Summary: Through mapping and research, students measure the availability of ethanol-blended fuels in their community, and the environmental benefits of using these fuels.

Corn in Your Car

Grade Level: 9-12

Subject Areas:
Agriculture, Science, Technology Education, Environmental Education

Setting: Classroom, Community

Time:
Preparation: One hour
Activity: One - two weeks

Vocabulary: Bioenergy, Biomass, Ethanol, Fermentation, Flexible-fuel vehicle (FFV)

Major Concept Area:
Theme IV
- Management of Energy Resource Use

Getting Ready:
For this activity, the number and size of student groups will depend on the size of your community. In a larger community, divide the community into regions and assign a group of students to each region. In a small community, you may want to assign individual streets to student groups.

Academic Standards:
Science: C.12.1, D.12.4, E.12.4,
AG: A.12.1, D.12.1, E.12.3, E.12.5, E.12.6
TE: B.12.2, B.12.5, B.12.6
EE: B.12.9, D.12.6, D.12.8

Resources
Web sites
Alternative Fuel Data Center - www.eere.energy.gov/afdc/altfuel/ethanol.html

How Stuff Works - www.howstuffworks.com

Objectives
Students will be able to
- identify the plant resources used to produce ethanol;
- describe the process of converting corn to ethanol;
- map the distribution of ethanol-blended fuel stations in their community; and
- explain the pros and cons of ethanol fuels.

Materials
- Street maps of your community
- Copies of ***Experimentation in Fermentation worksheet*** (optional)
- Small colored stars or circles
- Materials for posters/displays

Background
The term bioenergy, or biomass energy, means any plant-derived organic matter available on a renewable basis, including dedicated energy crops and trees, agricultural food and feed crops, agricultural crop wastes and residues, wood wastes and residues, aquatic plants, animal wastes, municipal wastes, and other waste materials. These sources can provide energy in the form of electricity, heat, steam, and fuels.

Biomass is a renewable resource—it can be replaced fairly quickly without permanently depleting Earth's natural resources. By comparison, fossil fuels, such as petroleum and coal, require millions of years of natural processes to be produced. Drilling for petroleum is considered a nonrenewable process since it depletes Earth's resources for thousands of generations.

More than 60% of petroleum resources in America are imported, and a majority of this petroleum is used as gasoline for automobiles. The burning of fossil fuels, such as gasoline, is a major contributor to air pollution and increased greenhouse gas. Ethanol represents an option for vehicle fuel that burns cleaner than gasoline, can be produced in the United States, and could reduce U.S. dependence on foreign oil.

Ethanol is ethyl alcohol. It is made via an advanced distillation process from crops and vegetable matter, such as corn (see ***Experimentation in Fermentation*** for more information). With many of Wisconsin's farmers growing corn, ethanol fuel production could benefit the state's economy. There are already a number of ethanol plants in Wisconsin, with others being proposed and planned.

Liquid ethanol can be used as a fuel when blended with gasoline or in its original state. There are three primary ways that ethanol can be used as a transportation fuel:
- As a blend of 10% ethanol with 90% gasoline (known as E-10)
- As a component of reformulated gasoline, directly and/or as ethyl tertiary butyl ether (ETBE)
- As a mixture called E-85 that consists of 85% denatured ethanol blended with 15% gasoline: E-85 does not burn well in conventional vehicles, but flexible-fuel vehicles (FFV) are designed to run on all blends up to 85%.

Ethanol can be used to increase octane levels, decrease engine emissions, and extend the supply of gasoline. According to the United States Deptarment of Agriculture, 3.9 billion gallons of ethanol were produced in the United States in 2005. Each bushel of processed corn yields 2.5 gallons of ethanol, along with several valuable by-products. The first blends in the 1970s were 10% by volume (E-10), and a blend of 85% by volume (E-85) was introduced in the mid 1990s.

Methanol, which is similar to ethanol, is a racing fuel for major sporting events such as the Indianapolis 500. Aside from being a component of fuel, ethanol is also widely used as a solvent, in industrial applications, and as the intoxicating ingredient in alcoholic beverages.

Procedure

Orientation

Ask students what they know about ethanol. Some students may know of farmers who grow corn for ethanol production or they may know of ethanol plants in Wisconsin. Describe some of the uses of ethanol in the United States (see **Background**).

Do students think that ethanol-blended products are already available in their community? Explain to students that through this activity, they will find out what resources are available.

Steps

1. Divide the class into working groups (see **Getting Ready**).

2. Each group will receive a street map of the community that shows their assigned study region. Encourage students to share responsibilities and come up with innovative ways to complete their research.

3. Allow students one to two weeks to conduct the following research:

- Develop a one-page fact sheet about ethanol, summarizing how it is produced, how it is used, and its economic and environmental costs and benefits.
  - Students can conduct Internet research to learn more about ethanol.
  - Make sure students explore E-10 and E-85 blends and understand the costs and benefits of each.
  - See **Experimentation in Fermentation** for a hands-on activity that illustrates some aspects of ethanol production.
- Map stations in their region that do and do not sell ethanol fuel (students can visit or call the stations).
- Classify stations that sell ethanol based on fuel blend:
  - Fuel stations that sell E-10 fuel (10% ethanol, 90% gasoline)
  - Fuel stations that sell E-85 fuel (85% ethanol, 15% gasoline)

4. Have the groups transfer their researched information to a class map. The class can create a key, using colored stars or dots to represent fuel stations of different classifications. NOTE**:** This step may not be necessary in small communities.

5. Challenge student groups to create a one-page informational flyer (or some other public service announcement) that provides an overview of ethanol and identifies fuel stations that sell ethanol-blended fuels. Encourage students to be creative! These flyers can be posted around the school or students can contact community planners about displaying the flyers around the community.

Closure

As a class, review the presence (or absence) of ethanol and ethanol blends in your community. Based on students' research and perceptions, discuss pros and cons of ethanol use in your community.

Assessment

Formative

- Did the students properly identify the major sources of ethanol production?
- How well did the students explore and map the fuel stations in the community?
- Are students able to identify the environmental benefits of using ethanol fuels?
- How extensively and thoughtfully did students develop their marketing strategy?
- Did students create plans that appropriately addressed the availability of ethanol-blended fuels in the community and reasons to use these fuels?

Summative

How has this activity increased students' knowledge of ethanol and their attitudes toward ethanol use? Have each student write a reflective essay to summarize their views.

Extensions

There are many resources available that describe how to produce ethanol or how to transform a gasoline vehicle into a FFV. Depending on the level and curriculum of your classroom, investigate these avenues for a possible student project. In urban areas such as Milwaukee, residents are required to purchase "reformulated gasoline" year round, but the formulation of the gas changes with the season. Have students explore this concept and survey community residents on their knowledge and perceptions of ethanol and reformulated gasoline. Integrate this data into a marketing strategy for promoting ethanol use.

Although methanol is the main component of superior racing fuels, other fuels utilized for racing contain varying amounts of ethanol. If students are interested in racing, have them research and analyze racing fuels and octane ratings. How do racing vehicles differ from FFVs? What effect would using an ethanol-blended fuel have on a non-racing car?

Math skills can be put to the test by having students calculate the miles an automobile can be driven using ethanol derived from a certain crop of corn. For example, have students compute the miles from 750 acres of corn in an automobile using E-10 (10% ethanol blend) that gets 26 miles per gallon. Consider that an acre of corn produces an average 127 bushels and each bushel produces about 2.5 gallons of ethanol.

Experimentation in Fermentation

Ethanol is made from a variety of plant substances including corn, sugar cane, and wood. The process used to make ethanol is called fermentation. Fermentation was discovered many years ago when bubbles or foam formed while making wine and beer. Studies by Louis Pasteur described fermentation as changes caused by yeasts growing in the absence of air. Fermentation is an energy-yielding process in which fuel molecules such as glucose (sugar) are broken down in the absence of oxygen. Changing corn to ethanol by fermentation takes many steps. Starch in corn must be broken down into simple sugars before fermentation can occur. In earlier times, this was done by chewing the corn. This allowed the salivary enzymes to naturally break down the starch. Today, this is achieved by cooking the corn and adding the enzymes alpha amylase and gluco amylase. These enzymes function as catalysts to speed up the chemical changes. Once a simple sugar is obtained, yeast is added. Yeast is a single-celled fungus that feeds on the sugar and causes fermentation. As the fungi feed on the sugar, they produce alcohol (ethanol) and carbon dioxide. In fermentation, the ethanol retains much of the energy that was originally in the sugar, which is why ethanol is an excellent fuel.

This experiment can be modeled by the teacher or used as a laboratory exercise.

Materials:
- 8 or more pkgs of yeast
- ice
- measuring spoons
- 4 clear half-liter glass containers
- stirrers
- heating element
- flour, salt, sugar, vinegar

Steps:

1. Empty a package of yeast into each half-liter (1 pint) beaker of warm water. Stir for 1 minute.

2. Add 10 ml (2 tsp.) of flour to each beaker and stir again.

3. Add 5 ml (1 tsp.) of salt to the first beaker, 5 ml of sugar to the second beaker, 5 ml of vinegar to the third, and do nothing to the fourth. Stir again.

4. Wait 5 minutes and record your observations.

Beaker 1_____
Beaker 2_____
Beaker 3_____
Beaker 4_____

5. Wait 15 minutes and record your observations.

Beaker 1_____
Beaker 2_____
Beaker 3_____
Beaker 4_____

6. Let the solutions sit overnight and record your observations.

Beaker 1_____
Beaker 2_____
Beaker 3_____
Beaker 4_____

On a separate piece of paper, describe the fermentation that is taking place, or have students answer the following questions:

1. What is the evidence that reactions are going on in the containers?

2. How are these observations related to fermentation?

3. State any conclusions about which of the substances tested was most helpful to yeast fermentation.