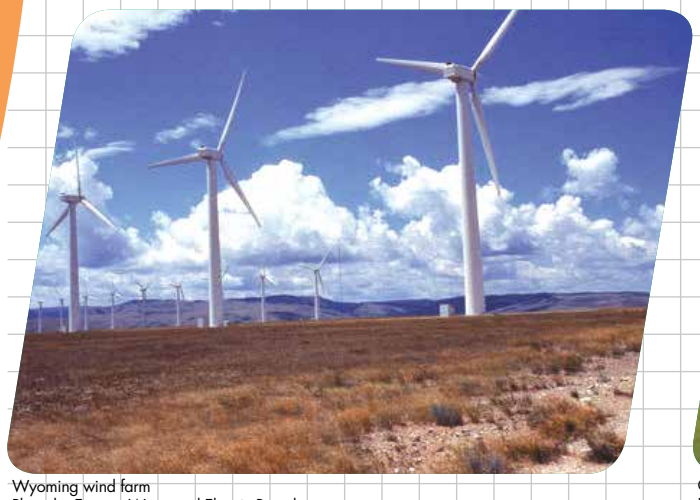
- Suggest some places in your state or community that could be considered for a wind farm. What places might not be ideal locations for a wind farm? Explain your choices.
- Why might people in your community be for or against the development of a wind farm in these areas? Are there social reasons? Economic? Cultural?
- How might community members from different professions collaborate to bring wind energy to their area?
- How can you help community members understand wind as a renewable energy source? Compose a news article for your local paper that would help community members learn about wind power.
- Wind is variable and does not always blow when electricity is needed. This is one of the reasons that wind cannot be our only power source. Scientists are working to find a practical method for storing electricity, but for now nearly all of our electricity is generated when we need it. Do research to find out more about how electricity is generated and delivered to meet the demands of communities and about new ideas for energy storage.

Learning from Others:

ORGANIZE A DEBATE

Work with your facilitator or adult leader to organize a debate or town hall meeting to explore the issues associated with building and operating wind turbines in your community.

- Choose a topic such sound, aesthetics, habitat protection, construction of turbines, economic impacts of turbines, or your local electrical supply needs.
- Take a pro or con position on the topic and research the facts that support each side of the topic.
- Write a logical argument in your notebook.



Wyoming wind farm
Photo by Eugene Water and Electric Board,
courtesy of the NREL Photographic Information eXchange

Cleveland, Ohio
Photo by Tom Maves, courtesy of the NREL Photographic Information eXchange

EXPLORATION

What Are Some Facts About Wind Farms?

The Mendota Hills Wind Farm

near Paw Paw, Illinois was the first Illinois wind farm. It began operating in November, 2003 and consists of 63 turbines that have a total capacity of 51.7 MW. Each tower is 214 feet tall, and the nacelle or housing is about the size of a small school bus. For more information on Illinois wind power, see Appendix G.

The turbines are located on land owned by several area farmers. The wind farm is spread over 2,600 acres, but the turbines and roads to them use only thirty-one acres. It is estimated that this wind farm produces approximately 125,000,000 **kilowatt hours** (kWh) of electricity every year.

There were 2195 wind turbines in Illinois at the end of 2013. Only three other states had more installed wind power. During 2012 wind provided 3.9% of the electricity used in Illinois.

Research a wind farm in your state or a nearby state.

How many turbines are there?

How tall are they?

How long are the blades?

What is the total power capacity?

How many houses do they provide power for?

Where are they located?

Twin Groves Wind Farm

is located in eastern McLean County, Illinois. Its 240 (1.65 MW) turbines have the potential to power about 120,000 homes. However, because wind is variable, wind turbines cannot be the only generation source. The best solution to high electricity need is a variety of energy sources.

Talk About It

- The person standing near the wind turbine is six feet tall. About how tall is the tower?
- Use a ruler and calculator to estimate the height of the tower. Calculate the length of the blades.
- How far does the outer tip of the blade turn in one revolution?
- If the turbine is spinning at 25 rpm, about how fast is the tip of the blade turning?
- Why are wind turbine towers so tall?
- Is this a high or low solidity turbine? What does this tell you about its ability to lift a load or produce electricity?
- How have wind farms changed since 2003?
- View a turbine in action at ***4-H.org/curriculum/wind***

Learning from Others

- List some ways that wind farms could be important to a community.
- Would you like a wind farm like the one in Mendota Hills located in your community? Why or why not?

Career Connections

Make a brochure of different careers that are required to build a wind farm. Include descriptions of careers, technologies they used, and educational requirements. Include other interesting facts that you think are important.

EXPLORATION

How Do Schools Use Wind Power?

Read

about these schools that have installed wind turbines to produce all or part of their electricity. Look for important data about the schools and fill in the School Wind Power Table below. Research at least two other school wind turbine projects and expand the table to add that information.

Photo courtesy of Tami McInroy, Forest City High School, Forest City, Iowa

A classroom's 32 fluorescent tubes need about 1 kW of power. Eighteen computers require about 3 kW.

CASE STUDY 1
Forest City, Iowa

The wind turbine at Forest City Community School District began as a high school physics project. Students and their teacher became interested in exploring the possibility of installing a turbine during a study of wind power. They were able to install an **anemometer** at the top of their water tower and collected wind data for one year.

The data showed that the wind speed at this site was high enough to support a wind turbine, so they investigated further. One student did a study of the costs and benefits of installing a wind turbine, and he and his teacher presented their work to the school board. The school board and school administrators continued the project in cooperation with the Forest City government and the Forest City Municipal Utility, and the 600 kW turbine began producing electricity in January 1999.

The turbine supplies approximately half of the school district's electricity, and according to Superintendent Darwin Lehmann, the resulting reduction in electricity costs consistently adds sufficient funds to the district's budget every year to pay the salary of an additional experienced teacher.

In 2004 the district installed a **geothermal** heating and cooling system and it is currently investigating adding a second turbine.

School Wind Power Table

School Name	Number of Turbines	Production Capacity of Turbines	Value of Electricity Produced Per Year	% of District's Electricity Needs	Year the Turbine Began Producing Electricity	Benefits from the Program
Forest City Community						
Erie Community Unit School District						
Spirit Lake Community						

CASE STUDY 2
Erie, Illinois

The 1.2 MW Vensys wind turbine first produced power for Erie Community Unit School District #1 in September 2008. The turbine provides energy to all four attendance centers in the district and is unusual because it uses only one wind turbine to generate energy for an entire school district with several buildings. Since the district's peak electrical load is only 0.8 MW, the turbine has the capacity to put energy back into the grid. In five and a half years of operation, the Erie turbine has produced 6.2 million kWh of energy. It would take approximately 2,500 tons of coal to produce this same amount of electricity from a coal-fired power plant. This environmentally friendly project is a great learning tool for the students. It provides a variety of learning opportunities on everything from the environment and alternative energy sources to electricity and geometry.

Setting the Inbed Ring to construct the tower.

The $3.6 million project was partially funded by a $720,000 grant from the Illinois Clean Energy Community Foundation, reducing the project cost to $2.88 million. Even though the turbine has saved the district over $100K annually in electrical costs, there have been maintenance and repair costs that have reduced the annual financial savings for the district. The district has experienced a total net savings of $55,000 - $105,000 per year.

For more information about wind turbines and schools go to:
www.4-H.org/curriculum/wind

Wind Power Numbers

Wind turbine power is measured in kilowatts or megawatts. Turbine capacity can range from 20 watts to 8 MW. According to the U.S. Department of Energy a 1.5 MW wind turbine will produce approximately 5,000,000 kWh per year, which is enough to power about 500 homes for that year. How do the sizes of the various turbine projects compare? How has turbine power changed over the past few decades?

Offloading sections of the tower.

EXPLORATION

How Do Schools Use Wind Power?

Career Connection

Iowa Lakes Community College at Estherville, Iowa installed a 1.65 MW turbine in 2005. The main reason for the turbine is to offer students the opportunity to become skilled technicians for the wind industry.

The college was first in the U.S. to offer an Associate in Applied Science degree in Wind Energy and Turbine Technology. Many other community colleges now offer similar programs

CASE STUDY 3
Spirit Lake, Iowa

Spirit Lake Community School District was the first school in the United States to be wind powered. In July 1993 the 250 kW turbine installed at Spirit Lake Elementary School began producing electricity. This turbine was so successful that the district installed a second larger turbine. This 750 kW turbine has been producing electricity since October 2001. **The two turbines provide enough electricity to power much of the school district's facilities and athletic fields.** The school district has agreements with Alliant Energy so that when the turbines produce more energy than the school district uses, Alliant purchases the excess. When the district needs more than the turbines produce, it purchases it from Alliant. There are two different contracts for the two turbines, but in each case Alliant purchases the energy for less than it sells it. The money that the school district saved on the electricity bill paid for the turbines until the loans were completely paid back. Now the district has additional savings from the turbines to use for the educational program.

The turbines save the school district money and reduce pollution. By using electricity that is not produced by burning coal or oil, the Spirit Lake Community School District reduces carbon dioxide emissions by over 2.5 million pounds per year. Carbon dioxide is produced when fuels are burned and its buildup in the atmosphere contributes to global warming by trapping the sun's rays. For more information about wind turbines and schools go to: ***www.4-H.org/curriculum/wind.***

Talk About It

- How did the students and teachers get started thinking about using wind turbines for energy?
- What community groups were involved with the students and teachers? Why is it important to have community support?
- What do you think the students learn from the school wind projects?
- Analyze the data you recorded in the School Wind Power Table on page 32. How are the school projects similar? How are they different? Which school seems to be getting the most out of its wind power project? Justify your answer.
- Use some of the data from your table to make bar graphs to help illustrate important facts.

Learning from Others

- What are some benefits to a school that installs a wind turbine?
- What limitations might they consider before installing a wind turbine?
- What are some environmental benefits of wind power?
- What are some environmental concerns of wind power?
- How could you use the experiences of these schools to begin investigating wind power as a possibility for your school?
- How can you make sure that everyone's opinion is respected as you explore wind energy options?

McGlynn Elementary and Middle School, Medford, Massachusetts Photo by Northern Power Systems, NREL 16728

Wind for Schools Project

Wind Powering America launched the Wind for Schools project in 2005. The first small turbine was installed in Colorado and during the eight years of the project, 134 schools in eleven states participated. The typical Wind for Schools turbine was a SkyStream 3.7, 2.4-kilowatt wind turbine. The project offered training and curricula to teachers and also established Wind Application Centers at colleges and universities in those states. Students at the Wind Application Centers assisted the K-12 schools with their turbine installations while they attended classes in the wind energy field. Additional states may receive support services through the Statewide Wind for Schools Affiliate Project.