Physical Sciences Lab

Wind to Hydrogen MS Phys. Sci.

HORIZON ENERGY CURRICULUM

Teachers' Guide

Physical Sciences	Middle School	8 hours

Unit Plan - Description

For this activity, students will learn about wind power, hydrogen fuel cells, and renewable energy. They will build a wind turbine, test its efficiency, and use it to generate hydrogen. The primary content includes forces and kinetic energy, transfer and conservation of energy, and designing and constructing engineering solutions.

Focus

Students will engage with multiple resources to understand how energy is transformed during chemical reactions and the relationship between chemical and electrical energy.

Behaviors

SWBAT construct a functioning electrolytic cell and explain its chemical reaction.

SWBAT explain how a wind turbine works.

SWBAT understand the difference between renewable and nonrenewable sources of energy.

NGSS Science and Engineering Practices

- Asking Questions and Defining Problems
- Planning and Carrying Out Investigations
- Analyzing and Interpreting Data
- Using Mathematics and Computational Thinking
- Constructing Explanations and Designing Solutions
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information

NGSS Crosscutting Concepts

- Patterns
- Cause and Effect
- Scale, Proportion, and Quantity
- Energy and Matter
- Structure and Function
- Stability and Change

NGSS DCIs

MS-PS1.B, MS-PS2.A, MS-PS3.A, MS-PS3.B

Energy Literacy Framework

1.1, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 4.1, 4.2, 4.6, 4.7, 6.1, 6.4, 6.5, 6.8

Common Core ELA and Math

RST.6-8.1, RST.6-8.3, WHST.6-8.7, MP.2, 6.RP.A.2, 6.RP.A.3, 6.SP.B.5

Classroom and Homework Activities

1. Lab Activity sheet
2. History of Wind Power
3. Aerodynamics of Wind Turbines
4. Parts of a Wind Turbine
5. Using a Multimeter
6. Stating a Scientific Claim

Electronic and Online Activities

1. What's Inside a Wind Turbine? Video
2. Wind Energy Virtual Lab
3. National Geographic Interactive Wind Activities
4. Wind Farm Virtual Tour
5. Global Wind Patterns
6. Convection and Worldwide Wind Cells

Procedure

Over the course of multiple lessons, students will engage with a variety of resources dealing with fuel cells, wind power, and renewable energy resources. Electronic and online resources will be available to supplement in-class resources as well as instructor-led small- and whole-group discussions. Formative assessment will be conducted with oral questions during activities and students will complete a final written assessment at the close of the activity.

Lab Setup

- Be sure to assemble the base and attach the red and black wires to their contacts before the lab begins to avoid having students use screwdrivers and potentially lose screws. This should take no more than 2-3 minutes per turbine.
- Assemble the fuel cell before the lab as described in steps 2-3 of the Assembly Manual so that students don't need to cut the tubing.
- Lab includes small parts that can go missing easily. Set up a resource area for each lab table or for the entire class to minimize lost pieces.

Safety

- With a powerful fan in front of them, the turbine blades can move very quickly. Students should keep their hands and faces at a safe distance.
- Do not allow the fuel cells to dry out or they will be irreparably damaged. Seal in a plastic bag for storage.
- Students should wear safety goggles at all times.

Notes on Using This Kit

- A small, handheld fan won't be powerful enough to turn the turbine blades. Be sure to use a large, desktop fan.
- A fan with multiple settings is ideal and will allow your students to conduct more experiments about how the turbines operate at different wind speeds. If you don't have a fan with multiple speeds, you can simulate different wind speeds by adjusting the distance between the fan and the turbine, but turbulence will cause some variation in your data.
- When using the fuel cell to generate hydrogen, be sure to connect red to red and black to black! Connecting the fuel cell incorrectly could permanently damage it.

Common Problems

- The turbine spins best when the center of the turbine is lined up with the center of the fan.
- Students might choose configurations of turbine blades that don't spin very well. If their fan is lined up correctly and they can't get their turbine to turn, have them try other blade configurations.
- If the hydrogen fuel cell seems to stop working before using all its hydrogen, uncap one of the small tubes to purge impure gases, recap, and wait 3 minutes before connecting the motor again.

Using the Comprehension Questions Formative Assessment Tool

- As your students are working on their activities and you circulate from group to group, use the grid system to keep track of how well individual students are understanding the material.
- You can use a code to quickly assess each individual's level of mastery after talking with them, for example: (B)elow Grade Level, (A)t Grade Level, (E)xceeds Grade Level.
- Feel free to adopt your own code, and be sure to write them in pencil so you can adjust them as your

students improve over time. Use this tool to take stock of your students' progress at a glance and provide resources to those who need it.
- You can even add your own questions to gauge your students' knowledge of other areas of your curriculum.

Resource Availability

- The electronic and print resources included in this mini-unit are designed to be accessible by students at all levels of achievement. We suggest that you make as many resources as possible available to your students as they engage with the new content so they have multiple opportunities to familiarize themselves with the information.
- If you have additional resources or feel that some of our resources cover material outside the scope of your class, feel free to customize as needed.

Creating New Materials

- We include all our instructional files as modifiable files so that you can customize them to your own class. We've aligned our activities with the Next Generation Science Standards and the US Department of Energy's Energy Literacy Framework. If you need to add content to comply with a specific state standard or the scope and sequence of your course, feel free to do so.
- In fact, if you develop a great new experiment or additional student resource, let us know! We regularly select the best teacher-submitted lessons, labs, and activities and share them with other educators all over the world. Winners are all listed on our website and receive free Horizon Educational Kits for their classrooms.

Alternative Final Products

Some students may benefit from expressing their mastery of the concepts of wind and hydrogen power covered in this activity in different ways. We offer these suggestions for alternative final products that they could create in addition to, or in place of, completion of the analysis and conclusion questions.

- Write a letter to the Mayor, Governor, or President, explaining why the results of your experiments support (or do not support) the use of wind power and hydrogen power in your community.
- Compose a song, poem, or short skit about the benefits of hydrogen and wind power.
- Create a poster, photo collage, or graphic that shows how hydrogen and wind power can work together in the power grid.
- Do we need wind power? Choose a side and hold a debate among your classmates.
- Research the development of wind and/or hydrogen power and write a paper that summarizes the major developments over the years.
- Record a video or audio presentation that describes why hydrogen or wind power is a good idea for your community.

Analysis

Make a scientific claim about the turbine blades: What characteristic was most important in getting them to turn faster? (Read Stating a Scientific Claim if you need help)

Level 1 example answer: "The type of blades was most important."
Level 2 example answer: "Higher angles made the blades turn faster."
Level 3 example answer: "Changing the number of blades had the biggest effect on the turbine speed."

What is the *evidence* you can use to back up your claim?

Level 1 example answer: "We counted 78 rpm."
Level 2 example answer: "Four blades turned faster than five blades."
Level 3 example answer: "The fan could still turn the blades from 36 cm away when we used type A blades."

Explain the *reasoning* behind your claim.

Level 1 example answer: "The turbine spun faster."
Level 2 example answer: "Since we counted more rpm, the turbine must have been spinning faster."
Level 3 example answer: "The farther away the fan was, the lower the wind speed, so the blades that could keep spinning at a larger distance were most efficient."

Did other people come to a different conclusion about their turbine blades? Use your observations to *develop an argument* that supports your position and defend your findings.

Conclusion

You were able to change the angle, shape, and number of your turbine blades. *Design an experiment* that would change a feature of your turbine that you weren't able to test.

Level 1 example answer: "We could test what material is best."
Level 2 example answer: "We could test what weight is best by measuring lighter and heavier blades."
Level 3 example answer: "We could compare different sizes of turbines in different wind speeds to see if different sizes are better in different wind speeds by measuring how fast they spin."

Based on your data, what angle, shape, and number of blades for your wind turbine would produce the most energy?

Level 1 example answer: "Type A, with 3 blades, at 6⁰"
Level 2 example answer: "Type C, with 2 blades, at 50⁰ because that's when we recorded the highest rpm."
Level 3 example answer: "2 Type B blades and 2 Type A blades, at 28⁰, because it produces power in both high and low wind speeds."

How could you use a hydrogen fuel cell with a wind turbine to generate power even when there isn't any wind?

Level 1 example answer: "Use the hydrogen in the fuel cell to make electricity."
Level 2 example answer: "Use the wind turbine to make hydrogen, then use the fuel cell to make electricity."
Level 3 example answer: "Use the wind turbine to provide power when there's wind and use some of the electricity to make hydrogen in the fuel cell. Then if there's no wind you can use the fuel cell to provide power."

Do you think that wind power could provide electricity to your school? Why or why not? Using your data from your experiments, *develop an argument* that you could present to your school's principal on whether or not your school should use wind power.

Level 1 example answer: "Yes because it's windy outside sometimes."
Level 2 example answer: "No because we don't have room to build one."
Level 3 example answer: "No because we would need to get wind almost all the time and there are many days where it isn't windy at all. Also there are lots of houses and trees around that would block the wind."

Full sized wind turbines have blades that can change their angle. Based on your observations, why do you think they would need to change the angle of the blades?

Level 1 example answer: "Sometimes they want the blades to spin faster or slower."
Level 2 example answer: "As the wind changes speeds, the blades will need different angles."
Level 3 example answer: "At lower wind speeds, the blades need a higher angle to keep turning, but they will spin more efficiently at higher speeds with a lower angle."

Modern wind farms use many turbines together to produce electricity. Using your observations from the experiments you performed, *design an experiment* that could test how multiple turbines should be connected electrically to produce the most electric current.

Level 1 example answer: "Hook up lots of turbines together until you get enough electricity out of them."
Level 2 example answer: "Take a lot of turbines and hook some of them together in series and some in parallel. Then measure the current produced by each of them."
Level 3 example answer: "Generators in series will produce more current, so we should see higher electric current when we link the turbines in series. We could test this by connecting the turbines in series and measuring the current they produce to see if it's more than just one turbine."

Measurement

This section requires a multimeter or the Horizon Renewable Energy Monitor. For help setting up a multimeter, see "Using a Multimeter."

If the turbine is spinning faster or slower, we should be able to figure out how much faster or slower it's moving based on how much electricity it's producing. Using a multimeter like the Horizon Renewable Energy Monitor we can measure the voltage and amperage of the electric current. See "Measuring Current in a Circuit" if you need to know the difference between volts and amps.

With your multimeter attached to the turbine and LEDs, you should be able to see differences in the current produced by the turbine. Change the number, type, or angle of the turbine blades and see what changes you can observe when the turbine is placed in front of the fan. Record your observations on the table below:

Blade Type (A,B,C)	***Number of Blades***	***Blade Angle (6º, 28º, 50º)***	***Volts***	***Amps***

Your energy monitor can also measure the revolutions per minute (RPM) of the wind turbine blades if you push the “Select” button until RPM appears. Knowing the RPM, you can calculate the angular velocity, or how long it takes for one blade to complete one rotation. For example, if your blades are spinning at 60 RPM, then one blade completes one rotation in one second.

How fast are your blades spinning? Start by recording the fastest RPM you can record, using the most effective blade angle, number, and type.

RPM: _____________

Since there are 60 seconds in a minute, you’ll need to divide by 60 to find out how many rotations your blades complete in one second.

Revolutions per second: ______________

Does your turbine spin faster or slower than one revolution per second?

How many times would it turn if you left it spinning for an hour?