ENERGY FOR EVERYONE
propane

Introduction to Energy and Fuels in Agriculture

LESSON 1
UNIT: PROPANE
PROBLEM AREA: PROPANE USE IN AGRICULTURE

Propane Education & Research Council

STUDENT LEARNING OBJECTIVES

Instruction in this lesson should result in students achieving the following objectives:

1. Define terms associated with energy and fuels.
2. Identify sources of energy and fuels.
3. Compare sources of energy and fuels.
4. Identify alternative and renewable energy and fuel sources.

NATIONAL SCIENCE STANDARDS ADDRESSED IN THIS LESSON

All students should develop an understanding of:

Life Science: Content Standard C

- Matter, energy, and organization in living systems

Science and Technology: Content Standard E

- Understandings about science and technology

Science in Personal and Social Perspectives: Content Standard F

- Natural resources
- Environmental quality

LIST OF RESOURCES

The following resources may be useful in teaching this lesson:

- Propane.com/Agriculture
- Energy.gov
- PropaneSafety.com

LIST OF EQUIPMENT, TOOLS, SUPPLIES, AND FACILITIES

- Candle (medium size; pillar style is best)
- Matches
- PC or MAC with LCD projector hookup and screen
- Copies of sample test
- Visuals from accompanying masters
- Copies of student lab sheets

TERMS

The following terms are presented in this lesson *(shown in bold italics throughout the lesson):*

1. alternative energy
2. biodiesel
3. bioenergy
4. bioenergy fuels
5. biomass
6. biopropane
7. BTU
8. coal
9. crude oil
10. diesel fuel
11. energy
12. energy source
13. fossil fuels
14. fuel cells
15. fuels
16. gasoline
17. geothermal energy
18. hydropower
19. kerosene
20. natural gas
21. nonrenewable energy
22. nuclear power
23. oil
24. propane
25. renewable energy
26. solar energy
27. solar power
28. wind energy
29. regulator
30. safety relief valve
31. service valve
32. sleeve

TELL STUDENTS...

"Today we are going to look at several sources of energy and fuels, including alternative and renewable energy and fuel sources. You will be expected to define terms associated with energy and fuels."

INTEREST APPROACH

Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible interest approach is included here.

THE RELIGHTING CANDLE

1. The purpose of this activity is to show that gaseous vapors from a candle are flammable and can be ignited. A solid substance must first turn into a gas before it will burn in a supply of oxygen.
2. Display **VM-A** and **VM-B** to help students see the process and understand what happened.
3. Use the following questions to help guide a whole-group discussion about what happened.
   a. Why does the flame travel back to relight the candle?
   b. What is actually burning in the candle?
   c. What creates the smoke after the candle is extinguished?
   d. Would wax without a wick still be able to hold a flame?
   e. Why does the candle have to burn for a few minutes and be in a draft-free room for the relighting activity to work?
4. Explain to the students that when a candle burns, what is actually burning is the heated candle's wax vapor. When a candle is lit, the wick burns first and heats up the wax. The heated wax vapor then sustains the flame. Blowing out the candle results in a smoke trail formed from the hot wick continuing to melt the surrounding wax. This releases highly combustible tiny particles of wax into the air in a gaseous form. Lighting a match near this area relights the candle as the flame burns the particles in the air back toward the wick.

TELL STUDENTS...

"We are going to look at one example of a fuel and energy source as well as conditions necessary for its ignition."

DEMONSTRATE THIS FOR THE CLASS:

A. Light a medium-sized candle, and let it burn until the flame is large and a puddle of thoroughly melted wax has formed beneath the flame. This will take about two to three minutes.

B. Strike another match. While holding the burning match in one hand, blow out the candle flame with one short gust.

C. Immediately hold the burning match in the smoke trail of the candle. Move the match toward the wick until the flame "jumps" and relights the candle. A few trials may be needed.
(**Note:** It is a good idea to practice this activity ahead of time to get a sense of the timing.)

D. Have students observe the flame traveling down the smoke trail to relight the candle.

Summary of Content and Teaching Strategies

OBJECTIVE 1

Define terms associated with energy and fuels.

ANTICIPATED PROBLEM

How are terms associated with energy and fuels defined?

Although energy and fuel are often referred to as if they are synonymous, there are important differences between the two.

A. ***Energy*** is the ability to do work. It can be neither created nor destroyed. Energy is stored in a fuel. It is divided into two major categories — potential and kinetic — and comes in different forms. (See the accompanying table.)

CATEGORIES OF ENERGY

POTENTIAL ENERGY

Energy that is stored or "in position"

- Chemical energy stored in the bonds of atoms and molecules, such as the energy stored in a fuel
- Mechanical energy stored by the application of a force, such as a tight spring or a stretched rubber band
- Nuclear energy stored in the nucleus of an atom
- Gravitational energy stored by an object sitting in place, such as by a rock sitting on the edge of a cliff or by water stored behind a dam

KINETIC ENERGY

Energy that is in motion within atoms, molecules, objects, etc

- Electrical — the movement of electrical charges, such as electrons, through a wire or lightning
- Radiant — energy that travels in waves such as x-rays, light, or solar energy
- Thermal — heat or internal energy in a substance, such as geothermal energy in a geyser
- Motion — movement of objects or substances from one place to another; for example, wind
- Sound — movement of energy through a source that causes vibrations

B. ***Fuels*** are materials with stored energy that can be converted to usable energy. Fuels release their energy either through chemical reactions, such as combustion, or by nuclear means, such as nuclear fission.

C. Much of the energy and many of the fuels on Earth, including fossil fuels, are derived from the sun. Exceptions are nuclear power, geothermal energy, and tidal energy. The sun's heat and light energy act as a fuel to many biological and planetary cycles.

1. For biological cycles, the sun's energy reaches the earth and is captured by trees and other plants using photosynthesis. These plants then become the foundation for beginning and continuing the biological energy cycle and food chain.
2. For planetary cycles, the sun's heat and light energy fuel many phenomena, such as the movement of air and water on a global scale. The heat from the sun creates differences in air temperatures, which ultimately result in wind and weather patterns. Evaporation and temperature differences, also caused by the sun, drive the water cycle and create clouds, rain, and rivers.

D. Energy sources are similar in their definition to fuels since fuels contain stored energy. An ***energy source*** is matter from which energy can be extracted or obtained for some use. A fuel is a source of energy.

1. ***Fossil fuels*** are fuels created from the compression of ancient remains of biological organisms that originally used the sun as fuel. With the passage of time and under high heat and pressure, this organic matter was turned into petroleum, coal, and natural gas. These ultimately contain stored solar energy and are thus considered both fuels and energy sources.
2. Moving water can be considered both a fuel and an energy source as it creates electricity by using a dam and a generator. The generator converts the water's stored kinetic energy into electrical energy.
3. Gasoline can be considered both a fuel and an energy source as its stored energy is released in a combustion engine to move a vehicle.

SUGGESTED TECHNIQUES TO HELP STUDENTS MASTER THIS OBJECTIVE

1. Begin the lesson with an interest approach, state the objectives, and introduce key terms.
2. Have the students read selections from appropriate resources (see below).
3. Have students take notes during the discussion

SUGGESTED RESOURCES FOR OBJECTIVE 1

1. Energy Sources: The Pros and Cons informs readers about the major sources of energy consumed in the world today: fossil fuels, hydroelectric energy, solar and wind energy, and nuclear power. Discussions of the pros and cons of each source are included, allowing readers to form their own opinions about the use of each type of energy. Photographs, charts, and diagrams support the text. The book is available by subscription service from Readinga-z.com.

OBJECTIVE 2
Identify sources of energy and fuels.

ANTICIPATED PROBLEM
What are the common sources of energy and fuels?

There are three major categories of fuels or energy sources: renewable, nonrenewable, and nuclear.

A. ***Renewable energy*** is any type of energy that can be naturally replenished at the same rate it is being used, usually energy derived from sunlight. Examples are wind and water movement and the growth of biomass on the earth, all of which are derived from the sun's energy. ***Biomass*** is renewable organic matter, such as agricultural crops, crop-waste residues, wood, animal and municipal wastes, aquatic plants, and fungal growth.

   Note: Energy sources such as geothermal (hot springs) and tidal energy are also considered renewable even though they are not derived from the sun.

   1. Energy and fuel sources:
      a. ***Bioenergy*** is energy produced from a biological or organic source. It can consist of a horse pulling a cart, auto fuel produced from switch grass or corn-based ethanol, wood being burned to heat a home, or organic waste fermenting to produce methane (natural gas) and later create electricity.
      b. ***Solar energy*** is the radiant energy of the sun that can be converted into other forms of energy, such as thermal or electrical. Photovoltaic cells can convert the sun's rays directly into electricity. Solar energy can be used for heating and illuminating an office building or house.
      c. ***Wind energy*** uses the motion of the wind to perform work, such as pumping water, milling grain into flour, or generating electricity. The earliest known use of wind power was to propel sailboats, which later had an important impact on the development of windmills.
      d. ***Hydropower*** involves the capture of water movement for useful work. Most people think of large dams when discussing hydropower; however, water movement in the form of tidal ebb and flow or rolling waves can also be converted to energy. Dams are currently the largest source of hydroelectricity and are considered clean and sustainable.
      e. ***Geothermal energy*** uses the heat released from molten rock within the earth's crust or plate boundaries to create electricity. Currently geothermal energy accounts for less than one percent of global energy production, but expansion of electricity generation using geothermal energy is possible.
   2. Renewable energy storage methods — energy created from a renewable source must either be used immediately upon its creation or be stored for later use in a fuel or energy source.
      a. ***Batteries*** provide a common way to store energy created using a renewable source. They store chemical energy and make it available as electrical energy.
      b. ***Fuel cells,*** like traditional batteries, are also electrochemical energy conversion devices. Unlike a battery, a fuel cell does not use a stored chemical that can be depleted, causing the battery to "go dead." A fuel cell converts oxygen and hydrogen from water to electricity. Chemicals (from water) flow constantly into the cell, so it never goes dead.

B. ***Nonrenewable energy*** is energy that cannot be replaced as quickly as it is being used. For example, fossil fuels (coal, crude oil, and natural gas) were created from the compression of ancient remains of biological organisms that originally used the sun as fuel. They contain stored solar energy in the form of carbon. Because we are using fossil fuels at a rate faster than they are being replenished, they are considered nonrenewable resources.

   1. Primary energy and fuel sources:
      a. ***Coal*** is a hard, black substance formed from vegetation. It is the most abundant fossil fuel in the world. The United States ranks first in coal production and sixth in coal exports. Burning coal is responsible for significant amounts of air pollution. Even though major efforts are underway to reduce pollution from coal, the mining process continues to contribute to high levels of pollution. In 2004, coal was used for more than one-fourth of the world's electricity generation.

b. ***Crude oil*** was formed from the preserved remains of prehistoric zooplankton and algae that had settled to a sea or lake bottom in large quantities. (The remains of prehistoric animals and plants tended to form coal.) The CIA's World Factbook estimated that the United States uses 20,800,000 barrels of oil per day.

c. ***Natural gas*** is a hydrocarbon mixture made up of methane (CH_4) and a small percentage of other light hydrocarbons. Natural gas is found underground or is produced by the gasification of coal. Natural gas is a clean-burning fossil fuel available in large amounts throughout North America and delivered to homes by an extensive pipeline network.

2. Secondary/derived energy and fuel sources — secondary energy and fuel sources are hydrocarbon (HC-) compounds categorized by the length of their carbon chains, which influences their boiling points. The following sources are listed in order from smallest to largest chains:

a. ***Propane*** (C_3H_8) is a hydrocarbon typically produced from both natural gas processing and crude oil refining. It is a liquefied petroleum (LP) gas. LP gas consists mainly of propane, propylene (C_3H_6), butane (C_4H_{10}), and butylene (C_4H_8) in various mixtures. However, for all fuels in the United States, the mixture is mainly propane. Although traditionally propane was classified as a nonrenewable fuel source, the Massachusetts Institute of Technology (MIT) has discovered a method to produce biopropane from corn and sugarcane. ***Biopropane*** uses a product of the fermentation of the sugars found in corn or sugarcane, along with high pressure and heat, to create propane from an organic source. This is a very important development and will move propane from the nonrenewable to the renewable fuel list. Besides being a clean-burning liquid fuel, it is nontoxic, colorless, and virtually odorless.

b. ***Gasoline*** (blends of C_7H_{16} through $C_{11}H_{24}$) is a mixture of small, light hydrocarbons that is produced by refining crude oil. Gasoline is commonly used in combustion engines and is one of the main sources of fuel for transportation vehicles.

c. ***Kerosene*** (in the C_{12} to C_{15} range) is a thin, clear liquid created during the production and processing of oil or coal. Kerosene was historically used for lanterns and as heating oil, but it is now the predominant fuel used in jet engines.

d. ***Diesel fuel*** (range C_{11} to C_{20}) is a fuel derived from petroleum and used in various diesel engines. These engines use the heat produced when air is compressed to ignite a mixture of air and fuel.

C. ***Nuclear power*** is generated by extracting energy from the nucleus of an atom in a controlled nuclear reaction. Enriched uranium or plutonium is used as the fuel. Most nuclear power plants use nuclear fission-the splitting of an atom into smaller atoms to extract energy. Whether nuclear energy is renewable or nonrenewable is debatable, because it uses a fuel considered finite (capable of running out) but inexhaustible because even depleted uranium can be reused in newly developed nuclear reactors.

SUGGESTED TECHNIQUES TO HELP STUDENTS MASTER THIS OBJECTIVE

1. Create three to six cooperative learning groups, depending on class size, to study each of the three sources of energy and fuels (primary, secondary/derived, and nuclear). Have each group research one of the sources using the internet and give a presentation to the rest of the class. Each group should take notes on the other two presentations.
2. Have students take notes on material and then create a data table, using Word or Excel, to describe and sort the information.
3. Create handouts based on sources of energy information cut and pasted into Word. Have groups use the information and internet research to create posters.
4. Be sure to discuss with the students the important discovery of biopropane production techniques and how this will move propane from the nonrenewable to the renewable list.

SUGGESTED RESOURCES FOR OBJECTIVE 2

1. U.S. Department of Energy website on fossil fuel formation: Energy.gov/Science-Innovation/Energy-Sources/Fossil.
2. U.S. Department of Energy Web site on renewable energy sources: Energy.gov/Science-Innovation/Clean-Energy.

OBJECTIVE 3

Compare sources of energy and fuels.

ANTICIPATED PROBLEM

What are some advantages and disadvantages of various energy and fuel sources?

All fuel sources have their advantages and disadvantages. For example, solar energy may be plentiful and renewable, but to use this energy in a vehicle, there must be some method to store it. Oil fuel may be easily transportable and efficient in many applications, but it is environmentally damaging, and its use is ultimately seen as an unsustainable practice.

A. Renewable energy:

1. Energy sources:

a. **Bioenergy fuels,** such as biodiesel and ethanol, are considered cleaner and more quickly renewable than fossil fuels. Domestic farmers can produce these fuels (often called biofuels) from crops, enabling the United States to reduce its dependence on foreign oil. Biofuels can be easily used in our existing vehicles and applications; however, complications, such as fuel pump and other fuel system problems, can arise when using them. Critics of biofuel production believe the use of traditional food crops, such as corn or soybeans, has an adverse effect on the world's food supply. When the demand for fuel and the demand for food are connected, a drop-in oil production and a rise in biodiesel and ethanol demand could lead to a food shortage. Critics also believe that aggressive rainforest harvest to produce biofuels is contributing to global warming.

i. ***Ethanol*** a fuel that currently in the United States is produced mostly from corn; however, it is also produced from other sources, including other grain crops and even plant-based garbage. There is some question whether the amount of energy required to produce ethanol is greater than the amount of fuel produced. The chemical formula for ethanol is $C_2H_{50}H$.

ii. ***Biodiesel*** is non-petroleum diesel fuel made from plant-based products. While critics question biodiesel production, as noted above, biodiesel does provide a market for alternative crops. This is good for crop rotation and land health. Biodiesel also provides a good market alternative for oilseed crops, which, when processed into biodiesel, make high-protein feed supplements for livestock.

b. ***Solar power*** is a clean and renewable source of energy and a viable solution to the world's energy needs. Unfortunately, cloud cover in some regions and at certain times of the year makes solar energy a very poor alternative energy source. Currently the cost of generating electricity from solar energy is much higher than the cost of using a more traditional source, but new technological developments are making solar energy cheaper and more available for the future.

c. ***Wind energy*** is considered clean, plentiful, and widely distributed, making it a healthy energy alternative; however, wind energy also has its drawbacks. For instance, wind is often unpredictable and variable, making it difficult to incorporate into a steady electrical-grid supply. Also, large wind energy farms have been controversial in regard to the death of birds and bats. Numerous studies have confirmed, however, that the number of birds and bats that die because of wind farms is negligible compared to the number that die because of traffic, hunting, power lines, high-rise buildings, and fossil fuel power sources.

d. ***Hydropower*** is generally seen as a plentiful and reliable source of renewable, clean energy; however, large-scale dams are often environmentally damaging to rivers. Dams stop nutrient-rich sediment and silt from reaching downstream and make it more difficult for migratory species, such as salmon, to reach their breeding grounds.

e. ***Geothermal energy*** requires no purchase of fuel, can consistently generate electricity, is sustainable, and is extremely price competitive with other energy sources. Geothermal power plants still emit carbon dioxide but generally less than 1 percent of that emitted by fossil fuel plants. After the steam and water from a geothermal reservoir have been used, they, along with the wastes, are injected back into the earth.

2. Fuel sources.

a. ***Batteries*** convert energy into chemical energy and then back into electrical energy. This creates certain problems when using batteries as a fuel source. For example, a large percentage of energy is lost during the conversion from chemical to electrical energy. Batteries also decrease in their capacity to hold stored energy over time or when the temperature is too high. While battery technology is improving, it still remains an obstacle when seeking more renewable energy sources.

b. ***Fuel cells*** are devices similar to batteries that combine hydrogen or methane gas with oxygen to produce electricity, water, and very little heat. Using hydrogen as a fuel source has several advantages. The use of fuel cells would allow more efficient conversion of fuel into electricity than would traditional batteries. When not at peak usage, power plants could create and store hydrogen for later use in vehicles and other applications. The movement toward using hydrogen faces a few challenges, particularly the costly change of our existing infrastructure to a hydrogen economy. Also, as with the generation of electricity, the production of hydrogen as a fuel would also be only as clean as the power plants generating the fuel.

Hydrogen cars are being developed, and some are already on the road; however, research and development are still needed to overcome many technological difficulties in performance.

B. Nonrenewable energy and fuel sources:

1. Primary energy and fuel sources:

a. ***Coal*** is one of the most abundant and inexpensive energy sources on the planet. The United States has a large domestic supply and the infrastructure to utilize it. Critics of coal cite the impacts of mining on the landscape and the release of large amounts of carbon dioxide and harmful chemicals into the air when coal is burned. Proponents of the use of coal cite that CO_2 emissions account for only 5 percent of greenhouse gases and that global temperatures since 1880 have more closely followed the sunspot cycle than the carbon emission cycle. Ultimately, while coal is considered one of the dirtiest sources of energy, it still produces more than 25 percent of the world's electricity.

b. ***Oil*** is still relatively inexpensive in comparison to many other energy sources. Our infrastructure relies heavily on oil, which is easy to transport. Current debates on oil production and use focus on environmental impacts from drilling and continued contribution of its use to global warming. The quantity of recoverable oil and the time when oil will no longer be economical for use in our numerous applications are also hot topics of debate.

c. ***Natural gas*** is the cleanest-burning fossil fuel, emitting 70 percent less carbon dioxide than other forms. With a heating value of 1,000 BTU per cubic foot of fuel, natural gas is a good fuel for cooking, heating, and other indoor applications. Although natural gas as it is marketed is nonrenewable and does release carbon dioxide, it is a clean alternative to coal and oil. (It is important to mention here that fossil natural gas is methane, which is renewable in the sense that it can be derived from other sources, such as biodigesters used on dairy farms to convert waste to energy.)

NOTE: A ***BTU,*** or British thermal unit, is the amount of heat required to raise the temperature of 1 pound of liquid water from 60° to 61°F at a constant pressure of 1 atmosphere.

2. Secondary/derived energy and fuel sources:
    a. ***Diesel fuel*** is a fuel used in many military and farm applications similar to those in which gasoline is used. A gallon of diesel fuel is denser and releases about 11 percent more energy than a gallon of gasoline. Diesel fuel can be used more efficiently and is less flammable than gasoline, but it is often higher in price because it must undergo filtration of many impurities. Unpurified diesel can release a large amount of particulate pollution into the air and create many health hazards; however, despite the traditional view of diesel as a dirty fuel, recent federal emission mandates are driving the development of cleaner diesel fuel and cleaner burning engines. The additional technology required to make diesel cleaner is expected to cut into its traditional cost advantage over other fuels.
    b. There is a reason that ***gasoline*** has developed as one of the most common fuels for vehicles. It is portable, contains a large amount of energy, is easily combustible, and is relatively inexpensive. Our current infrastructure is heavily based on the use of gasoline for our vehicles, but there are drawbacks to using gasoline in the quantity we do. Gasoline is nonrenewable, and prices fluctuate because supply and demand fluctuate. Gasoline also releases carbon dioxide, nitrogen oxides, and carbon monoxide when combusted in an engine.
    c. ***Propane*** is a clean, easily transportable, and highly versatile fuel. It is extremely clean burning, releasing only CO_2 and water. Thus, it is often used indoors for forklifts and towing vehicles. Other uses range from heating and cooling to numerous agricultural applications and various propane vehicles. Propane made from corn or sugarcane is biologically renewable; however, as with other biofuels, there is criticism of competition with the food supply. Propane also has disadvantages, particularly when used in certain mobile applications. Since propane is stored as a liquid under moderate pressure, the fuel system components are heavier and can be more expensive than those of gasoline systems. The space required for the fuel tank on a vehicle is sometimes difficult to find and can reduce cargo capacity.

C. The generation of ***nuclear power*** releases no atmospheric emissions other than steam. Nuclear power is considered a clean and relatively inexpensive form of energy in which most fuel can now be constantly recycled in a breeder reactor. However, many older reactors still require constant supplies of enriched uranium and produce toxic wastes that can last for thousands of years. The storage and protection of these wastes are often not accounted for in the energy's cost. Also, nuclear power is controversial because of the possibility of uranium falling into the wrong hands and the unlikely chance of a meltdown. If developed correctly, nuclear power does have a chance to be a clean and safe alternative for future energy needs.

SUGGESTED TECHNIQUE TO HELP STUDENTS MASTER THIS OBJECTIVE

1. Combine background material from this objective with that for Objective 2 and use in a cooperative learning activity.

OBJECTIVE 4

Identify alternative and renewable energy and fuel sources.

ANTICIPATED PROBLEM

What classifies an energy or fuel source as alternative, renewable, or both?

Alternative and renewable energy and fuel sources are generally considered cleaner and more sustainable sources of power. We live in a world threatened by global warming, a decreasing supply of fossil fuels, and an increasing population that requires more energy than ever before. Thus, the development of fuels that can be renewed indefinitely and do not put more carbon dioxide and other pollutants into the atmosphere is crucial for a sustainable earth.

A. ***Alternative energy*** is energy that is not considered traditional and creates less environmental damage and pollution than fossil fuels, such as coal and oil. Examples of alternative fuels are methanol, ethanol, biodiesel, electricity, hydrogen, natural gas, synthetic natural gas, and propane.

B. As stated earlier, alternative energy is any type of energy that can be naturally replenished at the same rate it is being used. (See **Objective 2**.)

SUGGESTED TECHNIQUES TO HELP STUDENTS MASTER THIS OBJECTIVE

1. Have students complete a short hands-on project to design a solar oven. One source for instructions is AlliantEnergyKids.com/ForEducators/Printables.
2. Find hands-on activities to teach students more about wind energy at KidWind.org
3. Be sure that students can distinguish alternative and renewable energy and fuel sources. Ask the class to name examples of each and list them on the board. Have students take notes during the discussion.
4. Have students complete **LS-A** and/or **LS-B**.

REVIEW/SUMMARY

Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle. The anticipated problems can be used as review questions.

APPLICATION

Use the included visual masters to apply the information presented in the lesson.

EVALUATION

Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the application activities. A sample written test is provided.

ANSWERS TO SAMPLE TEST

Use the included lab sheets to apply the information presented in the lesson.

PART ONE: MATCHING

1. b
2. a
3. d
4. e
5. c

PART TWO: SHORT ANSWER

1. Renewable energy is any type of energy that can be naturally replenished at the same rate it is being used. Nonrenewable energy is energy that cannot be replaced as quickly as it is being used.
2. Alternative energy is energy that is not considered traditional and creates less environmental damage and pollution than fossil fuels.
3. Answers will vary. Examples are methanol, ethanol, biodiesel, electricity, hydrogen, natural gas, synthetic natural gas, propane.
4. Answers will vary. Examples are bioenergy, solar energy, wind energy, hydropower, geothermal energy.
5. The Massachusetts Institute of Technology (MIT) has discovered a method to produce biopropane from corn and sugarcane. Biopropane uses a product of the fermentation of the sugars found in corn or sugarcane, along with high pressure and heat, to create propane from an organic source. This is a very important development and will move propane from the nonrenewable to the renewable fuel list.

PART THREE: COMPLETION

1. Nuclear
2. biofuels
3. diesel
4. Solar
5. hydropower
6. chemical
7. Fossil
8. heat
9. crude oil
10. wind

NAME: _____

Introduction to Energy and Fuels in Agriculture

PART ONE: MATCHING

INSTRUCTIONS: Match the term with the correct definition.

a. renewable energy
b. biomass
c. natural gas
d. fuel cell
e. coal

_____ 1. Renewable organic matter

_____ 2. Any type of energy that can be naturally replenished at the same rate it is being used

_____ 3. A device similar to a battery that combines hydrogen or methane gas with oxygen to produce electricity, water, and very little heat

_____ 4. A fuel considered one of the dirtiest sources of energy but that produces more than 25 percent of the world's electricity

_____ 5. A clean-burning fossil fuel available in large amounts throughout North America and delivered to homes by an extensive pipeline network

PART TWO: SHORT ANSWER

INSTRUCTIONS: Provide a short written answer to the following questions.

1. What is the difference between renewable energy and nonrenewable energy?

2. What is alternative energy?

3. Give three examples of alternative fuels.

4. Give three examples of renewable energy sources.

5. Why has propane recently been described as a renewable fuel source?

PART THREE: COMPLETION

INSTRUCTIONS: Provide the word or words to complete the following statements.

1. _____ power is generated by extracting energy from the nucleus of an atom in a controlled nuclear reaction.
2. One of the major advantages in using _____ is that they can be produced by domestic farmers.
3. One of the main reasons _____ usually costs more than gasoline is that various impurities must be filtered out before use.
4. _____ energy can generate electricity from the sun using photovoltaic cells or can be used to heat and light an office or house.
5. One of the major problems with _____ is that dams stop nutrient-rich sediment and silt from reaching downstream and make it more difficult for migratory species, such as salmon, to reach their breeding grounds.
6. Batteries store _____ energy and make it available as electrical energy.
7. _____ fuels are created from the compression of ancient remains of biological organisms that originally used the sun as fuel.
8. Geothermal energy uses the _____ released from molten rock within the earth's crust or plate boundaries to create electricity.
9. The three primary types of nonrenewable resources are coal, _____, and natural gas.
10. Numerous studies have confirmed that the number of birds and bats that die because of _____ farms are negligible compared to the number that die because of traffic, hunting, power lines, high-rise buildings, and fossil fuel power sources.

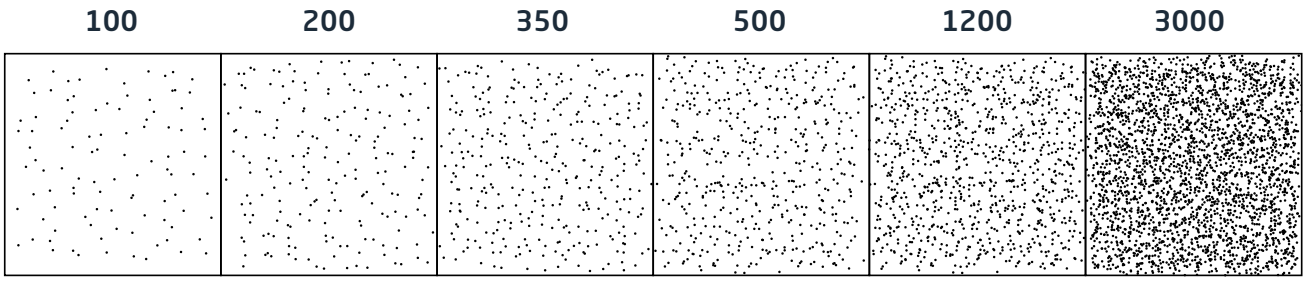
Igniting Gas Stream From a Candle

Note the blue flame beginning to follow the smoke stream down to the wick.

Candle Re-Lit from Burning Gas Stream

The candle relights as the flame burns the smoke stream and ignites the wick.

Particulate Scale



NAME: _____

Measuring Particulate Matter

PURPOSE

The purpose of this activity is to show how different fuels and engines put out different amounts of pollution and particulate matter.

OBJECTIVE

Measure the cleanliness of fuels when they are burned in internal-combustion engines.

MATERIALS

- Access to motor vehicles
- Six coffee filters
- Glue
- Microscope or magnifying glass
- Ruler
- Particulate scale (provided in **VM-C**)
- Scissors
- Six 3" x 5" index cards
- Tongs or other device for holding the cards

PROCEDURE

1. Cut a coffee filter into a 2" x 4" rectangular piece. Glue the piece of coffee filter to the center of an index card. Prepare six cards in this manner.
2. Find six subject vehicles from which to measure particulate matter pollution. You may use any vehicles to do the test. Use a wide range of engine and fuel types if possible.
3. Determine the age of each vehicle, the date of its last tune-up, the type of fuel it uses, and other details you find important. Record this information on the index card used for that vehicle.
4. Ask the owner to start the engine. Hold the index card a minimum of 6 inches from the exhaust pipe. Use a set of tongs or other holder to keep as far away from the exhaust as possible, and make sure to stand to the side. The filter side of the card should be directly in front of the exhaust for exactly one minute. Then, remove the card, and ask the owner to turn off the engine.

CAUTION: Be extremely careful not to touch the exhaust pipe, and avoid breathing the emission fumes! This experiment should be performed in a well-ventilated area and not in a garage or carport.

5. Repeat Step 4 for the other five vehicles.
6. Examine the particulate matter on each card using a microscope or magnifying glass. Using the particulate scale (**VM-C**), estimate the number of particulates per square inch on each card. Record this measurement on the card.
7. Analyze the six vehicle samples, and rank them from least to greatest in particulate pollution.
8. Compare your results with those of others in the class.
9. Write a report on your results.

Measuring Particulate Matter

There are a few different methods possible to acquire the needed vehicles for this experiment. You may ask students to measure and record their own data at home and then to bring the data in to share with the class, or you may obtain access to six or more vehicles at the school and measure the particulate matter pollution from each vehicle with different student groups.

To show varied results, different types of vehicles must be measured. Some vehicles that would be beneficial to measure are an older diesel bus, tractor, or truck; a propane or natural gas vehicle; a biodiesel or ethanol vehicle; a smaller vehicle, such as a motorcycle or moped; and a hybrid vehicle. Although results will vary between vehicles that use regular unleaded fuel, results will vary more and will be more educational if vehicles that use different types of fuel are used.

NAME: _____

Selecting Energy and Fuel Types

PURPOSE

The purpose of this activity is to illustrate the factors in selecting energy and fuels and to use those factors in given situations.

OBJECTIVE

Select energy and fuel types for given situations.

MATERIALS

- None

PROCEDURE

1. Divide into student teams based on your teacher's instructions.
2. Take turns reading the following scenarios (A, B, and C). Not every scenario will have the same result; the team's goal is to think through each scenario and use the information provided to determine the best source of energy.
3. Consider the fuels or energy sources listed in the far-left column of the table for each scenario.
4. Evaluate the fuels or energy sources based on the items listed across the top of the table for each scenario. If the fuel is acceptable based on the factor being considered, put a check (✓) in the cell. If the fuel is not acceptable, put an (X) in the cell. If you believe a case could be argued either way, leave the cell blank.
5. Select the best fuel for the scenario presented.
6. Answer the questions for each scenario.

SCENARIO A

You need to heat a vacation home in the mountains. You have electrical lines to the house, but no other utilities are connected. Which fuel is the best choice?

POSSIBLE SOLUTION	AVAILABLE	SAFE	COST EFFECTIVE	ENVIRONMENTALLY SOUND	CONVENIENT
Wood					
Propane					
Electricity					
Natural gas					
Coal					

FUEL CHOICE: _____

1. Give detailed evidence as to why you chose the heat source you did. Justify the marks you made or did not make in your chart to indicate that a fuel is "acceptable," "not acceptable," or "either."
2. Did you have a difficult time making your decision because two or more choices were very close? Do you have a second choice, and what made it or other fuels close to your first choice?
3. What is the main drawback to using your second-choice fuel?

SCENARIO B

You have corn that was harvested with moisture content too high for storage. The corn must be dried to the desired moisture level. What is the best fuel to do the job?

POSSIBLE SOLUTION	AVAILABLE	SAFE	COST EFFECTIVE	ENVIRONMENTALLY SOUND	CONVENIENT
Gasoline					
Propane					
Electricity					
Natural gas					
Solar heat					

FUEL CHOICE: _____

1. Give detailed evidence as to why you chose the heat source you did. Justify the marks you made or did not make in your chart to indicate that a fuel is "acceptable," "not acceptable," or "either."
2. Did you have a difficult time making your decision because two or more choices were very close? Do you have a second choice, and what made it or other fuels close to your first choice?
3. What is the main drawback to using your second-choice fuel?

SCENARIO C

A seed company needs to move large pallets of seed around in the warehouse, which is kept completely enclosed. A forklift using what energy source would be best suited for this task?

POSSIBLE SOLUTION	AVAILABLE	SAFE	COST EFFECTIVE	ENVIRONMENTALLY SOUND	CONVENIENT
Ethanol					
Propane					
Electricity					
Natural gas					
Diesel					

FUEL CHOICE: _____

1. Give detailed evidence as to why you chose the heat source you did. Justify the marks you made or did not make in your chart to indicate that a fuel is "acceptable," "not acceptable," or "either."
2. Did you have a difficult time making your decision because two or more choices were very close? Do you have a second choice, and what made it or other fuels close to your first choice?
3. What is the main drawback to using your second-choice fuel?

Selecting Energy and Fuel Types

The suggested answers to LS-B presented here will assist you in leading discussion and in guiding students in completion of the lab sheet.

Cells in the tables for the following scenarios have been checked, X'd or left blank. A check indicates that the fuel source would likely meet a factor. An "X" indicates that it would not likely meet that factor. A blank space indicates that a case could be argued either way or that the factor is neutral. It is important that the students be able to defend their fuel choices with logical arguments based on the factors for selection.

NOTE: Your location and local customs may have a lot to do with how students respond to filling in the chart. These factors should become an important part of the discussion. Make certain that students understand that other localities may have different circumstances to consider.

Explain to the students that you are looking for more than how they marked the chart; you expect them to justify their decisions. For example, you are looking for them to say that wood is a renewable resource, but that it can also lead to fires and may not always be cost-effective because of supply and demand, etc. Expect students to defend their choices even if their choices are not exactly what you consider to be right. It is important that they learn how to form and defend their own opinions.

SCENARIO A

You need to heat a vacation home in the mountains. You have electrical lines to the house, but no other utilities are connected. Which fuel is the best choice?

POSSIBLE SOLUTION	AVAILABLE	SAFE	COST EFFECTIVE	ENVIRONMENTALLY SOUND	CONVENIENT
Wood	✓	✓	✓		X
Propane	✓	✓	✓	✓	✓
Electricity	✓	✓			✓
Natural gas	X	✓	✓	✓	X
Coal	✓	✓	✓	X	X

FUEL CHOICE: PROPANE

Other possible acceptable choices:

- **Wood.** Although wood is not as environmentally sound as propane or natural gas, assuming it is not convenient in this circumstance is just that, an assumption. Depending on the location of the vacation home, the time of year it is used, how often it is used and for what, wood may be a suitable alternative.
- **Electricity.** Again, depending on the location of the home and its use, electricity may be a suitable alternative.

Selecting Energy and Fuel Types

SCENARIO B

You have corn that was harvested with moisture content too high for storage. The corn must be dried to the desired moisture level. What is the best fuel to do the job?

POSSIBLE SOLUTION	AVAILABLE	SAFE	COST EFFECTIVE	ENVIRONMENTALLY SOUND	CONVENIENT
Gasoline	✓	X	✓		✓
Propane	✓	✓	✓	✓	✓
Electricity	✓	✓			✓
Natural gas	✓	✓	✓	✓	✓
Solar heat		✓	✓	✓	X

FUEL CHOICE: PROPANE OR NATURAL GAS

Other possible acceptable choices:

- **Solar heat.** The convenience of using solar heat could be debated, as could be the cost since its installation is quite expensive. Once installed, solar heat is a very viable source of energy in some parts of the country.
- **Electricity.** Depending on location, electricity may be a more acceptable choice than either propane or natural gas.

SCENARIO C

You have corn that was harvested with moisture content too high for storage. The corn must be dried to the desired moisture level. What is the best fuel to do the job?

POSSIBLE SOLUTION	AVAILABLE	SAFE	COST EFFECTIVE	ENVIRONMENTALLY SOUND	CONVENIENT
Ethanol	✓	X	✓		
Propane	✓	✓	✓	✓	✓
Electricity	✓	✓			✓
Natural Gas	✓	✓		✓	
Diesel	✓	X	✓		✓

FUEL CHOICE: PROPANE