Corn in Your Car

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

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-blend fuel stations in their community; and
- explain the environmental benefits of ethanol fuels.

Rationale

Through a community investigation, students gain a greater understanding of fuel resources and consumption in their neighborhood.

Materials

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

Getting Ready

For this group 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 students.

Background

The term bioenergy, or "biomass," 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. Therefore, drilling for petroleum is considered a nonrenewable process as it depletes Earth's resources for thousands of generations.

Over sixty percent 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 greenhouse gas increases. Ethanol represents an option for vehicle fuel that burns more cleanly than gasoline, can be produced in the United States, and reduces dependence on foreign oil.

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

The 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 percent ethanol with ninety percent gasoline known as E10,
- As a component of reformulated gasoline, directly and/or as ethyl tertiary butyl ether (ETBE), or
- A mixture called E85 that consists of 85 percent denatured ethanol blended with 15 percent gasoline; E85 does not burn well in conventional vehicles, but flexible-fuel vehicles (FFV) are designed to run on all blends up to 85 percent.

Grade Level: 9–12 (5-8)

Subject Area: Agriculture, Science, Technology Education

Setting: Classroom and community

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

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

Major Concept Areas:

Theme I

- Definition of energy
- Energy flow in living systems
- Energy flow in ecosystems, including human societies

Theme II

- Development of energy resources
- Consumption of energy resources
- Development of renewable energy resources
  - Biomass

Theme III

- Quality of life
  - Lifestyles
  - Economic
  - Cultural
- Quality of the environment

Standards Addressed:

Wisconsin Model Academic:
AG: D.12.1, D.12.6, E.12.6
SC: B.12.4, C.12.1, C.12.2, C.12.4, C.12.5, C.12.6, D.12.4, G.12.3, G.12.5, H.12.1, H.12.4, H.12.5, H.12.6
TE: A.12.2, A.12.5, A.12.6, A.12.7, B.12.1, B.12.3, B.12.8, C.12.2, D.12.2, D.12.4, D.12.6

(Standards cont.)

Common Core ELA: RI.9-12.1, RST.9-12.3, RST.9-12.7, SL.9-10.1, W.9-12.2, W.9-12.7, W.9-12.8, WHST.9-12.10

Common Core Math: MP1, MP6, N-Q.1

NGSS: MS-PS1-2, MS-PS1-3, MS-PS1-4, MS-PS1-5, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3
SEP: Planning and Carrying Out Investigations, Analyzing and Interpreting Data, Constructing Explanations and Designing Solutions
DCI: PS1B: Chemical Reactions, PS2B: Types of Interactions, PS3.A: Definitions of Energy
CCC: Cause and Effect

Wisconsin Ethanol Plants

Name	Location
ACE Ethanol, LLC	Stanley
Badger State Ethanol, LLC	Monroe
Castle Rock Renewable Fuels, LLC	Necedah
Didion Milling, Inc.	Cambria
Fox River Valley Ethanol, LLC	Oshkosh
United Ethanol, LLC	Milton
United Wisconsin Grain Producers	Freisland
Valero Renewables-Jefferson	Johnson Creek
Western Wisconsin Energy, LLC	Boyceville

Source: www.stateenergyoffice.wi.gov/

Ethanol can be used to increase octane levels, decrease engine emissions, and can extend the supply of gasoline. U.S. ethanol production reached a record level of 14.8 billion gallons in 2015. Each bushel of corn processed yields 2–4 gallons of ethanol along with several valuable byproducts. The first blends in the 1970's were 10% by volume (E10), while a blend of 85% by volume (E85) was introduced in the late 1990's.

Methanol, which is similar to ethanol, is the required racing fuel for major sport 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 feature 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 ethanol plants that are 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? Tell students that through this activity, they are going to find out.

Steps

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

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

3. Allow students up to two weeks to conduct the following research:
   - Develop a one-page fact sheet about ethanol, summarizing how it is produced, used, and its economic and environmental costs and benefits.
     - Students can conduct Internet research to learn more about ethanol.
     - Make sure students explore E10 and E85 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 their fuel blend:
     - Fuel stations that sell E10 fuel (10% ethanol, 90% gasoline)
     - Fuel stations that sell E85 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.

5. Challenge student groups to create a one-page informational flyer (or some other public service announcement format) that provides an overview of ethanol and identifies fuel stations that sell ethanol-blended fuels. Encourage students to be creative! These fliers 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 their community. Based on their research and perceptions, discuss pros and cons of ethanol use in their community (see "Biofuel Beliefs" activity in the *BioFutures Activity Guide* on the KEEP website under **Curriculum & Resources,** then **Curriculum**).

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 fact sheets and informational flyers?

Summative

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

Extensions

There are many resources available that instruct a consumer in producing ethanol or transforming a gasoline vehicle into an 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 effects would using a methanol-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 E10 (10% ethanol blend) that gets 26 miles per gallon. Consider that an acre of corn produces an average 127 bushels; 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 fermentation. Fermentation was discovered many years ago when bubbles were 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 which feeds on the sugar and causes the fermentation. As the fungus feeds on the sugar, it produces alcohol (ethanol) and carbon dioxide. In fermentation, the ethanol retains much of the energy that was originally in the sugar, and this explains why ethanol is an excellent fuel.

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

Materials:

4 pkgs of yeast
4 clear glass, half-liter containers
measuring spoons
stirrers
flour, salt, sugar, vinegar

1. Fill each container with equal amounts of warm water.
2. Empty a pkg of yeast into each container. Stir for 1 minute.
3. Add 10 ml (2 tsp.) of flour to each beaker and stir again.
4. 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.
5. Wait 5 minutes and note your observations.
   Beaker 1 _____
   Beaker 2 _____
   Beaker 3 _____
   Beaker 4 _____
6. Wait 15 minutes and note your observations.
   Beaker 1 _____
   Beaker 2 _____
   Beaker 3 _____
   Beaker 4 _____
7. Let the solutions sit overnight and note your observations.
   Beaker 1 _____
   Beaker 2 _____
   Beaker 3 _____
   Beaker 4 _____

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 any of the containers?
2. How are these observations related to fermentation?
3. Which of the substances tested was most helpful to yeast fermentation?