Wind to Hydrogen HS Earth Sci.

Earth Sciences | High 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 human impacts on global climate 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

HS-ESS2.D, HS-ESS3.C, HS-ESS3.D

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

- 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.
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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.

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 6º"
Level 2 example answer: "Type C, with 2 blades, at 50º because that's when we recorded the highest rpm."
Level 3 example answer: "2 Type B blades and 2 Type A blades, at 28º, because it produces power in both high and low wind speeds."

Design an experiment that tests whether different types, angles, and numbers of blades work better in different wind speeds.

Level 1 example answer: "Run the turbine with different blades at different wind speeds."
Level 2 example answer: "Try out the same type, angle, and number of blades at different speeds see which works best. Then try the same thing with different angles, numbers, and types of blades."
Level 3 example answer: "Using the data from our previous experiment we could use the same angles, types, and number of blades and change the distance of the fan to change the wind speed and see if they still performed the same as in our first experiment."

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."

What characteristics do you think would make a good location for wind energy? Do you think your school is located in an area that could provide wind energy? Why or why not?

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."

Based on your observations, do you think there are more benefits of wind power than drawbacks? *Develop an argument* to defend your position and discuss your conclusion with your classmates.

Level 1 example answer: "There are more benefits because it's better for the environment."
Level 2 example answer: "There are more drawbacks because it's not windy all the time and it doesn't generate a constant amount of electricity."
Level 3 example answer: "There are more benefits because you can get electricity without making any pollution and you can use many turbines together so that you'll have power even when it's not windy in one place."

Could you generate more power with more turbines? Explain how you would connect multiple turbines together if you wanted to create more electric current.

Level 1 example answer: "You could attach them with wires so electricity would run between them."
Level 2 example answer: "You could run wires from one turbine to the next so they would generate more electricity."
Level 3 example answer: "You could hook up the wind turbines in series so that the amount of electric current would be greater."

Do you think a hydrogen fuel cell is better or worse for generating electricity than a wind turbine? *Develop an argument* to defend your position and discuss your conclusion with your classmates.

Level 1 example answer: "Hydrogen fuel cells are better."
Level 2 example answer: "Wind turbines are better because they don't need any fuel."
Level 3 example answer: "Hydrogen fuel cells and wind turbines are both good ways to generate electricity, but I think fuel cells are better because they keep generating power as long we give them hydrogen. They don't rely on the wind to work."

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***