Outreach Playbook

Wind Turbine Building Challenge

Metrics:

Grade Level: 8th grade	# of Student Participants: 20-24 students	Duration (hrs): 1 hr and 20 min	# of SWE Volunteers: 3 (could have more)	Partner orgs (if any): N/A

Overview of Activity

The purpose of this activity is to challenge students to create a working wind turbine that can power at least a red LED seed bulb (Note: a red LED seed bulb was used since it requires the least amount of mechanical energy to power, about 1.5V – 1.9V) and to learn about renewable energy. Using the materials provided, the students will construct a wind turbine in teams of 3-4 students. Once the turbine is constructed, the students will use an electric fan to act as a constant stream of wind that would simulate the windy weather conditions that could power a true wind turbine. As the blades spin, the mechanical motion spins the magnet within the DC motor to create a magnetic field, which generates an electric current. This current then travels through the wires connected to the LED seed bulb using a breadboard. A voltmeter is also connected to the LED so that students can see how much power their constructed turbines generate even if the bulb does not light up.

The main takeaways for the students include an introduction to prototyping and engineering design, the current percentage of global energy consumption due to renewable energy, and the benefits and limitations of using renewable energy as a power source.

The real-life connections we presented to our audience includes looking at the current percentage of global energy consumption attributed to renewable energy, how different conditions (i.e. weather conditions, budget, materials availability, and engineering design) affect the efficiency of renewable energy capture, and discussing how engineers can account for variable conditions such as sensors that allow wind turbines and solar panels to pivot to the optimal energy capture angle. One could also reference local renewable energy fields, and the emerging technology of solar powered cars is probably something these students are familiar with.

We created notes sheets and slideshows for our activities for volunteers to refer back to and provide visual aids for the audience. We highly recommend doing so when replicating the activity since the age group of our audience responds better to a mix of visual and aural stimuli than just aural stimuli.

Outline and Script

1. Introductions
    a. Names, majors, interesting fact (optional)
    b. What is the organization and why would the audience be interested in knowing you?
2. Engineering discipline focus of the activity
    a. Overview, roles, what specifically these engineers work with
        i. Environmental Engineering (example content below)
            1. A combination of chemistry, biology, math, and engineering to maintain the natural environment
            2. Purify wastewater, test air pollution, create renewable energy sources, prevent erosion
            3. Wind turbines, solar panels, greenhouses, and more!
        ii. Electrical Engineering (example content below)
            1. Electromagnetic energy and fields, electronics
            2. Designers and builders
            3. Electronics, power plants, communication networks
3. Main discussion question
    a. Why don't we use more renewable energy?
4. Introduction of activity
    a. Goal: build a wind turbine that powers an LED bulb
    b. List materials given and used for testing (optional)
5. Mention what the students should observe during the activity
    a. Does your turbine power the bulb?
    b. What voltage reading does your turbine produce?
6. Present different design ideas
    a. Suggestion: show diagrams of different wind turbine designs (different number of blades, blade shapes, HAWTs vs. VAWTs, etc.)
7. Building and Testing time (Note: use the most time doing this!)
    a. Give them a finite amount of time to account for discussion time after
    b. Provide a hub, at least four dowels, and a generator to each team from the turbine building kits
    c. Provide access to construction paper, tape, pencils, and scissors
    d. Allow the teams to plan and build their wind turbines
    e. Set up the testing area at the front of the room while the students build

i. Place a table between the volunteer(s) leading the testing and the student team members
ii. Face the fan so that the air flows between the volunteers and teams, facing away from people
iii. Insert a red LED seed bulb into the breadboard with the anode and cathode in different rows to prevent a short
iv. Attach the voltmeter to record the voltage across the LED (Note: this will show the students how many volts their wind turbines produce and whether that value is enough to power the LED)

f. Have some volunteers wander around groups and answer questions if the groups have any
g. Connect the students' wind turbine motors one-by-one into the breadboard with one wire in the same row as the anode and the other wire in the same row as the cathode, and turn on the fan once the students have their turbine positioned well to spin
    i. Make sure that all wires do not touch each other and/or cross
    ii. Explain to the students how the breadboard works
        1. Example: "There are small wires organized beneath the plastic in rows, and this allows for a well-organized circuit."
    iii. If the reading on the voltmeter is negative, do <u>one</u> of the following:
        1. Flip the LED connections to the motor wires
        2. Swap the motor wire connected to the anode to be connected to the cathode, and vice versa
        3. Swap the voltmeter wire connected to the anode to be connected to the cathode, and vice versa
h. Show the voltmeter to the students so that they can see what voltage value their turbine can produce and whether the LED lights up
i. Make suggestions to improve how the air hits their turbine to show them that there is an optimal angle to their wind turbine
    i. Examples: have them rotate the wrist holding the turbine to see if the turbine should be a HAWT or a VAWT, see if the turbine spins faster with the air not hitting the blades head-on, hold the turbine closer to the fan, etc.
j. Encourage them to go back and modify/redesign their turbines
k. Note: if the bulb does not light up anymore, swap out the bulb for another red one or even try a yellow one since it is harder to power, which means it is less likely to burn out

8. Discussion
    a. Suggestion: show the most current global primary energy consumption by source (Note: link is an example)
    b. Emphasize how much counts as renewable energy (solar, wind, hydropower, etc.)

c. Refer back to the main discussion question (Why don't we use more renewable energy?) and have students share their answers based on what they observed in the activity
d. Recap the limitations of renewable energy (examples below)
    i. Weather conditions: Renewable energy technology needs certain conditions to be successful
    ii. Engineering design: Engineers need to create machines that best capture the energy sources
    iii. Materials available: Design limits add more stress to the designer to get the technology right the first time

9. Circle back to environmental and electrical engineers' roles in renewable energy (examples below)
    a. Environmental Engineers understand where best to place wind turbines and what designs are best
    b. Electrical Engineers recognize how much energy needs to be captured to create enough electricity
10. Suggestion: spotlight a volunteer at the very end
    a. Why? This allows the audience to get to know the volunteers, possibly see commonalities in the volunteer with themselves, see "proof" that they can pursue a STEM education
    b. Name, year, major(s) and minor(s), words of wisdom (i.e. what the volunteer would say to themselves at that age)
    c. Feature pictures of projects that relate to the topic covered (if any) and cool projects that the volunteer has worked on
11. Suggestion: ask them if they have any questions for the volunteers about being a college student, engineering, etc.

Lessons Learned

What worked well:

- Giving the students creative freedom
    - The teams came up with designs that volunteers would not think of if performing the activity themselves
- Allowing students to test and modify their turbines multiple times
    - Students were able to see improvements in their designs and learn how to prototype
- Emphasizing to the students that the activity centered on building, testing, and modifying is what college engineering majors and professional engineers do in their careers
    - This shows the students that they have the capacity to become professional engineers and inspires them to chase that possibility

What did not work well:

- Creating a lecture
  - Talking for longer than 5 – 10 minutes is not engaging to the students
  - How to fix: break up the lecture to being more like a discussion so that the students can take in information conversationally rather than merely listening to the speaker

Accessibility Adaptations

Note: we did not offer accessibility accommodations since all students were in-person, spoke English, and were not ESL students

Rather than using the KidWind Basic Turbine Building Parts, one can use Tinker Toy parts that operate similarly to the different building parts and buy DC motors separately for a cheaper price and in bulk (see link as an example: Amazon.com: Topoox 12 Pack DC Motor 1.5-3V 15000RPM Mini Electric Hobby Motor for DIY Toys Science Projects : Toys & Games). If the rotors of the motors do not fit the Tinker Toy part holes, one can also use putty of some sorts to fill the hole (i.e. Play-Doh, Silly Putty, etc.).

Materials and Costs

Item	**Quantity**	**Where to Buy (link if applicable)**	**Total Cost**
KidWind Basic Turbine Building Parts	6	KidWind Basic Turbine Building Parts - Vernier	$144 (using 10 pack order)

Construction Paper Sheets	96	Multi-department stores (i.e. Walmart) Crayola Construction Paper, 8 Primary Colors, Beginner Child, 96 Pieces - Walmart.com	$2.46
Voltmeter	1	Home improvement stores (i.e. Home Depot) Stalwart Digital Multimeter Tester M550065 (homedepot.com)	$14.95
Breadboard	1	Amazon.com: BB400 Solderless Plug-in BreadBoard, 400 tie-Points, 4 Power Rails, 3.3 x 2.2 x 0.3in (84 x 55 x 9mm) : Toys & Games	$6.75
LED seed bulbs (various colors)	(at least) 10	Amazon.com: Chanzon 60 pcs(6 colors x 10 pcs) 5mm LED Diode Lights Assortment Kit Pack (Diffused Round Lens DC 3V 20mA) Lighting Bulb Lamp Assorted Variety Color Electronics Components Light Emitting Diodes Parts : Industrial & Scientific	$6.99
Electric fan	1	Home goods stores (i.e. Bed, Bath, & Beyond) Holmes® Blizzard 11.41-Inch 2-Speed Oscillating Table Fan in Black | Bed Bath &	$21.99

		Beyond (bedbathandbeyond.com)	
Roll of masking tape	1	Multi-department stores (i.e. Walmart) Duck Brand .7 in. x 55 yd. Beige General Purpose Masking Tape - Walmart.com	$1.24
Scissors	6	Multi-department stores (i.e. Walmart) Westcott All Purpose Scissors, 5", 7", 8", for Office, Blue, 3-Pack - Walmart.com	$10.54
Pencils	(at least) 10	Multi-department stores (i.e. Walmart) Pen+Gear No. 2 Wood Pencils, 12 Count - Walmart.com	$0.78

Describe any additional funding sources outside of section budget (if applicable):

This activity was created and completed for a middle school located close to our university's campus, and an alumna of both the middle school and our university donated funds for the activity's completion.

Also, nearly all the equipment was borrowed from our university's physics department since a member of the chapter's executive board is a teaching assistant for the department.