

Name: \_\_\_\_\_

Class: \_\_\_\_\_

Date: \_\_\_\_\_



Physical Sciences

Middle School

6 hours

## Objective

Run experiments with an ethanol fuel cell learn about chemical reactions, electricity, and renewable energy.

## Materials

- Horizon's Bioenergy Education Kit
- Ethanol solution
- Distilled water
- Stopwatch
- Horizon Renewable Energy Monitor (optional)

## Background



Fig. 1: This car runs on ethanol instead of gasoline.

What if you could get energy from plants like wheat or corn? If we could build cars that run on vegetables instead of fossil fuels, we could have a good use for plant waste and also reduce pollution. Biofuels (called that because they're fuels made from living things) could change the way we generate electricity in the future.

Amazingly, we can already do this! Modern technologies such as the ethanol fuel cell on your lab table now enable us to recycle plants into useful energy. But what does a chemical like ethanol have to do with vegetables?

Ethanol is a chemical that's a product of decomposing plants during a process called fermentation. Ethanol is being used to power cars (Figure 1) and as a heat source for homes. It can also be used by our fuel cell to produce electricity. You can learn more by reading [Introduction to Ethanol](#).

With the right mixture of ethanol, our fuel cell will provide enough electricity to power a small motor on a fan. But it won't always produce the same amount of electricity. We can change how well the fuel cell works by changing things like how hot the fuel is or how much ethanol we mix with water.

What concentrations of ethanol are better for the fuel cell? At what temperature should it run? When scientists are building cars and machines that run on ethanol, they have to ask these kinds of questions to make sure they get the most energy out of their ethanol fuel. Now we'll use the ethanol fuel cell to explore these questions and more during this activity.

## Method

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We will be using the ethanol fuel cell to power a small fan. We will run experiments to understand more the most efficient way to make our ethanol fuel cell work.

## Procedure

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As you assemble your fuel cell and run your experiments, write down any interesting observations you have in the **Observations** section below.

1. Open the purging valve on the bottom of the fuel cell by pushing it towards the back, away from the fan.
2. Make sure the tubing connecting the fuel cell, purging valve, and fuel container is secure.
3. Open the fuel container and pour the ethanol solution in, then close the lid.
4. Wait 5-10 minutes for the fuel cell to begin the chemical reaction.
5. Attach the red and black alligator clips to the fuel cell and observe what happens.
6. When you're finished, disconnect the alligator clips.

### **Observations:**

Write down anything interesting you observe while running the ethanol fuel cell.

**Experimentation: Concentration of Ethanol**

Will the fuel cell run better if the ethanol is more concentrated? Using the different concentrations of ethanol provided by your teacher, run the fuel cell as you did in the **Procedure** section.

Each time you run it with a different concentration, write down any observations below.

<b>Concentration</b>	<b>Observations</b>
<b>5%</b>	
<b>7%</b>	
<b>10%</b>	
<b>12%</b>	
<b>15%</b>	

What happened when you used different concentrations of ethanol in your fuel cell? *Construct an explanation* of what you observed.

**Experimentation: Temperature**

How does the fuel cell work with fuel at different temperatures? Using the heated fuel samples provided by your teacher, run the fuel cell as you did in the **Procedure** section. Record any observations below:

<b><i>Temperature (°C)</i></b>	<b><i>Observations</i></b>

Did the temperature of the fuel affect how fast the fan was spinning? *Construct an explanation* of what you observed.

## Analysis

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Make a *scientific claim* about your ethanol fuel cell. What are the conditions that would generate the most electricity from this fuel cell? To help you write a claim statement, see [Stating a Scientific Claim](#).

### Claim

What evidence can you use from your observations of the car to back up your claim? State the reasoning you used to make your claim.

### Evidence

State the reasoning you used to make your claim.

### Reasoning

Use the data you collected to *design an experiment* that you could run to test the effect of air temperature on the fuel cell. Explain the steps of your experiment here:

Does it matter if the fuel cell is attached to something other than the fan? *Design an experiment* that would test what happens when other electric machines are powered by the ethanol fuel cell. Explain the steps of your experiment here:

## Conclusion

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1. What happens if you attach the wires to the fan backwards (red to black and black to red)? *Construct an explanation* of what you observe.

2. Could you use an ethanol fuel cell to provide power to your house? *Develop an argument* to support your position using evidence you observed during this activity and defend your argument if there are different points of view in your group.

3. Was energy made or used up during this activity? *Construct an explanation* of what happened to the energy and why.

4. What would you do to improve the electricity production of your ethanol fuel cell? *Design a solution* that would increase the amount of electricity you would get from your fuel cell.

## Measurement

How much electricity is running through our circuit? To find out, we'll need to use an ammeter like the Horizon Renewable Energy Monitor to measure the amount of electric current being produced by the generator. Read [Measuring Current in a Circuit](#) for more information on how to set this up.

When your ammeter is connected to your circuit, run the ethanol fuel cell to power the fan. Use a stopwatch and measure the amount of current in the circuit at different times. If you have the Horizon Renewable Energy Monitor, you can also measure the volts. Record your data below:

<b><i>Time (min)</i></b>	<b><i>Amps (A)</i></b>	<b><i>Volts (V)</i></b>
<b><i>0</i></b>		
<b><i>2</i></b>		
<b><i>4</i></b>		
<b><i>6</i></b>		
<b><i>8</i></b>		
<b><i>10</i></b>		

Does the amount of electricity produced by the fuel cell change? *Construct an explanation* of what you observed.