REVIEWED & RECOMMENDED
National 4-H Curriculum

NATIONAL 4-H CURRICULUM
Product Number 08384

# THE POWER OF THE *Wind*

## FACILITATOR'S GUIDE

18 USC 707

# Acknowledgments

**Author**
Jana Sebestik, Curriculum Specialist, Office for Mathematics, Science, and Technology Education (MSTE) in the College of Education at the University of Illinois at Urbana-Champaign

**Engineering Consultant**
Susan M. Larson, Ph.D., Associate Professor of Environmental Engineering and Assistant Dean and Director of the Women in Engineering Program in the College of Engineering at the University of Illinois at Urbana-Champaign

**Project Director 2008**
Kathleen Jamison, Ph.D., 4-H Curriculum and Learning, Cooperative Extension Service, 4-H Youth Development, Virginia Tech

**Wind Energy Science Reviewers 2008**

Phil Dougherty, National Coordinator, Wind Powering America, U.S. Department of Energy

Alan Friedman, Ph.D., Noyce Foundation Board Member; Former director of New York Hall of Science

Carol D. Hanley, Ed.D., Director of Education and Communications, Cooperative Extension Service, 4-H Youth Development, University of Kentucky

Stephen Miner, Education Director, American Wind Energy Association

Ron Rebenitsch, Basic Electric Power Company, Bismarck, North Dakota

George Reese, Ph.D., Director, Office for Mathematics, Science, and Technology Education (MSTE) in the College of Education at the University of Illinois at Urbana-Champaign

**Youth Development Reviewers 2008**

William J. Million, Extension Specialist, 4-H Youth Development, University of Illinois Extension

Madonna Weese, Ed.D., Extension Specialist, 4-H Youth Development, University of Illinois Extension

**Educational Reviewer 2008**
Cary Sneider, Ph.D., Associate Research Professor, Portland State University, Portland, Oregon

**Layout and Design**
Slice, Inc., 18310 Montgomery Village Avenue, Gaithersburg, Maryland

**Photographers**

Ji-Young Kim, Graduate Research Assistant, Office for Mathematics, Science, and Technology Education (MSTE) in the College of Education at the University of Illinois at Urbana-Champaign

Beth Kirchgesner, Office for Mathematics, Science, and Technology Education (MSTE) in the College of Education at the University of Illinois at Urbana-Champaign

Support for this publication was provided by the Noyce Foundation. The Noyce Foundation is dedicated to stimulating ideas and supporting initiatives designed to produce significant improvement in teaching and learning in mathematics, science, and literacy for youth in grades K–12.

Support for this publication was provided by the 3M Foundation. The 3M Foundation invests in tomorrow's leaders to support the environment, energy solutions, and engineering.

This curriculum is a joint project of the Office for Mathematics, Science, and Technology Education (MSTE), the College of Engineering and University Extension at the University of Illinois. Initial funding for the project was provided by Ford and SBC.

The Office for Mathematics, Science, and Technology Education (MSTE) is a division of the College of Education at the University of Illinois at Urbana-Champaign. The goal of MSTE is to serve as a model-builder for innovative, standards-based, technology-intensive mathematics and science instruction at the K–12 levels. The Office serves as a campus-wide catalyst for integrative teaching and learning in mathematics, science, and technology education.

University of Illinois's College of Engineering gives students the tools to create and innovate, to build and restore. Our graduates are making a difference in corporate, government, and social organizations around the world.

University of Illinois Extension is the flagship outreach effort of the University of Illinois at Urbana-Champaign. Through learning partnerships that put knowledge to work, U of I Extension's educational programs make life better, healthier, safer and more profitable for individuals and communities.

Copyright © 2008 The Board of Trustees of the University of Illinois. All rights reserved.

For ordering information contact National 4-H Council Supply Service at: (301) 961-2934.

The 4-H Name & Emblem is protected under 18 USC 707.

# Contents



THE POWER OF THE *Wind*

The 4-H Youth Development Program promotes learning by doing and focuses on developing skills for a lifetime. This project is designed to teach youth about the wind and its uses while introducing them to engineering and engaging them in doing and reflecting on the activities. See Experiential Learning Model on page 5.

**CHALLENGE**

# How Can We Use Wind To Lift a Load?

| | |
|---|---|
| **Wind Power Skill:** | Designing and building a wind turbine that lifts a load |
| **SET Abilities:** | Observe, measure, record, compare/contrast, design solutions, evaluate, infer, redesign, troubleshoot |
| **Education Standards:** | NSES: Science as Inquiry; Transfer of Energy |
| **Life Skill:** | Problem solving, Teamwork, Contributions to group effort |
| **Success Indicator:** | Designs and builds a wind turbine; describes how the wind can be used to do work |

## Overview

This Challenge is a design problem and it can be solved with a variety of devices. In this activity, youth design and build a turbine that uses wind power to lift a load. To qualify as a wind turbine, the device has to include blades that turn a shaft. Youth might use a pulley or string that winds around the shaft to lift a container that holds pennies.

## Getting Ready

- Read the activity in the youth guide and gather the necessary materials.
- Find a table or shelf where youth will be able to test their wind turbine designs.

## Facilitating the Activity

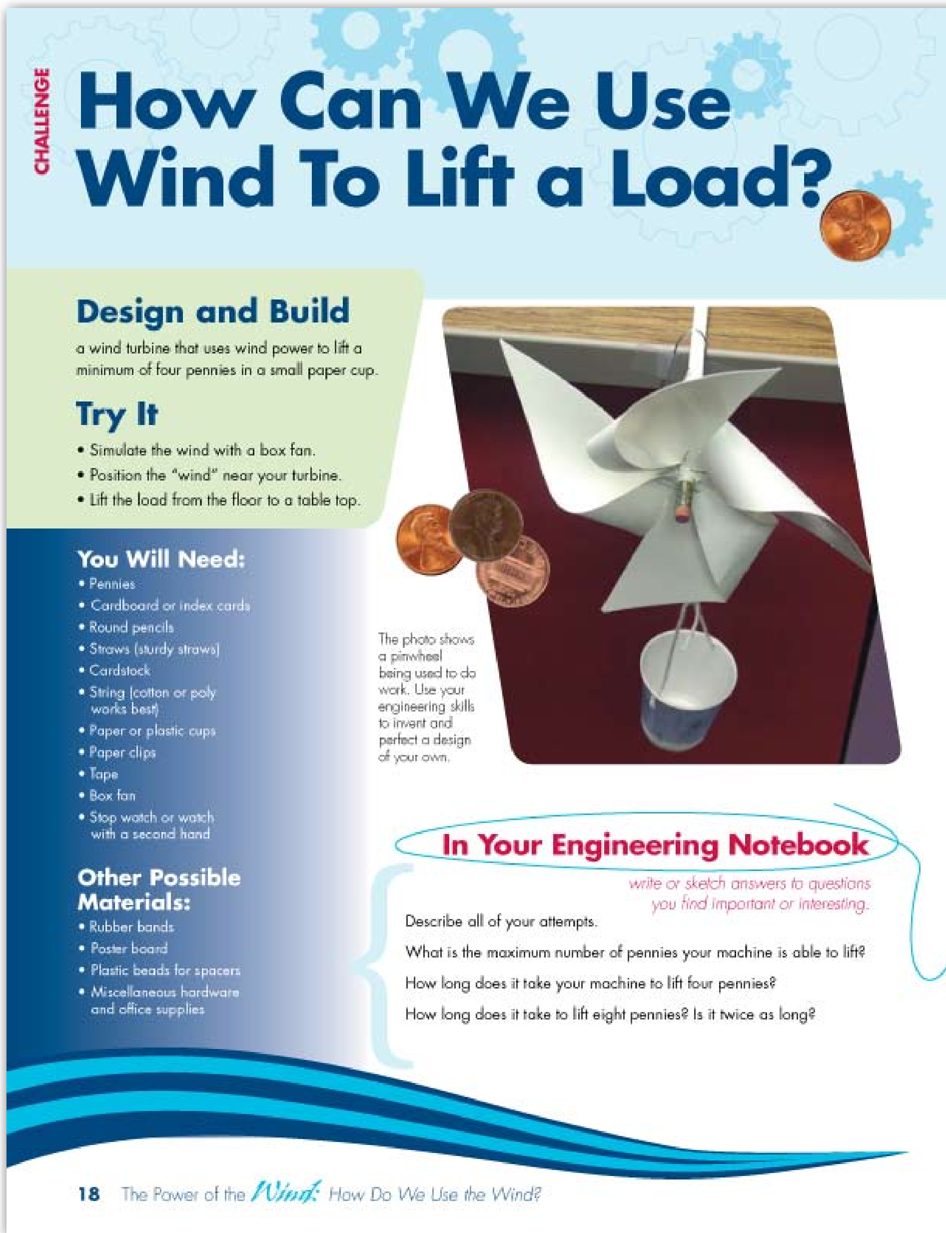
Explain to youth that they will be designing and building a turbine that uses wind power to lift a minimum of four pennies in a small paper cup. Allow youth to work individually or in small groups to create their own designs and build their turbines. Remind the youth that the device in the photo is not the best design.

Help the youth to conduct performance tests so everyone can see the designs and take advantage of the group's thinking. Allow the youth to make adjustments and retest their designs. Conduct a final test or competition. See how many pennies each turbine can lift.

## The Science Behind the Activity

The wind machines constructed in this activity do work, but energy is needed to do the work—and the energy comes from the wind. The amount of work done by the wind turbine in this activity is the product of the weight of the pennies multiplied by the distance they are lifted. It is harder to lift a load quickly so more power is needed to lift a load if it needs to be lifted in a shorter amount of time.

Scientists define work as a transfer of energy from one object to another. When you play



CHALLENGE

How Can We Use Wind To Lift a Load?

Design and Build

a wind turbine that uses wind power to lift a minimum of four pennies in a small paper cup.

Try It

- Simulate the wind with a box fan.
- Position the "wind" near your turbine.
- Lift the load from the floor to a table top.

You Will Need:

- Pennies
- Cardboard or index cards
- Round pencils
- Straws (sturdy straws)
- Cardstock
- String (cotton or poly works best)
- Paper or plastic cups
- Paper clips
- Tape
- Box fan
- Stop watch or watch with a second hand

Other Possible Materials:

- Rubber bands
- Poster board
- Plastic beads for spacers
- Miscellaneous hardware and office supplies

The photo shows a pinwheel being used to do work. Use your engineering skills to invent and perfect a design of your own.

In Your Engineering Notebook

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

Describe all of your attempts.

What is the maximum number of pennies your machine is able to lift?

How long does it take your machine to lift four pennies?

How long does it take to lift eight pennies? Is it twice as long?

18 The Power of the Wind: How Do We Use the Wind?

## Material Needed

- Pennies
- Round pencils
- Straws (sturdy straws)
- Card stock
- Cardboard or index cards
- Rubber bands *(optional)*
- String (cotton or poly works best)
- Paper or plastic cups
- Tape
- Box fan
- Plastic beads for spacers *(optional)*
- Stop watch or watch with a second hand
- paper clips
- poster board *(optional)*
- Miscellaneous hardware and office supplies

## Historical Perspective

The direction of the wind changes so methods were devised to turn the windmill into the wind. Some early windmills had to be turned by the windmiller using a large pole. Later a little windmill, called a fantail was attached to the back of the windmill and perpendicular to the plane of the large blades. The steel blade windmills popular in the American West had tail rudders placed perpendicular to the blades to turn them into the wind. The manufacturer's name was often printed on the rudder. Modern wind turbines use a system of gears and motors called the yaw mechanism. A wind vane on the turbine controls the yaw mechanism.


The Working Wind

We know that windmills were used to do work in Persia at least 3,000 years ago (Persia is now Iran). These windmills looked somewhat like modern day revolving doors. The wind pushed against the door-like paddles and turned a center **shaft**. The shaft was connected to a pump or to a millstone used to grind grain. These were vertical **axis** windmills which work no matter which direction the wind blows.

Early European windmills first appeared about 800 years ago. These horizontal axis windmills had large blades that faced into the wind like a pinwheel. The blades were often wood frames covered by cloth sails. When the direction of the wind changed the windmiller had to turn the blades to face the wind. Later, inventors developed ways for the wind to do this turning. Notice the small set of blades on the windmill in the photo.

In the later 1800's smaller windmills were invented to help farmers in the American West pump water. These windmills were mounted on **towers** and had many thin blades. There was also a fantail or rudder to turn the blades into the wind. These windmills were used by American farmers to do many chores. Over time, improvements were made in the shape of the blades. Some were made of steel. During the years 1880 to 1935, several million windmills operated in the American West.

This Dutch style windmill in Golden Gate Park in San Francisco was built in the early 1900's to pump water from an underground aquifer to irrigate the park.

Talk About It

Describe your first design. What works well? What do you want to improve?

Try Something Else and Test Again
- What improvements did you make in your initial windmill?
- Which adjustments to your design made the windmill work faster and which made it stronger? Discuss your design with your partner or group. Explain the adjustments you want to make and explain why you want to make them.

Learning from Others
- Observe the turbines built by others in your group. How are they similar? How do they differ? What are some features of the turbines that lift the most pennies?
- We need energy to do work. Moving or lifting something is work. Lifting 4 pennies 20 inches is twice as much work as lifting 4 pennies 10 inches. Describe how your turbine uses wind energy to do work.

Engineering Design with Sue Larson

Have you ever heard the phrase "go back to the drawing board?" It means that something has gone wrong with a design and it's time to start over. Engineering design always contains some "do-overs" (they're called iterations), where you learn something valuable from something that went wrong and you go back and fix it. Some of these iterations happen early in the design process and some happen much later—even after something is made and the designer sees how people use it. Part of design is testing what you've made to see how it works and being willing to adjust as necessary—even to the point of "going back to the drawing board." It's all part of getting something that works just like you want it to.

*In what other situations might you need to "go back to the drawing board?"*

The Power of the Wind: How Do We Use the Wind? 19

softball, you put energy into the bat so you do work on the ball. We usually don't think of work that way. We think about doing the dishes or doing our homework! But scientists think in terms of force and distance: work takes place when when a force is applied to make an object move in the direction of the force. So work means moving or lifting, and it also means making light or heat or sound.

## Going Further

Literacy Connection

There are many words that have a scientific definition and a casual, everyday definition. In science, work is defined as a force applied over distance, but in our everyday lives work means a mental or physical effort, like taking out the garbage or doing the laundry. Think of other words that have a strict scientific meaning and a casual, everyday meaning. Think about the scientific and everyday meaning of the words work and power.

## Notes

# Wind Power: *Learning At-a-Glance*

| Wind Power Skill | SET Abilities | National Learning Standards* |
|---|---|---|
| **Challenge: How Can We Design a Wind Powered Boat?** | | |
| Designing and engineering a sailboat | Observe, record, build/construct, compare/contrast, design solutions, evaluate, interpret/analyze/reason, measure, redesign, troubleshoot | NSES: Science as Inquiry; Transfer of Energy; Motion and Forces |
| **Exploration: How Do We Observe and Measure the Wind (Part 1)?** | | |
| Creating a tetraflexagon for gauging wind speed | Measure, use tools | NSES: Science as Inquiry<br>NCTM Geometry Standard: Use visualization and spatial reasoning |
| **Exploration: How Do We Observe and Measure the Wind (Part 2)?** | | |
| Observing and measuring wind speed | Observe, measure, record, use of tools | NSES: History and Nature of science: Earth and Space Science, Earth in the Solar System: Science in Personal and Social Perspectives, Natural hazards |
| **Investigation: How Does a Pinwheel Use Wind Power?** | | |
| Investigating how wind energy is transferred to a pinwheel | Observe, compare/contrast, evaluate, infer, predict, troubleshoot | NSES: Transfer of Energy; NCTM Geometry Standard: Apply transformations and use symmetry |
| **Investigation: How Can We Design a Better Pinwheel?** | | |
| Redesigning pinwheel designs to observe changes in performance | Observe, measure, record, redesign, compare/contrast, evaluate, infer, predict | NSES: Science as Inquiry; Transfer of Energy |
| **Challenge: How Can We Use Wind To Lift a Load?** | | |
| Designing and building a wind turbine that lifts a load | Observe, compare/contrast, design solutions, evaluate, redesign, troubleshoot | NSES: Science as Inquiry; Transfer of Energy |
| **Challenge: Which Turbine Design Is Better for the Job?** | | |
| Designing and building two wind turbines, one with high solidity and one with low solidity | Observe, measure, record, evaluate, predict, infer, compare/contrast, organize/order/classify | NSES: Science as Inquiry; Transfer of Energy; Motion and Forces<br>NCTM Geometry Standard: Use visualization, spatial reasoning,and geometric modeling to solve problems |
| **Challenge: How Can We Use Wind Power to Produce Electricity?** | | |
| Designing and building a wind turbine that uses wind power to create electricity | Observe, measure, record, evaluate, predict, infer, organize/order/classify, troubleshoot | NSES: Science as Inquiry; Transfer of Energy |
| **Investigation: How Do Motors and Generators Work?** | | |
| Investigating the relationship between motors and generators | Observe, compare/contrast, evaluate | NSES: Transfer of Energy; Earth and Space Science, Earth in the Solar System |
| **Exploration: Where and Why Does the Wind Blow?** | | |
| Reading and interpreting wind maps and charts | Research a problem, categorize/order/classify, interpret/analyze/reason | NSES: Transfer of Energy; Earth and Space Science, Earth in the Solar System; NCTM Data Analysis Standard: Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them. |
| **Exploration: Where Are the Wind Turbines?** | | |
| Evaluating locations for wind power | Research a problem, evaluate, categorize/order/classify, interpret/analyze/reason | NSES: Earth and Space Science, Structure of the Earth System; Science in Personal and Social Perspectives, Populations, Resources, and Environments; NCTM Data Analysis Standard: Evaluate inferences and predictions that are based on data |
| **What Are Some Facts About Wind Farms?** | | |
| Evaluating the Mendota Hills Wind Farm | Research a problem, categorize/order/classify, interpret/analyze/reason, evaluate, model/graph/use numbers | NCTM Numbers and Operations Standard: Compute fluently and make reasonable estimates |
| **Exploration: How Do Schools Use Wind Power?** | | |
| Evaluating successful school wind projects | Observe, measure, record, model/graph/use numbers | NSES: Physical Science; Transfer of Energy; Science in Personal and Social Perspectives, Populations, Resources, and Environments; NCTM Data Analysis Standard: Evaluate predictions that are based on data |
| **Exploration: How Does the Wind Move Through Art and Literature?** | | |
| Communicating influences of wind and wind machines on daily life using art and literature. | Communicate, observe, interpret/analyze/reason | NCTM Connections Principle: Recognize and apply mathematics in contexts outside of mathematics |
| **What Innovative Design Can You Create?** | | |
| Designing and engineering a wind powered machine, vehicle, or sculpture; sharing information about wind power with others in the community; investigating energy-related careers | Build/construct, design solutions, draw/design, troubleshoot, problem solve, redesign, optimize, invent/implement solutions,/ communicate/demonstrate | NSES: Physical Science; Transfer of Energy; Science and Technology, Abilities of Technological Design |

*National Science Education Standards (NSES), National Research Council, National Academy of Sciences, 1995.
Principles and Standards for School Mathematics, National Council of Teachers of Mathematics (NCTM), 2000.

| Life Skill | Success Indicator |
| --- | --- |
| Critical thinking, Problem solving, Teamwork | Designs and engineers a sailboat that travels forward, straight, and at least 75 cm; describes how the wind moves the boat |
| Acquiring and evaluating information | Creates a tool to observe and measure wind speed |
| Problem solving | Observes wind speed; uses a tool to measure wind speed |
| Critical thinking | Describes how energy is transferred from the wind to a pinwheel |
| Critical thinking | Redesigns pinwheel to observe changes in performance; collects and records data in a systematic way |
| Problem solving, Teamwork, Contributions to group effort | Designs and builds a wind turbine; describes how the wind can be used to do work |
| Critical thinking | Designs and builds two different types of wind turbines; compares turning speeds and lift abilities of various wind machines |
| Problem solving, Teamwork, Contributions to group effort, Planning/Organizing | Designs and builds a wind powered turbine that produces measurable electricity; describes how the wind turbine transfers energy |
| Critical thinking | Explains how motors and generators are related; identifies the ultimate source of our energy and can trace energy transfers |
| Acquiring and evaluating information | Reads and interprets wind maps and charts, classifying areas based on wind power potential; explains how wind energy is a form of solar energy. |
| Wise use of resources, Decision making | Evaluates states and communities for wind power capacity; describes factors that influence our use of natural resources |
| Acquiring and evaluating information | Evaluates the Mendota Hills Wind Farm and describes its value to the community |
| Wise use of resources, Decision making | Evaluates states and communities for wind power capacity; describes factors that influence our use of natural resources |
| Communication | Recognizes influences of the wind and wind machines in art and literature |
| Problem solving, Decision making, Communication, Community service, Leadership, Responsible citizenship, Planning/organizing, Learning to learn | Designs and engineers a wind powered machine, vehicle, or sculpture; describes how energy is transferred from the wind to a machine, vehicle, or sculpture; shares information about wind power with others in the community; investigates energy-related careers |

# Glossary

**Anemometer**
an instrument used to measure wind speed.

**Axis**
the line about which a rotating body, such as the rotor of a turbine, turns.

**Beaufort Scale**
a scale that uses numbers from 0 to 12 to categorize wind speed based on observing. The scale was created by the British naval commander Sir Francis Beaufort around 1805.

**Biodiesel**
a renewable fuel for diesel trucks, cars, buses, and tractors that is made from plants.

**Chemical Energy**
energy that can be released by a chemical reaction. A chemical reaction takes place inside a battery when the battery is part of a complete electrical circuit.

**Constraint**
a restriction on a design, such as performance, cost, and scheduling.

**Criteria**
the rules used to judge something.

**Cyclone**
any storm with circulating winds (a "twister") formed over water. Also refers to a hurricane that occurs in the Indian Ocean.

**Electrical Energy**
energy made available by the flow of electric charge through a conductor.

**Electron**
an elementary particle of an atom with negative charge.

**Energy**
refers to the ability to do work. It is defined as power over time. The unit of energy that appears on your electrical bill is kilowatt hour (kWh). A 1000 watt hair dryer uses one kWh of electricity if it is on for one hour. Different forms of energy include electrical, solar, wind, thermal, mechanical, and chemical.

**Engineering Design Process**
a process used by engineers to help develop products.

**Force**
a force is a push or a pull that results in a change of an object's velocity or direction.

**Generator**
a device that converts mechanical energy into electrical energy.

**Hurricane**
a storm with very fast circulating winds (a "twister") formed over water near North or South America.

**Kilowatt**
1,000 watts is equal to 1 kilowatt (kW). The unit of energy that appears on your electrical bill is kilowatt hour (kWh). A 1000 watt hair dryer uses one kWh of electricity if it is on for one hour.

**Kinetic Energy**
the energy of an object in motion.

**LED**
light-emitting diode: a semiconductor diode that emits light when conducting current and is used in electronic equipment (e.g. a string of holiday lights).

**Machine**
a device that does work and uses energy.

**Megawatt**
1,000,000 watts is equal to 1 megawatt (MW). One MW is enough power to light 100,000 standard 100 watt light bulbs or to operate 10,000 hair dryers.

**Mechanical Energy**
the energy an object possess due to its motion or its stored energy of position.

**Motor**
a device that converts electrical energy into mechanical energy to do work.

**Multimeter**
a device consisting of one or more meters used to measure two or more electrical quantities in an electric circuit, such as voltage, resistance, and current.

**Nacelle**
the housing that contains the generator and gear box of a wind machine mounted on top of the supporting tower.

**Potential Energy**
the energy stored in an object because of its position.

# Glossary

**Power**
energy transferred or work done per unit of time. It is measured in watts. A watt is a measure of power at a specific instant. A 100 watt light bulb changes 100 watts of electricity to 100 watts of light and heat.

**Prototype**
an early attempt at a working model for an idea.

**RPM**
stands for revolutions per minute.

**Rotational Symmetry**
an object with rotational symmetry is an object that looks the same after a certain amount of turning.

**Rotor**
a rotating part of an electrical or mechanical device.

**Rudder**
A blade at the rear of the turbine that keeps the turbine turned into the wind.

**Shaft**
a revolving rod that transmits power or motion.

**Solidity**
the ratio of rotor blade surface area to the area that the rotor blade passes through; the amount of swept area occupied by the blades.

**Swept Area**
the area of the circle that the blades of a turbine pass through.

**Tetraflexagon**
in geometry, flexagons are flat models made from folded strips of paper that can be folded, or flexed, to reveal a number of hidden faces. A tetraflexagon has four faces.

**Tornado**
a storm with very fast circulating winds (a "twister") formed over land.

**Torque**
force which causes something to rotate, turn, or twist.

**Tower**
column upon which the nacelle is supported.

**Transformer**
converts high voltage to low voltage or low to high.

**Tropical Storm**
a group of thunderstorms with fast wind speeds rotating in a spiral formed over water.

**Tsunami**
an unusually large sea wave produced by a seaquake or undersea volcanic eruption.

**Turbine**
any of various machines having a rotor, usually with blades, driven by the pressure and movement of water, steam, or air. A turbine converts kinetic energy of a moving substance (such as air) into mechanical energy.

**Typhoon**
a storm with very fast circulating winds formed over water in the South Pacific Ocean.

**Voltage**
the force or pressure pushing the electrons. It is measured in volts.

**Wind**
air in motion, ranging from still (no wind) to a breeze (slight wind) to a gale (strong wind) or hurricane.

**Windmill / Wind Turbine**
a device that converts wind energy to other forms of energy such as mechanical or electrical.

**Wind Farms**
a collection of wind turbines located on the same area and used to generate electricity.

**Wind Energy**
energy harvested from moving air in the atmosphere. Wind energy is dependent on atmospheric conditions such as temperature and pressure differences.

**Work**
occurs when a force is applied over a distance.

# Facilitator Tips

The Facilitator's Guide is provided as a reference tool for *The Power of the Wind* curriculum. It is not intended to replace curriculum-specific training. The following tips provide additional assistance for facilitators.

## Think Safety

Promote an inclusive environment where youth feel safe to have voice and openly share ideas. Remember to also account for physical safety issues, including electrical needs, fire exits, and flow of traffic in and out of the room, as related to the work spaces.

## Be Prepared

Read through each section of the Facilitator Guide. Remember that strong, upfront planning of the series of activities will allow you to make connections and see continuity that can be shared with the youth.

## Check the Physical Space

It is recommended to conduct these activities in a space that supports the curriculum and the learning. Some things to consider: Does the environment feel like a "science setting?" Think about appropriate use of visuals. Ex: White board with models of wind turbines drawn. Immerse youth in the visuals. If a corner of the gym or other shared space is the only place available, provide a visual connection to the science by use of models or visuals that can transported or brought out of storage each time. Move outside when possible and appropriate.

## Provide Consistent Expectations of Behavior

Provide opportunities for choice and include the strengths of all youth to enrich student experiences. Model clear communication strategies by talking directly to youth through maintaining eye contact and practicing active listening skills. Provide options for different learning preferences and intelligence types.

## Engage Youth

Note when youth are interested—take advantage of their curiosity and catch those "teachable" moments! Invite them to be actively engaged through your contagious enthusiasm and sense of humor. Notice what engages youth and build on that. Give youth opportunities to ask probing questions and share ideas with each other.

## Embed Essential Elements

In 4-H, the critical components of a successful learning experience are a sense of Belonging, Independence, Mastery, and Generosity. It is your role, as a facilitator, to provide guidance and support. Give youth opportunities to become leaders, practice citizenship, and develop a sense of independence and belonging, and an ability to master the content.

## Develop Scientists

Provide opportunities for youth to 'emulate' scientists. Model the use of scientific terms, such as "repeated trial" or "prediction," making sure that the definition can be understood in context. Offer youth an opportunity to use tools that scientists use. Let them share ways in which they are like scientists in everyday life.

## Limit Your Talking

Limit your talking. Interactive mini-lessons, approximately 5–10 minutes long are sufficient to provide core "chunks" of information. 4-H is about learning-through-doing. Alternate instruction with active hands-on learning. Ask yourself: What is absolutely essential to teach if I want youth to understand the concepts? What can they discover on their own?

Youth quotes:

> *"Least fun was the talking times when we weren't doing anything. We were just sitting in the classroom."*
>
> *"I like that we get to learn something different… Coming here we can feel good about what we do."*

## Evaluation

Provide ongoing feedback and evaluation throughout the project (formative evaluation) and at the end of the project (summative evaluation).

## Encourage Career Exploration

Make the connections to careers in the fields of science, engineering, and technology. Make connections with experts in the field and invite them to share their passion for their profession. Utilize experts as a resource for information and current trends and issues.

## Be Relevant

Encourage youth to demonstrate application to the real world. Model this by using relevant examples that apply to their daily lives.

## Go Further

Encourage youth to explore beyond the activity and take learning into their own hands. Notice when they become emerging experts and give them leadership opportunities.

## Use Additional Resources

Use a variety of resources to supplement project work. Remind youth that there are additional resources online at ***www.4-H.org/curriculum/wind***. Throughout the curriculum, each time a word in the glossary is used for the first time in the Youth Guide, it appears **BOLD**.

# The Essential Elements of 4-H Youth Development

*The Power of the Wind* curriculum is designed to engage youth in learning opportunities that promote positive youth development. In 4-H, the critical components of a successful learning experience are a sense of Belonging, Independence, Mastery, and Generosity.  Across the curriculum, each of the 4-H Essential Elements (Belonging, Independence, Mastery, and Generosity) are embedded through the learning experience. In this Facilitator's Guide, opportunities are provided to put the Essential Elements into practice. It is your role, as the facilitator, to foster growth of the Essential Elements through the learning experience.

## Belonging

Youth need to know they are cared about by others and feel a sense of connection to others in the group. As the facilitator, it is important to provide youth the opportunity to feel physically and emotionally safe while actively participating in a group. In the facilitator's guide, tips are provided on how to create a safe and inclusive environment and how to foster a positive relationship with youth learners. Under the sections in the youth guide titled Learning from Each Other, there are discussion questions that encourage youth to learn from each other, synthesize, and use ideas collaboratively.

## Independence

Youth need to know that they are able to influence people and events through decision-making and action. They learn to better understand themselves and become independent thinkers. Throughout this curriculum, youth are given opportunities to reflect, design, and journal their thoughts and responses to the challenges, explorations, and investigations. Youth begin to understand that they are able to act as change agents with confidence and competence as a result of their learning.

## Mastery

In order to develop self-confidence youth need to feel and believe they are capable and they must experience success at solving problems and meeting challenges. Youth need the breadth and depth of topics that allow them to pursue their own interests. Through this curriculum, youth are introduced to expert knowledge. In the sections titled Engineering Design with Sue Larson, youth are given an expert perspective that is practical and relevant to their age and explorations. Across the curriculum, youth are encouraged to think and act like engineers and scientists and use tools to examine, experiment, evaluate, and draw their own conclusions.

## Generosity

Youth need to feel their lives have meaning and purpose. Through this curriculum, youth examine the use of wind power across the United States. They are encouraged to broaden their perspective, find relevance in it, and bring ideas back to their community. In the sections in the Youth Guide titled Learning from Each Other, they learn to work together as partners or teams and learn to value the contributions of others.

*Adapted from 4-H Essential Elements of 4-H Youth Development, Dr. Cathann Kress, 2004.*

# Notes

# Resources

## Print Resources


Diehn, Gwen and Krautwurst, Terry. Science Crafts for Kids. New York, NY: Sterling Publishing Co. Inc., 1994.

Gipe, Paul. Wind Energy Basics: A Guide to Small and Micro Wind Systems. White River Junction, VT: Chelsea Green Publishing Company, 1999.

Harris, Coy and Meinzer, Wyman. Windmill Tales. Lubbock, TX: Texas Tech University Press, 2003.

Jones, Madeline. The Mysterious Flexagons: An Introduction to a Fascinating New Concept in Paper Folding. Tokyo, Japan: Zokeisha Publications Ltd., 1966.

McBride, Carol. Making Magnificent Machines: Fun with Math, Science, and Engineering. Chicago, IL: Zephyr Press, 2000.

Petersen, Christine. Wind Power. New York, NY: Children's Press, 2004.

Picoturbine Windmill Kit. Xibokk Research, Inc., 2004.

Sherman, Josepha. Wind Power. Mankato, MN: Capstone Press, 2004.

Stillinger, Doug. Battery Science. Palo Alto, CA: Klutz, 2003.

Wandrey, Uwe. Power House: Sustainable Living in the 21st Century. Portsmouth, RI: Thames & Kosmos LLC, 2001.

Wind Power Today. Washington, DC. U.S. Department of Energy, 2006.

Woelfle, Gretchen. The Wind at Work: An Activity Guide to Windmills. Chicago, IL: Chicago Review Press, Incorporated, 1997.

Zubrowski, Bernie. Wheels at Work: Building and Experimenting with Models of Machines. New York, NY: William Morrow and Company, Inc., 1986.


## Internet Resources

*For Internet Resources, please go to The Power of the Wind online at* ***www.4-H.org/curriculum/wind***

# 4-H Pledge

I Pledge my **Head**
to clearer thinking,

my **Heart** to greater loyalty,

my **Hands** to larger
service,

and my **Health** to
better living,

for my club, my community, my country, and my world.

18 USC 707