Renewable Energy

Goals

- Assemble different renewable energy generators
- Compare the ways in which they generate electricity
- Make calculations based on data

Background

For two weeks in December 2015, the residents of the Chinese capital of Beijing, a single city home to more people than any US state except California or Texas, had a "Red Alert" for air pollution. Thick smog from factories and the more than 5 million cars in the region had made the air unsafe for people to be outside and the government was forced to close schools and limit travel to keep the 22 million residents from being exposed to dangerous amounts of toxins in the air they were breathing. Anyone who dared to venture outside wore protective masks over their faces in an attempt to limit the damage this severe pollution caused to their body.

This is an extreme example of human dependency on fossil fuels, but it's exactly the kind of situation that scientists around the world have been trying to prevent by researching the potential of clean sources of energy to replace the coal and oil fuels that cause the pollution found in Beijing and elsewhere.

Three promising technologies are wind power, solar power, and hydrogen fuel cells. They each have limitations and drawbacks, but none of them pollute the air like their fossil fuel counterparts.

If our cars, factories, and power plants could rely on clean, renewable energy, not only would our air be cleaner but our planet would be healthier too. Without the need to mine our fuels from inside the Earth, and without the climate-altering greenhouse gases produced from exhaust, the human impact on Earth's environment would be significantly reduced.

Special semiconductors in solar panels convert the endless supply of sunlight directly into electricity. A wind turbine uses its massive turning blades to capture the energy of moving air and spin a turbine to create electricity. Hydrogen fuel cells combine hydrogen and oxygen gases in a chemical process that produces water and electricity.

Is one of these technologies a clear favorite to replace fossil fuels as a source of energy, or should we keep looking?

In this activity, we will generate electricity with these three different technologies and compare the results to determine which would be the best renewable energy source.

Wind Turbine Procedure:

1. Look at the three different types of blades available (labeled A, B, and C). How are they similar? How are they different? Discuss with your group which type of blade you think would work best with your turbine and record your observations below.

2. Select the type and number of blades you want to test. Why do you want to test this type of blade first? Do you think it will be better or worse than the other types?

3. Check that the blades are in the same position using the three notches near the white bases of the blades. Rotate the individual blades if needed to get all the blades into the same position. Would your turbine still

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work if the blades were in different positions?

4. Insert the blades into the Rotor Base and put the Blade Holder and the Blade Assembly Lock, then attach the Blade Unit to the metal shaft of the turbine. Can your blades be positioned backwards? How do you know if there's a "right way" for a blade to be positioned?

5. Connect the base of the turbine to the LED lights using the black and red wires. Why do you think the lights need two wires to work?

6. Turn on the fan and position it in front of the turbine. It will work best if you keep the fan close to the turbine and line up the center of the fan with the center of the turbine. Why would changing the position of the fan affect the wind hitting the turbine?

7. Record your observations in the Data Table below: Did the lights turn on? Were they dim or bright?

8. Discuss what you observed with your group and discuss what you want to change: the number of blades, the angle of the blades, the type of blades, or some combination of those.

9. Repeat steps 1-8 with as many changes as you can think of.

Observations

Data Table:

Blade Type (A, B, C):	Number of Blades:	Blade Angle (6°, 28°, 56°):	Other Observations:

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Wind Turbine Experimentation:

1. Based on your data from the previous experiment, keep the angles of the blades the same and try different numbers of different types of blades to see which works best. Record your observations below:

Number of Each Type of Blade:	Observations:

What combination worked best?

2. If you used a combination of different types of blades, try changing the arrangement of the blades (A, B, A, B or A, A, B, B, for example) to try and get the rotor to turn faster. If your rotor spun fastest with only one type of blade, you can skip this experiment.

Blade Order:	Observations:

What arrangement worked best?

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3. Move your fan farther back, to reduce the speed of the wind hitting your turbine. Test different configurations of blades and record your observations below.

Blade Type (A, B, C):	Number of Blades:	Blade Angle (6°, 28°, 56°):	Observations:

Was the best arrangement the same as at the higher wind speed?

4. What's the farthest distance you can move your fan and still turn your turbine? Use your ruler to measure how far your fan is from your turbine blades. Try different arrangements to see if you can get the turbine to turn at even farther distances.

Blade Type (A, B, C):	Number of Blades:	Blade Angle (6°, 28°, 56°):	Distance (cm):	Observations:

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Solar Panel Procedure:

1. Use your solar cell to power the small motor that controls the fan. You'll need to connect the solar cell to the fan using wires to carry the electricity. Why do you think you need two wires?
2. When you've connected the solar cell to the motor, you may have to give the fan a little push to get it started. The solar cell will work best in direct sunlight. What happens to the fan if you try the solar cell with other light sources?
3. Now try using the solar cell to power the LEDs. Record your observations below.

Observations

Solar Panel Experimentation:

1. You can use colored plastic gels, or different lightbulbs, to change the color of light hitting the solar panel. Do certain colors work better than others? Try using the solar panel to run the fan and LEDs while the panel is hit with different wavelengths of light and record your observations below:

Light Color:	Observations:

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2. The solar panel is dark in color. Does the color of its surroundings affect how well it collects light for generating electricity? Try using the panel to run the fan and LEDs while the panel is in front of different colored backgrounds and record your observations below:

Background Color:	Other Observations:

3. Attach the solar panel to the motor and use a piece of paper or other method to shade parts of the panel and observe the effects. How much of the solar panel can you cover before the motor stops running? Does it matter which side of the solar panel is shaded?

Fuel Cell Procedure

1. You can use the electricity from the battery pack to generate hydrogen gas using the electrolyzer. The electrolyzer is the square with "H2" and "O2" printed on either side. What do you think will happen if you connect it to a source of electricity like the battery pack?

2. Your electrolyzer is also a hydrogen fuel cell that can generate electricity from hydrogen and oxygen. It has two small tubes attached to it. Is there anywhere else on the fuel cell that you could attach the longer tubes?

3. Look at the remaining pieces of your kit. If the fuel cell splits water into hydrogen and oxygen gases, what could you use to trap the gases so they don't float away? Connect the tubes of your fuel cell so that you can trap the gases. To generate hydrogen, you'll need to supply an electric current. You can do this with the battery pack or the solar cell. Try both. Which is better at producing hydrogen? How do you know?

4. When you've produced hydrogen, you can use the fuel cell to power the motor just like you did with the solar cell. Plug the motor into the fuel cell and it should start turning. Note in your observations if you see any difference in how the motor works with the fuel cell instead of the solar cell.

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Observations

Fuel Cell Experimentation

1. Use the battery pack and fuel cell to generate hydrogen gas as before. Then attach the fuel cell to the LEDs and measure how long they run. Repeat and note any changes. Record your observations below:

Trial:	Run time (sec):	Observations:
1		
2		
3		
4		

2. Try the same experiment with the fan motor. Record your observations below:

Trial:	Run time (sec):	Observations:
1		
2		
3		
4		

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Measurement

For this section, you will need a multimeter or the Horizon Renewable Energy Monitor. For an introduction to using a multimeter, click here.

1. Measure the current in amps and the voltage in volts while the wind turbine at its fastest configuration powers the LEDs. Record your answers below:

Current: _____ A

Voltage: _____ V

2. Measure the current in Amps and the voltage in Volts while the solar panel powers the LEDs. Record your answers below:

Current: _____ A

Voltage: _____ V

3. Measure the current in Amps and the voltage in Volts while the fuel cell powers the LEDs. Record your answers below

Current: _____ A

Voltage: _____ V

4. Power is the current times the voltage (P = IV). Based on your data, which energy source generated the most power?

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Analysis

1. Make a scientific claim about your electric generators.

2. What evidence do you have to back up your scientific claim?

3. What reasoning did you use to support your claim?

4. Design an experiment that would test how to improve the power output of one of your generators.

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Conclusions

1. Do you think the fuel cell, wind turbine, or solar cell makes the best source of electric energy? Explain your reasoning.

2. What is the biggest limitation of the power source you chose above? Why do you think it's the biggest?

3. What could you do to possibly overcome that limitation?