Activity 6:

Wind Turbine Tech Challenge

Overview

Participants consider what they know about how wind turbines work and how wind energy could be used to provide electricity to a community park. In small groups, they build a model wind turbine, then explore and test common materials to identify a modification that would enable their model to better catch the wind.

Activity Time:

20 to 30 minutes

Intended Audience:

Families or other mixed-age groups, including children ages 5–7
School-aged children ages 8–9
Tweens up to about age 14

What's the Point?

- Wind is a renewable energy source that can supply electricity to a community park, as well as at home and in communities around the world.
- Engineering helps solve large and small problems that we encounter every day, such as developing renewable wind energy technology to supply electricity.
- Children, like engineers, can improve an existing wind turbine design through the creative process of thinking, building, testing . . . and doing it again!

Facilitator's Note: Young participants in this activity are potentially the next generation of engineers, and those engineers will face an array of pressing challenges identified by the National Academy of Engineering as Grand Challenges for Engineering. "Restore and improve urban infrastructure" is one of those challenges. Engineers of the 21st century must work to improve the systems that support our communities, including energy systems. These systems must also use energy wisely and be better for the environment.

One potential part of the solution, wind energy, is explored in this activity.

Materials

For the Facilitator

- ☐ *Implementation Guide* (available at www.starnetlibraries.org), which includes:
    - ☐ *Playful Building's* key features
    - ☐ Annotated facilitation outline
    - ☐ Facilitator background information
    - ☐ Shopping list
    - ☐ Extended supporting media suggestions
    - ☐ Correlations to National Science Education Standards
    - ☐ Contact information
    - ☐ STAR_Net project overview
    - ☐ Credits and acknowledgments
- ☐ *Brief Facilitation Outline* page
- ☐ *Playful Building* PowerPoint presentation (or the instruction slides printed for the groups to use) (available at www.starnetlibraries.org)
- ☐ 1 hole punch

Facility Needs

- ☐ 3 or more or more tables
- ☐ Optional: 15–20 chairs arranged at the table(s) for groups or families to sit together while they create their wind turbines
- ☐ Optional: computer, speakers, projector, projection screen, and access to the Internet
- ☐ Optional: a writing surface where the groups may sketch and write, such as:
    - ☐ 1 white board

      OR
    - ☐ 2–4 (~36" × 48") pieces of butcher paper, posted on the wall or used to cover the tables

      OR
    - ☐ 5 or more sheets of poster paper
    - ☐ AND
    - ☐ 4–8 dry-erase or other appropriate low- or no-odor markers

      OR
    - ☐ 4–8 crayons

For Each Participant

- 2 drinking straws
- 4 (3" × 3") small Post-It Notes®
- 3–4 round toothpicks
- 1 small (approximately 1" × 1") scrap of paper (preferably left over, repurposed paper)
- 1 (1"-diameter) chunk of Play-Doh® or putty adhesive, such as Sticky Tack
- Materials from which to choose to modify his or her model wind turbine:
    - 1 paper towel tube
    - 4 (3" × 3") pieces of thin cardboard (for example, from a cereal box or folder), index cards, or cardstock
    - 4 (3" × 3") pieces of corrugated cardboard
    - 2 (8½" × 11") sheets of printing paper (can be used for blades or vertical support)
    - 2 sheets of tissue paper
    - 2 sheets of construction paper

For an Audience of 15–20 to Share

- 6 or more rolls of Scotch tape
- 6 or more glue sticks
- 3 or more boxes of brass brads
- 1 (8½" × 11") *Be Creative…Be an Engineer!* poster (for tweens, teens, and adults)
- Optional: 1 (8½" × 11") *Grand Challenges of Engineering* poster (for teens and adults)

Supporting Media

Consider setting up a digital media player (such as a computer), speakers, and access to the Internet to display videos, images, podcasts, or websites before, during, or after the activity.

A more extensive list is included in the *Implementation Guide*.

Online Resources

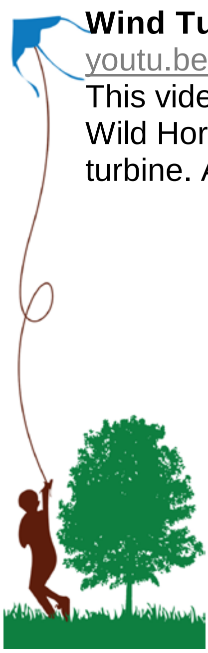
The Inside of a Wind Turbine
www1.eere.energy.gov/wind/inside_a_wind_turbine.html
The U.S. Department of Energy offers details about a wind turbine's parts, including an animation of a moving wind turbine and a wind farm providing electricity to the power grid. While the text is geared toward teens and adults, all ages may enjoy these insights into wind energy.

As the Rotor Turns: Wind Power and You
www.teachersdomain.org/resource/psu06-e21.sci.rotor
This lesson plan lists video clips, such as those listed below, about the Bear Creek Wind Farm in Pennsylvania under "Multimedia Resources." Appropriate for all ages.

"Blade onto Tower"
"Turbine Type and Specs"

EWB-SF: Prototyping Low Cost Wind Turbine at AIDG Guatemala
aidg.org/blog/?p=1035
Tyler Valiquette demonstrates his work with the San Francisco chapter of Engineers Without Borders as part of the Appropriate Technology Design Team, which traveled to Guatemala to build a prototype of their vertical axis wind turbine. Appropriate for ages 5 and up.

Wind Turbine Tour
youtu.be/8lWTQdHEazg
This video follows the maintenance and operations team at the Puget Sound Energy's Wild Horse Wind and Solar Facility as they climb the interior of a 351-foot-tall wind turbine. Appropriate for ages 8 and up.



Engineer Your Life: Energy Consultant Tanya Martinez
www.engineeryourlife.org
This guide to engineering for high-school girls offers videos, photos, career stories, and personal "tidbits" for each of 12 engineering professionals. For example, Tanya Martinez has provided expertise on renewable energy — including wind and solar energy resources — to diverse communities, including a Navajo reservation and villages in the Andes mountains of Peru. High school students might find the additional tools and information helpful for pursuing a career in engineering. Appropriate for ages 8 and up.

Wind Engineers — Vestas Education Series
www.youtube.com/watch?v=N4ZzJWsVe9k
Professionals at Vestas Wind Systems A/S describe their different roles at the company. Appropriate for ages 10 and up.

Green Careers: Clean Energy — Wind Power
www.youtube.com/watch?v=vYSlfE53SFs
This three-minute clip provides insights into the various roles in the wind industry. Appropriate for ages 10 and up.

UC Davis Engineers Lighter Blades for Wind Farms
www.youtube.com/watch?v=hBRfboAscww
This brief news reel showcases a wind farm and the lighter blades developed by University of California–Davis engineer Case van Dam. Appropriate for ages 10 and up.

Grand Challenges for Engineering
www.nae.edu/Activities/Projects/grand-challenges-project/Videos_grandchallenges.aspx
National Academy of Engineering videos provide insights into the Grand Challenges for Engineering, and include interviews with engineering professionals. Appropriate for ages 10 and up.

"Build your Dream"
"Sustainability"

NREL Wind Technology Center
www.youtube.com/watch?v=UzLtaLGowtg
A senior engineer provides a technical tour of the National Wind Technology Center (NWTC). Appropriate for teens and adults.

Planet Forward: Fossil Fuels & Beyond, "Chapter 2 — Follow the Wind"
video.pbs.org/video/1095269427/
Chapter 2 is a seven-minute excerpt of the full 2009 episode and features conversation between citizens, experts, and policymakers about wind energy and technology. Appropriate for teens and adults.

Preparation

Before the day of the activity

- ☐ Use the *Implementation Guide* to determine the setup of your engineering program(s), organize and prepare your presentation, and help you collect the materials.
- ☐ Prepare publicity materials for these or any other future engineering and technology programs.
- ☐ Optional: Incorporate the *Playful Building* PowerPoint presentation into your facilitation plan. Modify the presentation to suit your needs.
- ☐ Collect and prepare materials.
  - ☐ Punch a hole in the center of the small scraps of paper.
  - ☐ Make a model wind turbine to get an idea of how the initial design can be constructed:
    - Roll the Play-Doh into a ball and flatten it into a disk about 1" thick.
    - Place the three to four toothpicks into the center of the Play-Doh as close to vertical as possible. Arrange the toothpicks so that the straw will be able to easily slide over them, as shown below. These will be used to support the straw.

    - Set the small scrap of paper at the base of the toothpicks to prevent the straw from becoming stuck on the Play-Doh.
    - Attach the Post-it notes to the top of a straw as shown below. Place the notes such that they do not overlap each other. The four notes will extend out from the straw at right angles to each other.

- Slide the straw over the toothpicks.
- Use a second straw to blow across the blades.

Facilitator's Note: For young children, have three or more wind turbine designs already created and ready to use. Have them blow across the blades of the different designs and decide which materials work best to make the blades spin.

The day of the activity

- ☐ Set up the facility.
- ☐ Set out the materials.
- ☐ Print the *Brief Facilitation Outline* page, which integrates the steps of the activity with the annotated facilitation outline presented in the *Implementation Guide*, to use as presentation notes.
- ☐ Provide access to any supporting media and the *Playful Building* PowerPoint presentation (or printed copies of the instructions slides for this activity).
- ☐ Set out the *Grand Challenges* page and the *Be Creative* poster (or hang them on a nearby wall).

Activity

1. Ask questions about what the participants have observed and know about wind turbines to facilitate a conversation about the following points:
   - Engineers work to develop renewable wind energy technology to supply electricity.
   - Wind is a renewable energy source; wind is found across the globe and will never run out.
   - Wind turbines convert wind energy into electricity. As their blades (also called sails or vanes) move, they spin other parts inside a generator, which produces electricity.
   - The blades of a turbine must be light enough to spin easily, but sturdy enough to withstand a breeze.

Facilitator's Note: How wind turbines work: Wind blows against the blades of a wind turbine, making the blades spin. The blades are connected to one end of a shaft that rotates with the blades. The other end of the shaft is connected to a gear box. These gears are connected to another shaft and the gears cause this second shaft to rotate faster than the blades and the first shaft. This second, faster shaft is connected to a generator. As the second shaft rotates inside the generator, electricity is produced.

Types: There are two basic types of wind turbines: horizontal-axis wind turbines (HAWT) and vertical-axis wind turbines (VAWT). The blades of a HAWT rotate around a horizontal axis, like the blades of a box fan. The blades of a VAWT rotate around a vertical axis, like the blades of a ceiling fan. The wind turbine families or groups of children will construct in this activity can be either a HAWT or VAWT, although a VAWT is easier to construct.

Professional engineers also build models of wind turbines and test them! The speed and direction the wind primarily blows varies across Earth's surface. Wind turbines are designed to take advantage of wind patterns in the locations they are installed. Engineers create physical models of wind turbines and place them in wind tunnels to simulate the wind conditions of a certain locality. Tests are run to understand how different designs will stand up to the conditions created inside the wind tunnel. Engineers use the information from these tests to determine the best way to construct components of wind turbines: tower height, number of blades, and blade shape, for example.

2. Optional: Use the supporting media to explore how engineers are designing, building, testing, and modifying wind turbines.

Facilitator's Note: If teens and/or adults are present, offer the *Grand Challenges of Engineering: Restore and improve urban infrastructure* page as a source of further information.

3. Challenge the participants to individually build an initial working model of a wind turbine, and then coordinate with others to modify the design to more efficiently supply electricity to a community park. Allow time for questions.

4. Break into groups (with three to four people each) and begin. Encourage each family to work together as a group — parents too!

5. Guide the individuals through the initial engineering design process of think and build as they use the straws, Post-It Notes, toothpicks, and Play-Doh to create a working model of a wind turbine.

6. As the participants complete their initial working models, help them test them (and if necessary, adjust them so that they spin):
    - Use a second straw to blow across the blades.
    - Blow from a distance of about six inches from the wind turbine.

7. After they have an initial working design based on Post-Its for the blades, encourage everyone to coordinate with others in their groups and methodically change only one aspect of their designs at a time. Suggest:
    - Identifying a material that could better catch the “wind” and testing it.
    - Changing the
        - Angle at which the blades are attached;
        - Size of the blades;
        - Shape of the blades; or
        - Amount or direction that the blades are curved (cupped).

Facilitator’s Note: As time allows, have the groups change one thing at a time after each test. Adjusting and retesting their ideas is the best way to experience the ongoing work of an engineer! They will be rewarded by seeing improvement.

Reassure the participants that there isn’t a “right” answer that they must arrive at on the first try. Furthermore, failure is an essential part of figuring out what works and what doesn’t. It is OK to fail — and try again . . . and again . . . and again!

8. Optional: Have each group present their final model to the entire audience.

Extensions

Additional Activities

Allow additional time, per the instructions provided on these external websites, if incorporating these activities.

Make Your Own Wind Turbine
sparklab.si.edu/downloads/sparklab-wind.pdf
In this activity guide from the Smithsonian National Museum of American History, children cut out and assemble their own pinwheels. Appropriate for children ages 5–8, with assistance from an adult for pinning the wheel.

Electricity

Power plants distribute energy through the power grid, an interstate highway system for electricity. The National Academy of Engineering named this distribution network one of the greatest achievements of the 20th century. Explore electricity — how it moves and how wind turbines capture the wind, transforming motion into electricity — through further activities.

Squishy Circuits
courseweb.stthomas.edu/apthomas/SquishyCircuits/
Even small children can create circuits using two types of homemade dough and equipment purchased at the Squishy Circuits Store (squishycircuitsstore.com/kits.html) or an electronics store, including a battery pack and fun things that "go": LED lights, a motor, and/or a buzzer. Note their recommendations for cleaning the electronics to prevent corrosion and safety precautions. The website offers video overviews, recipes for the dough, and directions for building circuits.

KidWind Science Snack: Wind Turbine Blade Design
learn.kidwind.org/teach
Middle- and high-school-aged youth modify a model wind turbine, such as a kit available from store.kidwind.org. They plan a design and test different blade materials (such as cardboard, balsa wood, coroplast, and index cards) or other variables. The models produce electricity, which is measured with a multimeter. A selection of PowerPoint presentations about wind, wind power, and wind turbine technology can support this more advanced investigation into wind energy. Product videos on using a multimeter and the KidWind basic wind experiment kit are available on the site.

4-H: The Power of Wind Curriculum and Free Activities
www.4-h.org/resource-library/curriculum/4-H-the-power-of-the-wind
The Power of the Wind Curriculum is available for purchase and provides lessons on wind energy and wind-powered devices. "Grab and Go" activities are available for free download. In "4-H Grab and Go: Community Wind Project," youth research issues

behind building and operating hypothetical wind turbines in their community, then role play a town hall meeting. Appropriate for ages 8–14.

Wind

Engage children in science crafts and investigations about wind.

Discover Earth: Wind Streamer
www.lpi.usra.edu/education/explore/discoverEarth/activities/Activity5_Packet.pdf
As a part of the activity "Weather: The Many Faces of Mother Nature," children create a wind streamer out of common materials and use it to determine the wind's direction. Appropriate for use with ages 4–7, with assistance from an adult for cutting.

Discover Earth: Winds
www.lpi.usra.edu/education/explore/discoverEarth/activities/Activity6_Packet.pdf
As part of the activity "Weather Stations," children investigate the source of wind. They use a toaster to heat air and observe the movement of a small aluminum foil kite — due to wind! They compare the appliance's heat source to Earth's warmed surface and discover that wind is a type of convection. Appropriate for ages 8–13.

Kites

Stanford environmental and climate scientists Cristina Archer and Ken Caldeira are investigating how wind currents high in Earth's atmosphere could be harnessed with special kites. Wind turbines on the kites could capture energy and send electricity down the wire that anchors the kites to Earth. To emphasize this connection between kites and renewable energy, invite tweens ages 10–13 to create their own kites. For younger children, provide pre-folded kites for them to decorate and fly.

4-H Grab and Go: Kites
University of Illinois, 2009, retrieved through howtosmile.org/record/3442.
This instruction sheet describes how to fold a kite and then modify the design to help the kite fly better.

4-H Into the Wind, "Part 1: The Kite"
www.youtube.com/watch?v=Pp-If6qQNPk
This three-minute video uses kites to explain that wind is the movement of air from high- to low-pressure systems. Appropriate for ages 10–14.

References

This activity was inspired by the following educational materials:

Energy Tracker Supplementary Curriculum Middle School Teacher Guide, Miami Science Museum, Copyright ©2010 Miami Science Museum, www.miamisci.org/www/educationdocs/Energy_Tracker_Curriculum_Guide.pdf.

Brief Facilitation Outline

Introduction

- Introduce yourself and the library.
- Frame the activity with the main message: Engineers work to solve the basic challenges of life — including having fun!
- Conversation:
    - Ask open-ended questions about things we need for *enjoyment* in life.
    - Discuss examples of the systems (infrastructure) that engineers design and support for our cities and parks, e.g., how people move, access clean water and electricity, and remove waste.
    - Discuss what participants have observed and know about wind turbines:
        - Engineers work to develop renewable wind energy technology to supply electricity.
        - Wind is a renewable energy source; wind is found across the globe and will never run out.
        - Wind turbines convert wind energy into electricity. As their blades (also called sails or vanes) move, they spin other parts inside a generator, which produces electricity.

Activity

- Use the supporting media to explore how engineers are designing, building, testing, and modifying wind turbines (optional).
- Challenge (in groups of 3–4; parents too!): Build an initial working model of a wind turbine, and then modify the design to more efficiently supply electricity to a community park:
    - Individually think about, build, and test a model constructed from straws, Post-It Notes, toothpicks, and Play-Doh (making adjustments as needed so that it spins).
    - In groups, coordinate to methodically change only one aspect of the design at a time (e.g., the material or the angle, size, shape, or curve of the blades).
- Encourage persistence: Successful engineering involves a process of thinking, building, testing . . . and doing it again!
- Present the modified wind turbine designs (optional).

Conclusion

- Summarize the groups' explorations of how engineers solve life's challenges.
- Congratulate the groups on their accomplishments.
- Advertise any future engineering and technology events.

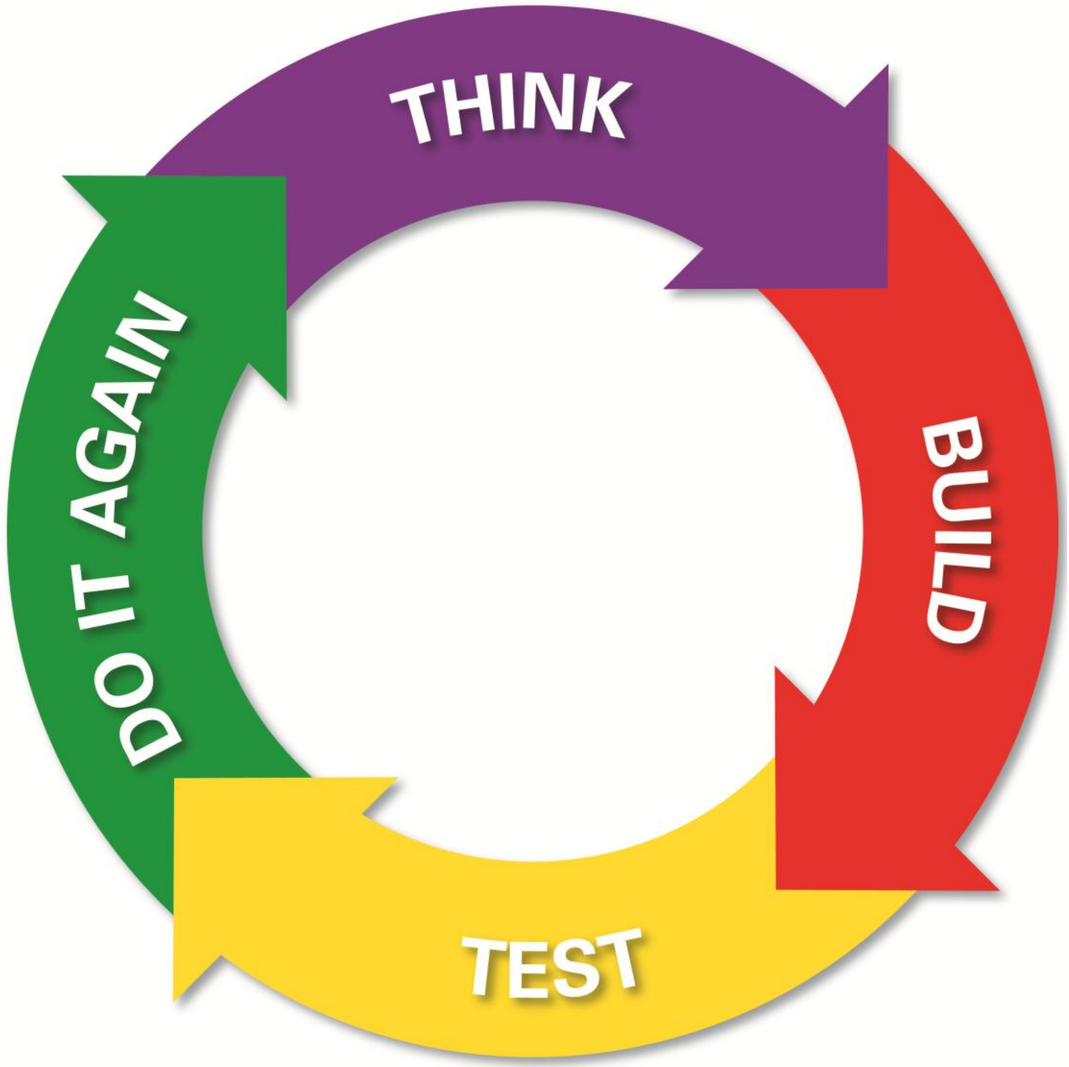
Activity Materials to Print

Be Creative...Be an Engineer!

Think, build, test, do it again: That's the process engineers use when they tackle a problem. Engineers don't have official rules telling them to follow this set of steps. But, over time they've learned that they get the best results this way:

They think and brainstorm about a problem and factors they have to consider to solve it. They come up with an idea and build a prototype. They test the prototype. And, then they repeat the process to improve their results.

Engineers often move back and forth within the loop, repeating two steps over and over again before moving forward. It's a key to engineering success.



Provide Access to Clean Water

This GRAND CHALLENGE encourages engineers to **find ways to provide all people on Earth with access to clean water.**

One in six people in the world don't have sufficient access to clean water for drinking, sanitation, and agriculture. To meet this challenge, engineers **need to find ways to transport water** from areas where it is abundant to remote communities where it is not. They must also develop **effective systems for cleaning contaminated water**.

Restore and Improve Urban Infrastructure

This GRAND CHALLENGE encourages engineers to **improve aging roads, railways, water facilities, sewage treatment, and other city systems.**

Urban infrastructures have been crumbling for decades. The problem is especially acute in Asia, home to the world's largest cities. Engineers must find **environmentally safe ways to modernize outdated and inadequate city support systems**. Billions of people's health, safety, and quality of life depend on it.