

Renewable Fuels



Renewable Fuels Foundation



Renewable Fuels Association



Ethanol and the Environment

Unit 4 Lesson 1

Precepts

- A. Action
 - A4. Identify and use resources.
 - A5. Communicate effectively with others.

National Standards

NSS-G.K-12.5. Environment and Society.
NT.K-12.2. Social, Ethical and Human Issues.

Student Learning Objectives

- As a result of this lesson, the student will ...
1. Describe how ethanol promotes a cleaner environment.
 2. Identify the effects ethanol has on emission levels of other pollutants.
 3. Discuss the negative effects of biofuels on the environment.

Time

Instruction time for this lesson: 90 minutes.

Resources

www.energyportal.eu

Tools, Equipment, Supplies

Writing surface
Projector
Blank paper- one per student
Butcher paper- six large pieces
Colored pencils/markers
TM.A
TM.B
TM.C
TM.D
AS.A – one per student
Assess. A – one per student

Key Terms

The following terms are presented in this lesson and appear in ***bold italics***:
Clean Air Act of 1990
Hydrocarbons (HCs)

Ozone

Aldehyde

Carbon monoxide (CO)

Carbon dioxide (CO₂)

Nitrogen oxides (NO_x)

INTEREST APPROACH

*Begin class by having a brief discussion about the importance of having clean air. Ask students to draw why they think it is important to have clean air, and then allow them to share their drawings with the class. After they have shared, show TM.A, the overview of the **Clean Air Act of 1990**. Have them read the overview and then discuss what the act mandates.*



Close your eyes and picture a beautiful, sunny summer day. The sun is shining and there is a gentle breeze blowing. You decide you are going to rest for a minute, so you lay down in the lush, green grass. As you are lying down, you notice how incredibly blue the sky is. There are just a few large, puffy clouds in the sky. You think you could lay here for the rest of the day!

Pause for about five seconds before moving to the directions.



When I say “draw,” open your eyes and notice there is a blank piece of paper on your desk. We will have three minutes to draw why we think it is important for us to have clean air. Once time is up, we will share our drawings with the class. Questions? Draw!

As the students are drawing, check their progress and provide them ideas of what could be drawn. When time is up or students are finished, have them share their drawing with someone sitting next to them. After that, ask for three or four students to share their drawings with the entire class.



Great work! We have some great ideas about why it is important to have clean air. Let’s share our drawings and why we think it is important to have clean air with someone sitting close to you. Allow students to share. Thanks for sharing.

Who will share their drawings with the entire class?

Again, allow three or four students to share their drawing with the entire class. Be sure to ask them why they think it is important to have clean air. Thanks for sharing! Great work!



Just as we have identified, clean air is important to life on earth. Unfortunately, in today’s world, clean air does not just happen. There are many pollutants that keep our air from being clean.

In 1990, the federal government passed amendments to the **Clean Air Act**. The amendments set minimum standards for air quality in America’s cities. These amendments also included provisions that required the use of oxygenated fuels in areas where excessive amounts of **carbon monoxide (CO)** existed. Since the majority of air pollution is caused by vehicle exhaust, using cleaner burning fuels is one alternative that provides nearly immediate results.

*Show TM.A and share the provisions of the **Clean Air Act** with the class.*



Direct your attention to the screen and we will see a few provisions of the **Clean Air Act of 1990**. Of the provisions listed which one do we think is most important? Allow students time to decide which provision listed is the most important. Excellent ideas!

Since passage of the *Clean Air Act of 1990*, ethanol has emerged as a possible solution for keeping our air cleaner. It is also important to know that ethanol-blended gasoline is one oxygenated fuel being offered as a solution.

Today, we are going to explore the benefits of ethanol and how its usage can improve our environment.

OBJECTIVE 1. Describe how ethanol promotes a cleaner environment.

Let's take a look at a few of the benefits that ethanol has on the environment. While we are examining these benefits, keep the picture of the beautiful summer day in our minds.

Write the following information on a writing surface or show TM.B, which lists benefits of ethanol. Have the students write the information in their notes.

- I. Ethanol is one of the best tools to fight air pollution.
 - A. Ethanol is a clean burning, renewable fuel. E85 is the cleanest burning fuel available on the market today.
 - B. Ethanol contains 35 percent oxygen.
 - C. Ethanol is present in low levels in the environment; it is a natural product that results in the fermentation of plants.
 - D. Ethanol used in gasoline has tremendous potential for a net reduction in atmospheric **carbon dioxide** levels.
 - E. Ethanol is biodegradable, meaning it won't harm groundwater in the event of a spill. Therefore, no water guidelines have been established for ethanol.
 - F. The American Lung Association of Metropolitan Chicago credits ethanol-blended fuel with reducing smog-forming emissions by 25 percent since 1990.

After the students have written the information in their notes, use the Hieroglyphics Moment to review the information. To complete the Hieroglyphics Moment, follow these steps:

- 1. Teach the lesson. Ensure that students have a solid understanding of the information you just presented (how ethanol promotes a cleaner environment).*
- 2. Present the problem. Ask students: What pictures or icons will help you remember the component concepts of this information?*
- 3. Brainstorm. Generate a bank of ideas on the board or overhead.*
- 4. Have students create representations. Using scratch paper divided into six squares, students will draw a "hieroglyphic" that helps them each of the benefits of ethanol.*
- 5. Share. After a specified amount of time, have students compare with one another and explain their creations.*



Using ethanol and ethanol-based fuels can benefit our environment. Thinking about the six types that we just discussed, identify one picture or icon that could be used to illustrate each benefit.



When I say “draw,” you will have four minutes to draw one icon for each of the six ways that ethanol promotes a cleaner environment. Draw the icon beside the statements in your notes. Questions? Draw!

When students have finished, give them about 30 seconds to share their icons with a neighbor.



Turn to your neighbor and show them the icons you drew to help you remember how ethanol promotes a cleaner environment. Nice work! As we move forward, keep those icons in your mind.

One benefit of using ethanol is that it affects emission levels of all pollutants. Let’s take a look.

OBJECTIVE 2. Identify the effects ethanol has on emission levels of other pollutants.

Write the following information on a writing surface or show TM.C.

I. Ethanol results in reductions in every pollutant regulated by the Environmental Protection Agency.

- A. **Hydrocarbons (HCs)**
- B. **Ozone**
- C. **Aldehyde**
- D. **Carbon monoxide (CO)**
- E. **Carbon dioxide (CO₂)**
- F. **Nitrogen oxides (NO_x)**



Ethanol can help reduce these pollutants, but how? And what exactly are the impacts of these pollutants? Let's examine this further.

For the next activity, the students will be divided into six groups. Each group will be assigned one of the pollutants, and using the information provided on AS.A, they will teach their classmates the information about the pollutant they have been assigned. Provide each group with a large piece of butcher paper and access to markers so each group can make a poster to help teach the content. Encourage them to make sure they are getting the most important information. Once the posters have been created, each group will share their information with the class.

Before giving the directions, place the students into six groups.



Each group is about to become an expert, but an expert in what? Each group will become an expert on the impact ethanol has on one of the pollutants we just wrote down. Each group will be assigned one pollutant.

Each group will teach our class about that pollutant, what it is and how ethanol helps reduce it. Keep your presentation as simple as possible, and feel free to draw pictures if that helps explain the information. We will have ten minutes to create our poster and then each group will share their posters with the class. Questions? Okay, starting on the right side of the room let's begin to count off one through six. You may get in your groups and begin.

Give each student a copy of AS.A and then assign each group one of the pollutants. As students are working on this activity, be available to answer their questions. Monitor their progress and provide benchmarks for how much time is remaining. When time is up or when all groups are finished, have each group share their poster with the class.



Thanks for your hard work. This is a pretty complex topic, but we all have done an outstanding job! Congrats! Which group will share first?

Make sure each group shares their poster and answer any questions that might arise. Make sure you mention that each student has all of the information on AS.A.



Even though we know that ethanol can help our environment, it is important to understand that using ethanol is not without risks. In some cases, the use of ethanol can have a negative effect on our environment. Let's examine a few of those negative effects.

Objective 3. Discuss the negative effects of biofuels on the environment.

Write the following information on a writing surface or show T.M.D. Have students write the information in their notes.

III. Ethanol production can have negative effects.

- A. It can decrease biodiversity through the deforestation of forests the clearing of grassland and wetlands.
- B. Changes in the carbon content of soils and carbon stocks of forests/peat lands could offset some of the benefits of greenhouse gas reductions.
- C. It can increase global warming because of a decrease in biodiversity.
- D. In high concentration, ethanol may cause biota, or the killing of living bacteria.

After students have written the information in their notes, use the Karaoke Moment to review how ethanol production can have a negative impact on the environment. To complete the Karaoke Moment, follow these steps:

1. *List key points. Instruct students to list the key words and phrases from the negative effects of ethanol production. As they write their information, create your list on the board or overhead. Students should check their lists with yours.*
2. *Create a song. Tell students that they are to rewrite the words of a song they know using the words from their list. Note: You may want to share an example as a model. If your students are new to the Karaoke Moment, consider providing the lyrics of a simple song for them and allow them to work in small groups. Simple songs include: “Twinkle, Twinkle Little Star,” “Three Blind Mice,” “Row, Row, Row Your Boat,” “Take Me Out to the Ball Game,” “Mary Had a Little Lamb,” “The Ants Go Marching,” “Whistle While You Work,” or other songs your students know by heart.*
3. *Share. After a designated amount of time, invite each group to share their new version of the song. Note: Time varies according to the amount of content expected in the lyrics. For songs like the ones listed above, allow 10-15 minutes.*



On a piece of paper, write down some of the key words or phrases from the list of negative effects of ethanol production. Let's share those together. *Allow students to share their words or phrases. As they do, write them on the board and add information they might have missed.*



Using those words and phrases, let's rewrite the words of a common song. *Share an example with your students that you have pre-made.* When I say “sing,” get into groups of three to rewrite your song. We will have eight minutes to complete this task. Once all groups have finished, we will take volunteers to share with the class. What questions are there? Sing!

As students are working, be available to provide assistance if they need it. This could be challenging, so make sure you have plenty of examples ready to help them. Once time is up or all groups have finished, ask for a few volunteers to share their song with the class.



Wow! Great job everyone. It sounds like we have some songwriters in the room!

REVIEW/SUMMARY

To review the lesson, use the Descartes Moment. To complete the Descartes Moment, follow these steps:

1. Pose three questions. Ask the students to write the following three questions in their notebook: What do you know the risks or benefits of ethanol production? What do you think you understand? What don't you understand? Note: You may want to introduce students to the questions one at a time to focus their thinking.
2. Students write letters to themselves. Students compose a letter to themselves (Descartes was a writer as well as a philosopher) explaining what they know, what they think they know and what they don't understand about the topic. Allow about one to three minutes for thinking and writing on each question. You may want to have students share aloud after the first two questions to stimulate other students' thinking.
3. Collect the letters. The information is valuable for your lesson planning and assessment.

Turn to a blank page in your notebook and jot down the following three questions.

1. What do we know about the risks or benefits of ethanol production?
2. What do we think we understand?
3. What don't we understand?

On a blank sheet of paper, we will draft a short letter to ourselves answering those three questions. We will have three minutes to gather our thoughts and then another three minutes to write your letter. This letter will be your ticket out of the door. Questions? Begin.

Monitor the students time and give them warning to help them pace their time before the end of the class period.

Awesome work and thank you for your effort and attention today; I will collect your letters as you leave the classroom.

APPLICATION

Extended classroom activity: *Have students brainstorm new mandates to include in a new Clean Air Act and then write a draft of the policy proposal.*

FFA activity: *Encourage students to participate in the Agricultural Issues Forum Career Development Event and develop a presentation about the risks and benefits of ethanol production.*

SAE activity: *Arrange a tour of a local corn farm and discuss the impacts that ethanol production has on their farming operation.*

EVALUATION

Assess. A

Answers to Assessment:

Matching

1. Carbon monoxide
2. *Carbon dioxide*
3. *Nitrogen Oxides*
4. *Hydrocarbons*
5. *Ozone*

Essay

Ethanol and other oxygenates take the place of some of the gasoline and add oxygen to the combustion process which reduces levels of all pollutants controlled by the EPA.

Unscramble

1. Ethanol
2. Gasoline
3. Carbon dioxide
4. Grain
5. Corn
6. Alcohol
7. *Ozone*
8. Oxygen
9. Fuel
10. *Hydrocarbons*

TM.A***Clean Air Act of 1990***

On November 15, 1990, Congress enacted the ***Clean Air Act*** Amendments. The amendments made sweeping changes to the way air quality is regulated in the United States. The legislation was designed to curb three major threats to human health and the environment: acid rain, urban air pollution and toxic air emissions.

Clean Air Act Highlights:

- Classifying nonattainment areas according to the extent to which they exceed the standard, tailoring deadlines, planning and controls to each area's status.
- Tighten auto and other mobile source emission standards.
- Requires reformulated and alternative fuels in the most polluted areas.
- Revise the air toxics section, establishing a new program of technology-based standards and addressing the problem of sudden, catastrophic releases of toxics.
- Establishment of an acid rain control program, with a marketable allowance scheme to provide flexibility in implementation.
- Require a state-run permit program for the operation of major sources of air pollutants.
- Implement the Montreal Protocol to phase out most ***ozone***-depleting chemicals.
- The control of ***ozone*** based on regulating emissions of VOCs and NO_x.

TM.B

I. Ethanol is one of the best tools to fight air pollution.

A. Ethanol is a clean burning, renewable fuel. E85 is the cleanest burning fuel available on the market today.

B. Ethanol contains 35 percent oxygen.

C. Ethanol is present in low levels in the environment; it is a natural product that results in the fermentation of plants.

D. Ethanol used in gasoline has tremendous potential for a net reduction in atmospheric *carbon dioxide* levels.

E. Ethanol is biodegradable, meaning it won't harm groundwater in the event of a spill. Therefore, no water guidelines have been established for ethanol.

F. The American Lung Association of Metropolitan Chicago credits ethanol-blended fuel with reducing smog-forming emissions by 25 percent since 1990.

TM.C

I. Ethanol results in reductions in every pollutant regulated by the Environmental Protection Agency.

- A. *Hydrocarbons (HCs)*
- B. *Ozone*
- C. *Aldehyde*
- D. *Carbon monoxide (CO)*
- E. *Carbon dioxide (CO₂)*
- F. *Nitrogen oxides (NO_x)*

TM.D

III. Ethanol production can have negative effects.

- A. It can decrease biodiversity through the deforestation of forests the clearing of grassland and wetlands.
- B. Changes in the carbon content of soils and carbon stocks of forests/peat lands could offset some of the benefits of greenhouse gas reductions.
- C. It can increase global warming because of a decrease in biodiversity.
- D. In high concentration, ethanol may cause biota, or the killing of living bacteria.

AS.A

A. Hydrocarbons (HCs) are formed from products made from crude oil. Petroleum and gasoline consist of blends of more than 250 diverse **hydrocarbons**. Many of these are toxic; some, such as benzene, are carcinogens (cancer causing agents). **Hydrocarbons** escape into the air when refilling the gas tank, from the gas tank and carburetor during normal operation, and from engine exhaust. **Hydrocarbons** that evaporate from gasoline are sometimes called *volatile organic compounds (VOCs)*. If uncontrolled, transportation sources would make up 30-50 percent of the total hydrocarbon emissions in the atmosphere. The automotive industry has developed and is using various vehicle emission control systems that control hydrocarbon emissions. **Hydrocarbons** also contribute to the formation of ground level **ozone**. Since ethanol is an alcohol, it does not produce **hydrocarbons** when being burned or during evaporation.

B. Ozone, sometimes referred to as photochemical smog, is formed in the air when **hydrocarbons** and **nitrogen oxides** react in the presence of sunlight. It is more of a concern on warm, quiet, summer-like days when smog fills the air, creating a brownish haze in the lower atmosphere. This ground level **ozone** causes human respiratory stress and can cause plant damage, sometimes reducing crop yields. This ground level **ozone** does not increase the **ozone** that is in the stratosphere and does not block the sun's harmful ultraviolet rays. Several U.S.-based studies conclude that, overall, the **ozone** forming potential of ethanol blends, which vaporize at lower temperatures due to higher volatility, is about the same as gasoline. In Canada, however, the volatility of ethanol blends must match normal gasoline.

C. Aldehyde emissions from the combustion of ethanol blends are slightly higher than when burning gasoline alone. The concentrations are extremely small and are sufficiently reduced by the vehicle's three-way catalytic converter found on all recent cars. The Royal Society of Canada termed the possibility of negative health effects caused by **aldehyde** emissions from the use of ethanol blends as being "remote."

D. Carbon monoxide (CO) is a poisonous gas formed by incomplete combustion. It is readily produced from burning petroleum fuels which contain no oxygen in their molecular structure. It is especially produced when excessive fuel-to-air mixtures are delivered and burned in the engine. More fuel and less air are necessary to start a cold engine and to keep it running until reaching normal operating temperature. Vehicles operating at colder temperatures (in winter months, during engine warm up, or in stop-and-go traffic) produce significant quantities of this toxic gas. By adding ethanol, which contains oxygen, combustion in the engine is more complete and CO is reduced. Research shows that reductions may reach as high as 30 percent depending on the type and age of the automobile, the emission system used, and the atmospheric conditions. Because of health concerns over carbon monoxide, the 1990 amendments to the Clean Air Act mandate the use of oxygenated fuels in many major urban areas (CO non-attainment areas) during the winter months.

E. Carbon dioxide (CO₂) is a normal non-toxic product of burning fuel, but it contributes to the greenhouse effect (global warming). All petroleum-based fuels cause increased atmospheric **carbon dioxide** levels. Using renewable fuels, such as ethanol, does not increase atmospheric **carbon dioxide** levels. The **carbon dioxide** formed during combustion is balanced by that absorbed during the annual growth of plants used to produce ethanol. Plants "breathe"

carbon dioxide and give off oxygen. Therefore, increased use of renewable fuels made from plants will partially offset the global warming effect of burning gasoline. It is also worth noting that renewable fuel technology can result in a net reduction in atmospheric **carbon dioxide** levels. This is accomplished by transforming **carbon dioxide** into organic matter that is returned to the soil, thereby increasing soil fertility and reducing erosion. Ethanol use in gasoline has tremendous potential for a net reduction in atmospheric **carbon dioxide** levels.

F. **Nitrogen oxides (NO_x)** are produced when high combustion temperatures exist. NO_x contributes to ground level **ozone** (photochemical smog). Several components of gasoline that impact NO_x emissions, including olefins and aromatics, are reduced by adding ethanol to gasoline. EPA studies indicate the use of ethanol blends may slightly increase NO_x emissions under some conditions, but the extent and effects are uncertain.

Assess.A**Matching:**

Hydrocarbons
Nitrogen Oxides

Carbon dioxide
Carbon monoxide

Ozone

Place the emission name next to the statement which best matches each term in the blank provided.

- _____ 1. Unburned fuel from evaporation of gasoline and incomplete combustion.
- _____ 2. Non-toxic vapor produced by complete combustion.
- _____ 3. Produced during high combustion temperatures.
- _____ 4. A toxic vapor produced when burning excessively rich air/fuel mixtures.
- _____ 5. Created when unburned fuel vapors and ***nitrogen oxides*** react when sunlight is present.

Essay:

Answer the following question:

1. How does burning ethanol-blended gasoline in a vehicle lower ***carbon monoxide*** levels?

Unscramble the following words that relate to ethanol fuels:

- _____ 1. THLANOE
- _____ 2. OSALINGE
- _____ 3. BRANCO XOMNOIDE
- _____ 4. RAING
- _____ 5. NORC
- _____ 6. HOLACOL
- _____ 7. NOZEO
- _____ 8. GENYXO
- _____ 9. EUFL
- _____ 10. DRYHOBORCANS