

**Summary:** Through scenario writing, students envision future uses and sources of energy.



# Fuel Cell Futures

**Grade Level:** 5–8 (9–12)

**Subject Areas:** English Language Arts, Science (Chemistry)

**Setting:** Classroom

**Time:**

**Preparation:** 15 minutes

**Activity:** One week

**Vocabulary:** Alternative energy resources, Alternative fuel sources, Electrolysis, Electron, Fuel cell, Hydrogen, Proton

## Major Concept Areas:

Theme I

- Energy flow in ecosystems, including human societies

Theme II

- Development of renewable energy resources

Theme IV

- Future outlooks for the development and use of energy resources

## Standards Addressed:

Wisconsin Model Academic:

ELA: A.8.4, B.8.1, B.8.2, B.8.3, F.8.1

SC: A.8.1, A.8.5, A.8.6, A.8.8, B.8.1, B.8.2, B.8.3, B.8.4, B.8.5, B.8.6, C.8.1, C.8.2, C.8.3, C.8.4, C.8.5, C.8.6, C.8.7, C.8.8, C.8.9, C.8.10, D.8.3, D.8.4, D.8.9, G.8.4, G.8.6, G.8.7, H.8.2

Common Core ELA: L.7.3, W.7.3, W.7.4, W.7.5, W.7.9

NGSS: MS-ETS1-1, MS-ETS1-2

SEP: Asking Questions and Defining Problems, Engaging in Argument from Evidence

DCI: ETS1.A: Defining and Delimiting Engineering Problems, ETS1.B: Developing Possible Solutions

CCC: Influence of Science, Engineering, and Technology on Society and the Natural World

## Objectives

Students will be able to

- describe how a hydrogen fuel cell works;
- analyze the benefits and challenges of using hydrogen fuel cells to meet our energy needs; and
- discuss the role of hypothetical thinking in planning for the future.

## Rationale

Envisioning future sources and uses of energy helps students consider possible alternatives to current energy use trends.

## Materials

- *Wisconsin Energy Statistics*
- Newspapers
- Magazines
- Internet access
- Computers and word processing software

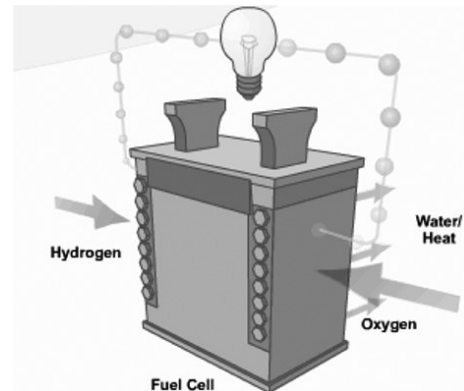
## Background

Every day, Americans use more fossil fuels, primarily coal, to produce electricity. There are other sources of energy that can be used to generate electricity including renewable sources such as solar, wind, and water.

More new and innovative sources for electricity are being developed, tested, and implemented each year. One of these sources is the fuel cell. According to the Department of Energy's Energy Efficiency and Renewable Energy website:

Fuel cells have the potential to revolutionize the way we power our nation, offering cleaner, more efficient alternatives to the combustion of gasoline and other fossil fuels. A fuel cell is a device that uses hydrogen (or a hydrogen-rich fuel) and oxygen to create an electric current.

There are many types of fuel cells. The polymer electrolyte membrane (PEM) fuel cell is lightweight and relatively small. PEM



From the United States Department of Energy, Energy Efficiency & Renewable Energy website, 2005.

Fuel cells generate electricity from the electrochemical reaction between hydrogen fuel and oxygen from the air.

The fuel cell basically reverses electrolysis; hydrogen and oxygen are combined to produce electricity. In the fuel cell, the hydrogen is separated into protons and electrons. The design of the fuel cell forces the electrons and protons to travel different pathways. The path through which the electrons flow creates an electric current. Eventually, the protons (H<sup>+</sup>) and electrons (e<sup>-</sup>) combine with oxygen to form water (the fuel cell's only "waste product").

The above paragraph is a very simple and limited description of how fuel cells work. Visit the KEEP website for links to other more scientific and thorough explanations and diagrams.

Fuel cells hold many promises for future energy use, especially transportation. They are expensive to build, however, and require certain metals such as platinum that are limited in supply. Another challenge involves producing hydrogen for the fuel cells.

Hydrogen is one the most abundant elements in the universe. On Earth it does not exist naturally as a gas (H<sub>2</sub>). It is found combined with other elements such as with oxygen to make water (H<sub>2</sub>O) and with carbon

to make organic compounds including sugars, fats, proteins, and DNA. By mass, our bodies are about ten percent hydrogen. Hydrogen is also found in fossil fuels such as methane, propane, coal, and petroleum.

The most cost-effective way to produce hydrogen is through an industrial process called steam reforming. Large quantities of fossil fuels are used during steam reforming, however. Hydrogen can also be made available through electrolysis (using electricity to split water into hydrogen and oxygen). Electrolysis produces very pure hydrogen that is ideal for fuel cells, but is very expensive (the resulting hydrogen gas costs ten times more than natural gas).

Although more expensive, using water as the hydrogen source would make fuel cells less dependent on fossil fuels. This independence could be further enhanced if the electricity used for electrolysis came from renewable energy sources such as wind or solar.

Besides issues related to expense and technology, there are other considerations needed before switching from a fossil fuel based economy to one based on hydrogen. For example, there are hydrogen storage issues and other environmental issues. Imagine what would be involved in changing gasoline stations around the country to hydrogen fueling stations! Despite these challenges, there are communities, even entire countries, which are exploring the merits of becoming hydrogen-based fuel economies. Iceland, for example, has fuel stations producing hydrogen using geothermal sources of energy. They use the hydrogen to power fuel cell buses within their public transit system. Time will tell when, if, and how fast the United States will change to alternative sources of fuel and electrical generation.

## Procedure

### Orientation

Have students list major sources of energy used by most Wisconsinites (see *Wisconsin Energy Statistics* for more information). Ask students to express their opinions about benefits and problems with our current use and consumption of traditional fuel sources (e.g., convenience, resource depletion, pollution).

Remind students that energy use, like many activities, changes over time. Briefly discuss past energy consumption practices that rarely, if ever, are used today (e.g., heating homes with coal, traveling by horse and buggy). Likewise, many of the ways we use energy today will no longer take place in the future.

Introduce the terms alternative energy and alternative fuel sources. Ask students to share what these terms mean to them. Why might they be the same as or different than renewable energy? Have they heard about alternative energy or fuels in the news? Note if they bring up fuel cells.

### Steps

1. Ask students if they have ever imagined a future situation. Discuss the reasons why they spent time doing this exercise and what purpose it served. Help students to understand that envisioning the future can help prepare for possible events and to plan appropriately.
2. Revisit the analysis of current energy use practices discussed in the **Orientation**. Ask students how imagining the future might help to prepare for future energy use practices. In particular, how might the use of an alternative fuel source such as hydrogen affect future energy use practices?

## Scenario Writing:

Scenario writing is used in futures studies and is a learning strategy in which students write a story about what the world would be like if certain events were to happen. It is an imaginative prediction of the outcomes of current issues and solutions, and how they are affected by current trends and issues. The stories are a fusion of current data, some trend extrapolation, and imaginative thinking.

Although scenarios envision the future, they must be based on what is happening in the present. They must show an appreciation of how current events, decisions, and attitudes brought us to the world being described. While scenarios do not need to be accurate, they should be useful. The purpose of the stories is to increase awareness of where we might be heading and who or what is directing us. It should make us ask: Is this how we want the world to be? or, What will the world be like if certain events come to pass?

In conclusion, a scenario blends research, understandings, imagination, and creativity with the elements of short story writing—conflict, plot, character, setting, and theme. It provides us with a problem solving tool for analyzing alternative futures to current trends.

3. Provide an overview of hydrogen fuel cells, referring to the **Background** and other sources. Have students create a chart that compares and contrasts potential benefits and challenges to fuel cells.
4. Introduce the activity of scenario writing and its purpose (see **Scenario Writing**). Tell students they are to use scenario writing to envision how fuel cell use might affect life in the future.
5. Provide students with the parameters of the project. They should write a two-page fictional essay about a day in the life of a student living in the year 2050, focusing on energy consumption, in particular, the use of hydrogen fuel cells. The essay should cover how hydrogen fuel cells work and how they are used. The class can develop other ideas and criteria for their stories (they can search the Internet for “scenario writing”).
6. Have students work individually or in pairs to write their scenarios. Allow them one week to complete the project. Encourage them to base their stories on research, browsing newspapers, the Internet, and other resources for information about alternative fuels and, in particular, fuel cell technologies.

### Closure

Have students share their scenarios and scrutinize the stories for credibility and feasibility. How do the different stories compare to each other? Discuss what the class has learned about hydrogen fuel cells and other alternative fuels. What do they predict for the future of energy use? Would they use hydrogen energy if it becomes available in their lifetime?

## Assessment

### Formative

- Do their stories include an accurate description of how fuel cells work?
- Were the scenarios two pages in length?
- How thoughtfully and thoroughly did students envision a day in the life of a student their age in the future?
- Did student scenarios show an appreciation of how current events, decisions, and attitudes influence future activities?
- Do their stories provide a realistic vision of future energy use?

### Summative

Have the class analyze practical uses of the scenario writing exercise, exploring how the scenarios can be used as a problem solving tool. How might the stories solve current problems and issues? What new problems could arise out of their scenarios?

## Extensions

Have students share their scenarios with community leaders, energy and utility professionals, urban planners, local elected officials, etc. and get their impressions about fuel cells and hydrogen fuel for our future.

Several science companies sell fuel cell kits. Students can learn more about how fuel cells work by building these models.

A group of concerned citizens in your area has asked your class to develop a plan to reduce emissions from city vehicles—including school buses, public buses, sanitation trucks, police and emergency vehicles, and the city fleet of automobiles. Divide students into six groups and have each group develop a plan to present at a public forum with local politicians and citizens, listing recommendations and costs for each type of vehicle and the rationale for each recommendation. Encourage students to research different alternative transportation fuels. After students have developed their plans, stage a class debate. List the recommendations of each group on the board by vehicle category.

Where there are several recommendations, have representatives from groups defend their recommendations until a consensus is reached by the class or a majority vote determines the most popular.

