Electric Vehicles Toolkit

HARNESSING THE WIND

MIDDLE SCHOOL SCIENCE

For more information on Ignited, visit:
https://igniteducation.org

For more information on RAFT visit:
https://www.raft.net

For more information on Acterra visit:
https://www.acterra.org

Powered by:
electrify america

Harnessing the Wind

How do we transform wind energy into electricity?

Lesson Overview	Career Highlight
Students will explore the purpose and function of generators, build a wind turbine using a RAFT Wind Turbine kit, and draw a connection to regenerative braking in electric vehicles.	Test Lab Supervisor

STEM Course Connections	21st Century Skills	CTE Alignment
Middle School Earth Science Middle School Physical Science	Creativity Innovation	Career Readiness

Engineering Activity	
Science and Engineering Practices #2 & 8	Students will build a model of a wind turbine and troubleshoot how to maximize the energy capture.

Materials

- RAFT Wind Turbine kit
- Table top fans
- Student Handout

Essential Questions

1. How do we transform wind energy into electricity?
2. What is a generator? How does it work?
3. How do electric vehicles capitalize on the use of a generator for regenerative braking?

Background Information

How do wind turbines work? A wind turbine works by using blades to collect the wind's kinetic energy, then as the blades rotate the energy is transformed from mechanical energy into electricity through the generator. When the wind flows across the surface of the blade, an air pressure imbalance occurs, leaving more lift on one side, and more drag on the other. This imbalance in the aerodynamic shape of the blades causes the rotor, which is connected to a generator, to spin.The kinetic energy transforms into mechanical energy as the wind turns the turbine's blades, which spins a rotor, which then turns a shaft. The shaft then powers a generator. The generator

produces electricity due to a magnetic field flowing through a coil of wire. When this happens, a buildup of charge occurs, voltage is created, and an electric current is generated.

Mission Prep

Engage (5 mins)

Warm-Up

- Show Switch Energy's video clip, "How Wind Energy Is Made"
- Have students respond to the following questions in their student handout:
  - What is the function of a generator?
  - Where does our electricity come from?

Explore (25 mins)

BUILD IT Activity

- Students will create a wind turbine using the supplies and directions from RAFT in the kit
- Students will then sketch the model that they built in their student handout
- Students can then test out their turbine at one of your "Wind Stations" to learn how it works
  - Wind stations: Have a few tabletop fans set up around the classroom. Measure 1 meter from the fan and place a piece of tape on the tabletop to indicate where turbines should be placed for testing.

Launch

Explain (10 mins)

KWL: What is a generator?

- Borrowing one of the RAFT Wind Turbine kits from a student, hold up the generator.
- Ask students to fill in the "Know" column of their KWL chart in the student handout with anything that they already know about generators
- Have students share out what they wrote down (with elbow partners or whole class)
- Now, have students record questions and wonderings that they have in the "W" column of their KWL chart.
- Play this video for the class and narrate as the video plays how a generator works.
  - *A generator is a tool that converts mechanical energy into electrical energy. This demonstration uses a crank and belt drive to spin the coil between the north and south poles. By moving a coil of wire next to a magnet, it produces an electric current. To trace the energy transfer, mechanical kinetic energy becomes electrical energy which then transforms into light energy.The electrical energy that our wind turbines are generating comes from the kinetic energy of the wind moving the turbine blades which cranks the generator which generates the electric current.*
- Have students fill in the "Learn" column of their KWL with how a generator works

Elaborate (40 mins)

1. Introduce R & D
   - Transition from KWL to the next iterative step by explaining what research and design is. Something like: "Now that you have learned how a generator works, you must be thinking… I can make my wind turbine better! This is called "Research and Design" in industry. Many people work

in this sector of R & D. Here is a short video clip of a Test Lab Supervisor for Tokyo Electron Limited"
- Show SEMI's career profile video clip.
- Transition into brainstorm session… "We are now going to be Test Lab Supervisors ourselves and explore how to improve the design of our wind turbines."

2. Class Brainstorm
   - Now that students have established working definitions for a generator and the idea of iterations, pose to the class: How could we make our wind turbines perform better? Spin faster? Rotate with the wind?
   - Using the whiteboard, or a digital platform like Jamboard, hold a class brainstorm session to determine ways to improve the design of their wind turbines
   - Students will share ideas like changing the shape of the blade, changing the number of blades, changing the thickness of the blade, and changing the angle of the blade (Note: blade angle is the most impactful and can impact the performance of other factors if not kept constant)
3. WIND OFF Challenge
   - Have students pick one of the variables from the brainstorm session and change their wind turbine accordingly
   - For these adjustments, you may want to be ready with some common classroom supplies for them to use. Examples might include things like extra paper, card stock, tape, scissors.
   - Students will use the following key to measure their turbines' performances:

1	2	3	4
Turbine does not spin fast enough to light the LED	LED occasionally flickers dimly	LED consistently flickers for longer time periods and brighter light is emitted	LED produces a consistent bright light (no flickering)

   - Students will collect data, graph, and analyze their results in their student handout

Exploration

Evaluate (20 mins)

WIND OFF Reflection

- Student share: have students share their design, what they chose to change and why it improves their turbine's performance. (This can be as a whole class or as partners/small groups)
- Students will set up their new and improved turbine models to demonstrate to their classmates how it performs.
- Once students have shared, they can complete the peer reflection in the student handout

Extend (20)

Regenerative Braking in Electric Vehicles

- Show the class the video, "How to Stop Your Car without Braking" or have them read "Regenerative Brakes: How Do They Work?"
- In small groups, have students discuss:
  - What is regenerative braking?

- When we use the brakes on a regular bike or gas-powered car, what happens to the kinetic energy?
- With regenerative brakes, what happens to the kinetic energy?
- Why does regenerative braking have the term “generator” in it? How is it working like generator?

CA NGSS Standards

- MS-PS2-2. Plan an investigation to provide evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object.
- MS-PS3-1. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object
- MS-PS3-2. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.
- MS-PS3–5. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object
- ETS1.B: Developing Possible Solutions - A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.
- MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

CTE Alignment

- B2.3 Present conceptual ideas, analysis, and design concepts using freehand graphic communication techniques.
- B6.0 Employ the design process to solve analysis and design problems.
- B6.3 Choose between alternate solutions in solving a problem and be able to justify the choices made in determining a solution.
- B6.6 Construct a prototype from plans and test it.
- B6.7 Evaluate and redesign a prototype on the basis of collected test data.

Resources

Basic Electric Generator | Generator Teaching Demo https://www.physicsfunshop.com/search?keywords=generator

The electrical energy that comes to your home is produced by some device... | By Physicsfun | Facebook. (2019). Facebook.com. https://www.facebook.com/physicsfunbyrhall/videos/basic-electric-generator/526759145578815/

Brandt, E. (2022, August). *Regenerative Brakes: How Do They Work? - Kelley Blue Book*. Kelley Blue Book. https://www.kbb.com/car-advice/regenerative-brakes-how-they-work/

Moso, J. (2021). How to Stop your Car without Braking [YouTube Video]. In *YouTube*. https://www.youtube.com/watch?v=Pd8CU6qlRY8

Switch Energy Alliance. (2017). How Electricity is Made - SWITCH ENERGY ALLIANCE [YouTube Video]. In

YouTube. https://www.youtube.com/watch?v=rMyi3-6e6vM