

**CLASSROOM ACTIVITY**

Fuel for the Future

OBJECTIVES

Students will:

- **Research** and **summarize** how biofuels are created and how they are used.
- **Determine** the positive and negative impacts of one biofuel source.
- **Compare** and **contrast** this biofuel source with other possible sources.
- **Develop** and **revise** a recommendation that justifies the biofuel source that could best fuel sustainable and economical travel.

OVERARCHING QUESTION

Which biofuel, when combined with petroleum, may have the most potential to fuel future travel and transportation?

ACTIVITY SUMMARY

Students will become chemical engineers as they investigate how biofuels, when combined with petroleum, can contribute to sustainable travel and transportation. They will research and compare various biofuel sources as they consider their environmental and economic advantages and disadvantages. They will then apply their analysis as they develop a recommendation that outlines the biofuel source that they believe has the greatest potential for fueling future travel.

BACKGROUND INFORMATION

Biofuels that complement conventional transportation fuels, such as renewable diesel, can play an important role in reducing the carbon intensity of transportation fuels while meeting the world's growing energy needs. Renewable diesel, also known as biomass-based diesel, is a hydrocarbon diesel vehicle fuel produced from nonpetroleum renewable resources such as vegetable oils (soy, corn, canola, etc.), animal and poultry fat, used cooking oil, municipal solid waste, and wastewater sludges and oils.

MATERIALS

- Devices with internet access, at least enough for half the class
- *Designing Solutions Handout*, one per student
- Device with the ability to project video, one for the instructor

CHALLENGE

1. Encourage students to turn to a partner and share their dream travel destinations.
2. Then lead a class discussion around the pros and cons of this kind of travel. How could it affect themselves, their community, and the world both positively and negatively?
 - Be sure students address that some of the benefits of travel and exploration include opportunities to grow as a person and better understand the world around them, as well as a chance to contribute to the economy. Explain that petroleum products, including gasoline, accounted for more than 90% of the U.S.'s transportation energy use in 2019. Therefore, petroleum products can be credited with giving us the energy we need to explore the world around us!
 - Go on to share that most travel also results in greenhouse emissions, which in turn negatively affects the environment. In 2018, the largest source of greenhouse gas emissions in the United States (accounting for 28% of all emissions) was from transportation.¹
3. Tell the class what actions petroleum companies are already taking to increase their sustainability. One important step is the use and continued innovation of biofuels.

Explain that biofuels are renewable transportation fuels that are made from biomass (or organic material from plants or animals). Today's most popular biofuel is ethanol, which is made from plant sugars and starches. Biofuels are mixed with gasoline and used in today's cars. More than 98% of gasoline in the U.S. contains some ethanol. Most cars are able to operate with a fuel composed of 10% ethanol and 90% gasoline. In order for cars to run on fuel that contains more than 10% biofuel, their engines would need to be rebuilt or replaced!

4. Tell the class that today they will be challenged on behalf of the U.S. Department of Energy (DOE), the U.S. Department of Transportation (DOT), and the nation's leading petroleum manufacturers to develop a proposal to make travel and exploration more environmentally friendly. Explain that ethanol is not the only option for biofuels, and these organizations would like to explore all possibilities. Distribute one *Designing Solutions Handout* to each student, and elaborate on the challenge by reading aloud the steps listed under *Step 1: Define the Challenge*.
5. Explain that students will complete this challenge in groups of five, as they each take on the role of a chemical engineer focused on a different biofuel source.

Play the Chemical Engineer/Chemist Career Profile Video available at <https://stemcareerscoalition.org/careers-portal> to prepare students for the activity, and ask students to listen for different ways that chemical engineers work to positively affect the environment.

Explain that chemical engineers who focus on biofuels strive to design biofuel systems and processes that are as efficient, sustainable, and economical as possible. One important responsibility is to analyze existing and potential biofuel systems as they consider the pros and cons of alternative energy sources—which is what they will be doing today!

¹ epa.gov/ghgemissions/sources-greenhouse-gas-emissions

6. Then prepare student groups to perform research to better understand the challenge.
 - Write the following websites on the board:
 - energy.gov/eere/bioenergy/biofuels-basics
 - eia.gov/energyexplained/biofuels/
 - Explain that groups will have about 20 minutes to learn more about biofuels and their specific biofuel source. Encourage them to use these websites to gain a general understanding of biofuels and then continue with additional research.
 - Encourage groups to divide the biofuel sources and then begin their research.

DESIGN

1. Bring the class back together and explain that it is time to compare and contrast their biofuel sources in order to develop a solution to the challenge.
2. Call on a student to read the handout's *Step 2: Create a Design* section aloud. Recommend that students take notes on each source as their peers share, so they can ultimately compare and contrast the benefits and risks of each one.
3. Explain that as groups complete these steps, they should continue to look at the challenge through the eyes of chemical engineers whose goals are economic and environmental success.
4. Tell the class that they will have about 20–25 minutes to complete the *Design* portion of this handout. At the end of this time, they should be ready to explain the reasoning behind their biofuel source recommendation.

SOLVE

1. When there are about 10 minutes left in the class period, randomly pair student groups together.
2. Instruct a spokesperson from each group to briefly share the biofuel source they selected, and why they believe this is the best option in terms of sustainability and economics.
3. As groups share with each other, encourage them to listen carefully to each other's explanations. Challenge students to apply what they have learned in their own research to ask at least one or two clarifying questions.
4. Once both groups have shared, asked, and answered questions, they should complete the *Step 3: Analyze Solutions* portion of the handout to strengthen their own recommendation.
5. For homework, encourage students to continue exploring careers related to biofuels. Instruct them to use <https://stemcareerscoalition.org/careers-portal> to watch one or more of the following Career Profile Videos and consider each one's connection to this fuel source:
 - Distributed Energy Resources Engineer
 - Trucker Driver
 - Renewable Energy Engineer

STANDARDS

Next Generation Science Standards

- Engineering Design:
 - ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
- Earth and Human Activity:
 - HS-ESS3-2: Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
 - HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

ITEEA Standards for Technological Literacy

- Standard 16: Students will develop an understanding of and be able to select and use energy and power technologies. In order to select, use, and understand energy and power technologies, students should learn that:
 - M. Energy sources can be renewable or nonrenewable.

Step 1: Define the CHALLENGE

Your challenge is to:

1. Perform research to understand how biofuels are created, as well as why and how they are used in the United States.
2. Split the following biofuel sources among your group members, and complete further research on one source listed below. Look for information that will help you understand how this biofuel is produced, its environmental impact, its economic impact, and any potential production limits.

Biofuels to research:

- a. Corn
 - b. Switchgrass
 - c. Oil
 - d. Wood
 - e. Algae
3. Work with your group to develop a recommendation on the biofuel source that you recommend the United States invest in moving forward.

As you complete your research, take notes below:

Step 2: Create a DESIGN

Overview: Share the environmental impact, economic impact, and possible production constraints of your biofuel source with your group. Then compare each biofuel source in order to develop a recommendation for the Department of Energy and Department of Transportation that details the best biofuel source to pursue moving forward.

Requirements: Your plan must include:

1. **Overview:** How can biofuels, when mixed with petroleum, benefit the environment *and* allow people to travel more sustainably?
2. **Recommendation:** Based on your analysis, which biofuel source do you recommend the United States invest in moving forward? Be sure to include:
 - **Advantages:** Its environmental and economic advantages
 - **Disadvantages:** Any environmental and economic disadvantages, as well as why these disadvantages did not dissuade you from selecting this source
3. **Future considerations:** What additional research or studies should be performed on this fuel source and why?

Jot notes below and then complete your plan in a format of your choice on a separate piece of paper.

Step 3: Analyze SOLUTIONS

Reflect on the question(s) that your peers asked. Then consider: How could you revise your recommendation to include this information? Work as a group to decide where and how you could incorporate this new information. Then revise your recommendation accordingly.