

Sources and Processing of Propane

LESSON 3

UNIT: PROPANE

PROBLEM AREA: PROPANE USE IN AGRICULTURE



STUDENT LEARNING OBJECTIVES

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

1. Identify the sources of propane.
2. Trace the history of propane processing.
3. Explain the extraction and processing of propane.

NATIONAL SCIENCE STANDARDS ADDRESSED IN THIS LESSON

All students should develop an understanding of:

Physical Science: Content Standard B

- Structure and properties of matter
- Chemical reactions

Science and Technology: Content Standard E

- Abilities of technological design
- Understandings about science and technology

Science in Personal and Social Perspectives: Content Standard F

- Natural resources
- Science and technology in local, national, and global changes

History and Nature of Science: Content Standard G

- Historical perspectives

LIST OF RESOURCES

The following resources may be useful in teaching this lesson:

- Propane.com/Agriculture
- Energy.gov

LIST OF EQUIPMENT, TOOLS, SUPPLIES, AND FACILITIES

- 1-pound propane cylinder
- Plastic bag (1 gallon) filled with green, leafy materials or a potted plant
- Copies of sample test
- Visuals from accompanying masters

TERMS

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

1. Alternative fuel
2. Biopropane
3. Byproduct
4. Fossil fuel
5. Liquefied petroleum (LP) gas
6. Methane
7. Nonrenewable resource
8. Renewable resource
9. Volatile

TELL STUDENTS...

"We have been talking a lot about fuels, especially about propane, so today we are going to look at propane use in agriculture in a little more detail. You will be expected to identify sources of propane, trace the history of propane processing, and explain the steps of propane processing."

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.

1. If possible, bring a 1-pound propane cylinder to class, or display VM-A and either a plastic bag of green, leafy materials or a potted plant.
2. While looking at the gas cylinder or the visual, ask students what type tank is on display, what it contains, and for what the contents are used. Lead students to identify the tank as a propane cylinder. You may want to let students talk about where tanks and propane are sold, what stores provide exchange or refilling of propane tanks, and what use is made of propane at their homes.
3. Ask students the connection between the vegetation on display and propane gas. Lead students to identify propane as a fossil fuel, and help them realize that ancient deposits of plants and animals under high heat and pressure provide us with natural gas as well as petroleum and propane today.

Summary of Content and Teaching Strategies

OBJECTIVE 1

Identify the sources of propane.

ANTICIPATED PROBLEM

What are the sources of propane?

Propane gas is a **liquefied petroleum (LP) gas**. It is a **fossil fuel** derived from ancient deposits of plant and animal life. Another related gas sold commercially is butane. Propane is the most widely used LP gas.

- A. Propane is produced as a **byproduct**, or secondary product, of natural gas and petroleum processing. **Methane** is the major component of natural gas. Gases such as propane and butane are removed from methane during natural gas processing.
- B. Heat and pressure converted the remains of sea plants and animals trapped many years ago under layers of sediment to vast deposits of petroleum and natural gas. These deposits remained within the earth until tapped by modern civilization. We can say that the energy in propane originally came from the sun. Plants harnessed energy from the sun and stored it as carbohydrates (CHO_2). Animals that ate the plants stored energy in their bodies as a different form of carbohydrate, or as fat (CH-OH). The stored energy from those ancient plant/animal deposits is released when petroleum and natural gas are burned.
- C. Propane is found naturally underground mixed with natural gas and oil deposits.
- D. Propane is classified as a **nonrenewable resource** because it is currently derived from natural gas and crude oil, both also classified as nonrenewable resources. Propane, therefore, cannot be replaced quickly; however, it has been demonstrated that propane can be derived from numerous other biological sources, such as corn, sugarcane, and others. Research investigating the production of propane from biological sources is ongoing, and we could see commercial production emerge in the near future. Propane would then be referred to properly as a **renewable resource**, a resource that can be readily replaced in a short period. Propane extracted from processing biological material is called **biopropane**.
- E. The vast majority of the U.S. propane supply is produced domestically, as shown below.
 1. Fifty percent is produced domestically from natural gas processing.
 2. Forty percent is produced domestically from petroleum refining.
 3. Ten percent is imported, mostly from Canada.
- F. The long-term outlook for a ready supply of propane is excellent, as the technology for its extraction is steadily improving. The United States has large reserves of natural gas that will last many years. Natural gas and crude oil processing presently yield more propane than needed to meet the demand. Development of better technology and methods for the extraction of biopropane from biological materials will also assure the United States a ready supply of propane into the foreseeable future.

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 and discuss selections from appropriate resources (see below).
3. Use VM-B, and lead a discussion on the sources of propane gas. Have students take notes during the discussion.

SUGGESTED RESOURCES FOR OBJECTIVE 1

1. Department of Energy website with illustrated reading material on propane: EIA.gov/Kids/Index.php
2. Propane supply chain infographic from the National Propane Gas Association: NPGA.org/Industry/Propane-Supply-Chain/

OBJECTIVE 2

Trace the history of propane processing.

ANTICIPATED PROBLEM

What is the history of propane processing?

Dr. Walter O. Snelling, of the U.S. Bureau of Mines, first identified propane as a component of gasoline in 1910.

- A. During the early part of the twentieth century, automobiles and gasoline were new to most people. Storing gasoline was a problem. Gasoline stored under normal conditions evaporated. Automobile owners complained that some of the gasoline they put into containers evaporated by the time they got home.
- B. Dr. Snelling identified propane as a **volatile** component of gasoline, along with other liquefied petroleum gases. Volatile means easily evaporated to form a vapor.
 1. Propane was the secondary gas found in greatest abundance in raw natural gas, which is mostly methane.
 2. Dr. Snelling discovered that propane could be changed to a liquid under pressure—thus, the name liquefied petroleum gas (LPG).
 3. Dr. Snelling devised a way to containerize the liquid gas and store it for long periods under pressure. He is often referred to as the father of the liquefied petroleum gas industry.
4. In 1912, the New York Times reported that “Dr. Snelling has developed a liquid gas, and a steel bottle will carry enough to light an ordinary house for three weeks to a month.”
5. Containerized propane became known as the portable gas. It was sometimes called bottled gas. Because of its convenience and portability, propane came into common use in remote locations, such as on farms and in homes not located near natural gas or electrical lines—a major advancement for remote farms and families. Compared with other motor fuels, propane is probably the best known and most widely used **alternative fuel**. An alternative motor fuel is described by the Department of Energy as anything other than gasoline and diesel fuel.
6. Although propane production is tied directly to the production of natural gas and petroleum products, propane is a valuable commodity in its own right. It is used in a wide variety of applications and has its own distinct marketing advantages and uses. For example, propane is a feedstock in the production of plastic materials, and it’s an excellent refrigerant that is more environmentally-friendly than other alternatives.

SUGGESTED TECHNIQUES TO HELP STUDENTS MASTER THIS OBJECTIVE

1. Before providing students with the background information for Objective 2, ask them to explain what they already know about propane gas and its uses. Answers and discussion may vary widely but will help get students thinking about the subject.
2. Ask students what happens to gasoline left in an open container. Explain that gasoline evaporates quickly, and propane even more so. Gasoline used at the turn of the twentieth century contained propane; because propane is more volatile than gasoline, the propane would quickly evaporate, and the gasoline purchased for automobile fuel would “shrink” in volume!
3. Review VM-C with the students. This visual outlines some of the major events in propane history.

OBJECTIVE 3

Explain the extraction and processing of propane.

ANTICIPATED PROBLEM

How is propane extracted and processed?

Propane is a nontoxic, colorless, and odorless byproduct of natural gas processing and crude oil refining.

- A. In many industries, a byproduct is an undesirable product—a necessary part of processing but of little value. Propane, on the other hand, is a highly valuable and desirable byproduct.
- B. Propane is extracted from natural gas and petroleum through the process of distillation, which separates the parts of a mixture based on their boiling points. Each compound in the mixture will have a different boiling point. As heat is applied to the mixture, the substances with lower boiling points will escape the mixture first. Propane has a boiling point of -44°F and is one of the first gases released during distillation.
- C. Propane and other LP gases are removed from natural gas to prevent condensation of these gases in the natural gas pipelines.
- D. Because propane is a byproduct and not produced especially for itself, the supply is not adjustable based on demand. The current supply of propane is directly related to the supply of, and demand for, natural gas and petroleum. Ongoing research into the production of biopropane from biological sources may someday change propane from a byproduct to a primary product.
- E. Propane gas has a boiling point of -44°F and liquefies under moderate pressure inside a storage container. Because of its low boiling point, propane must be stored inside an airtight container. The container pressure fluctuates with the ambient temperature. For example, at 50°F the container pressure of propane would be approximately 86 pounds per square inch (psi), while at 70°F the container pressure would be about 120 psi. Liquid propane is 270 times more compact than propane gas, making it highly economical to store and transport. Two hundred seventy gallons of propane gas are converted to 1 gallon of liquid.
- F. After propane is processed, about 96 percent is stored in large underground facilities. Approximately 4 percent is stored in aboveground facilities. Propane is moved from the underground storage facilities to aboveground secondary storage tanks by rail, truck, or pipeline.

SUGGESTED TECHNIQUES TO HELP STUDENTS MASTER THIS OBJECTIVE

1. Conduct a discussion on the topics above relating to propane as a byproduct and to the extraction and primary storage of propane.
2. Lead the students to identify the reason the propane supply correlates to the quantity of natural gas and petroleum processed.
3. Lead students to identify the factors that make propane an attractive fuel alternative in certain situations.
4. Use VM-D to illustrate the compactness of propane.
5. Use VM-E to explain how propane gets to where it's needed. Have students take notes during the discussion.

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. c
3. e
4. a
5. d

PART TWO: SHORT ANSWER

1. Currently propane comes from natural gas and crude oil. In the future propane could be derived from numerous biological sources, such as corn, sugarcane, and others.
2. Propane is 270 times more compact as a liquid than as a gas.
3. Because of its low boiling point (-44°F), propane must be stored inside an airtight container.
4. Portability of propane gas in containers allows people not near natural gas lines to have ready access to gas fuel.
5. In the early days of automobiles and gasoline fuel, propane was left in the gasoline. Propane is highly volatile and evaporated quickly.

PART THREE: COMPLETION

- | | | |
|-----------|----------------|------------------------------|
| 1. one | 5. 40 | 8. Liquefied petroleum gases |
| 2. 1910 | 6. Liquid | 9. 90 percent |
| 3. Fossil | 7. Underground | 10. 2,430 |
| 4. 50 | | |

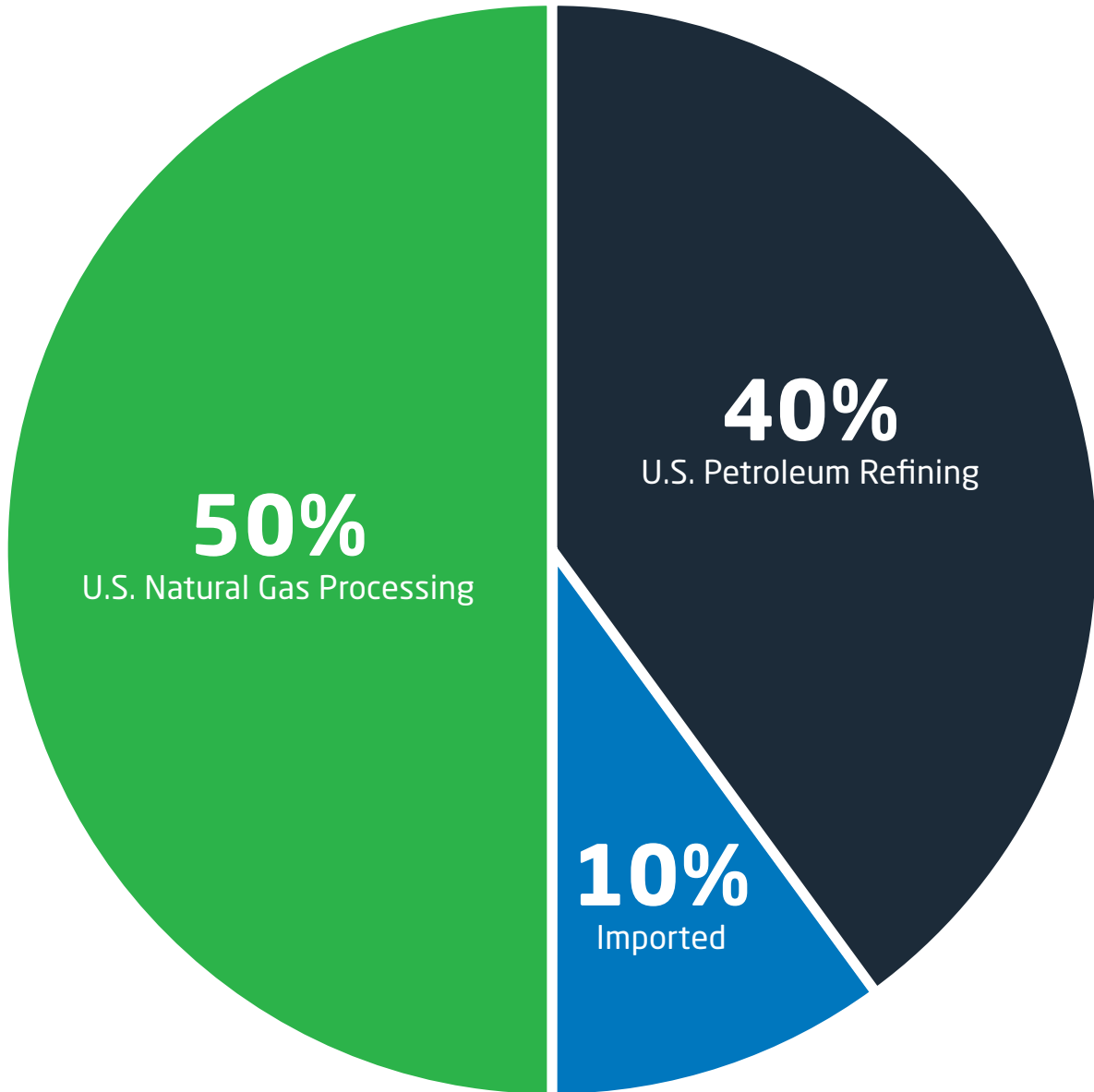
PART THREE: COMPLETION**INSTRUCTIONS:** Provide the word or words to complete the following statements.

1. Two hundred seventy gallons of propane in a gaseous state convert to _____ gallon(s) in liquid form.
2. Propane was discovered by Dr. Snelling in _____.
3. Natural gas, propane, and petroleum are all _____ fuels.
4. Approximately _____ percent of propane is obtained as a byproduct of U.S. natural gas processing.
5. Approximately _____ percent of propane is obtained from U.S. petroleum refining.
6. Under pressure, propane becomes a _____.
7. Almost all propane (96 percent) is stored _____ in primary storage until transported to secondary storage units.
8. It is necessary in the processing of raw natural gas to remove all the propane and other _____ to prevent their condensation in the natural gas pipelines.
9. The United States produces _____ percent of the propane it uses.
10. If released from pressure, 9 gallons of liquid propane would convert to _____ gallons of propane gas.

Grill Cylinder



Sources of Propane



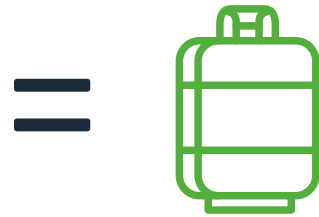
Propane Chronological History

In 1910, Dr. Walter O. Snelling, a chemist and explosives expert for the U.S. Bureau of Mines, was contacted to investigate vapors coming from a gasoline tank vent of a newly purchased Ford Model T. Dr. Snelling filled a glass jug with the gasoline from the Ford Model T and discovered on his way back to the lab that volatile vapors were forming in the jug, causing its cork to repeatedly pop out. He began experimenting with these vaporous gases to find methods to control and hold them. After dividing the gas into its liquid and gaseous components, he learned that propane was one component of the liquefied gas mixture. He soon learned that this propane component could be used for lighting, metal cutting, and cooking. That discovery marked the birth of the propane industry.

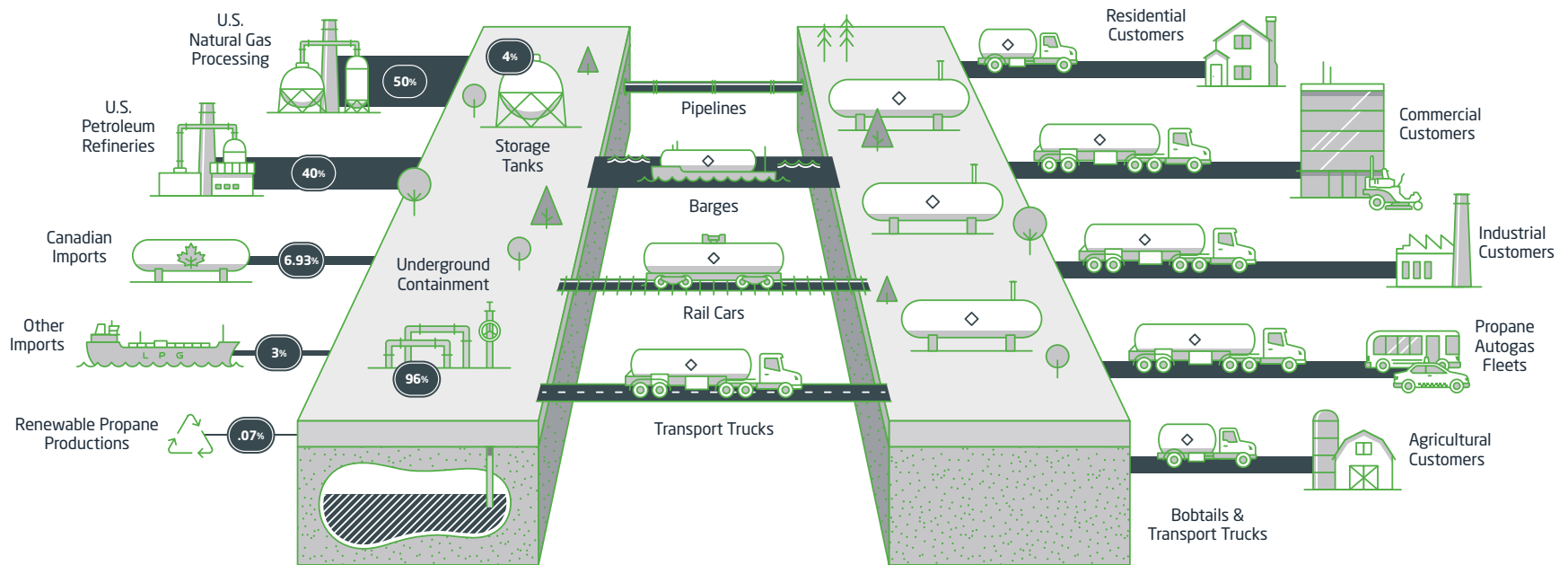
THE GROWTH OF AN INDUSTRY

- 1912** Dr. Snelling and colleagues established the American Gasol Co., the first commercial marketer of propane.
- 1913** Dr. Snelling sold his propane patent for \$50,000 to Frank Phillips, the founder of Phillips Petroleum Co.
- 1918** Propane was primarily used for cutting metals. J. B. Anderson of Sharpsburg, PA, developed the first propane-powered pumpless blowtorch.
- 1927** Phillips Petroleum, now ConocoPhillips, began the research and development of domestic appliances and gas equipment. The Tappan Stove Co. began producing gas ranges.
- 1928** The first bobtail truck was built to transport propane. The first propane refrigerator was produced.
- 1931** H. Emerson Thomas, George Oberfell, and Mark Anton founded the first propane industry trade group, the National Bottled Gas Association, in Atlantic City, NJ.
- 1932** At the 1932 Olympics in Los Angeles, CA, propane powered all the appliances for cooking and heated the water in the Olympic Village.
- 1933** A propane odorant was developed to detect leaks easily.
- 1945** The end of World War II brought great industrial development, leading propane into its so-called Golden Years. Sales reached 1 billion gallons.
- 1950** The Chicago Transit Authority ordered 1,000 propane-powered buses, and Milwaukee converted 270 taxis to run on propane. In addition, an estimated 7.5 million propane installations occurred on farms and in suburbs.
- 1955** Propane containers, equipment, and appliances were exposed to an atomic explosion at a federal test site in Nevada. After the explosion, all were in perfect working order, and the ranges were used to cook meals for the test personnel.
- 1963** Hot-air balloons began using propane. The first 50,000-gallon tank car was built.
- 1973** Propane price controls were instituted in the wake of the Arab oil embargo.
- 1981** President Reagan eliminated price controls on propane, gasoline, and crude oil.
- 1990** Propane was listed as an approved, alternative clean fuel in the 1990 Clean Air Act and, two years later, was listed again as an alternative fuel in the Energy Policy Act of 1992.
- 1996** The Propane Education & Research Council (PERC) was authorized by the U.S. Congress with the passage of Public Law 104-284, the Propane Education and Research Act (PERA), signed into law on October 11, 1996. PERC's mission is to promote the safe, efficient use of odorized propane gas as a preferred energy source.
- 2007** MIT researchers announced they had developed an efficient chemical process for making biopropane from corn or sugarcane.

Propane Gas to Propane Liquid Ratio



How Propane Gets to Where It's Needed



PROPANE PRODUCTION

Ninety percent of the U.S. propane supply is produced as a part of U.S. natural gas processing, crude oil refinement, and from renewable sources such as vegetable oils.

PRIMARY STORAGE

After its production, propane is stored in large above-ground tanks and underground facilities.

TRANSPORTATION

Tanker trucks, railcars, barges, and pipelines also carry propane to thousands of secondary storage facilities throughout the U.S.

SECONDARY STORAGE

These facilities typically contain one or more storage tanks, holding from 18,000 to 30,000 gallons of propane each.

FINAL DELIVERY

From secondary storage, propane is delivered to local propane suppliers and then to more than 60 million customers nationwide.