

Fossil Fuels to Products

Hands-on activities and background information that introduce students to fossil fuels and the processes involved to create many of the products we use. Students will learn about exploration, production, refining, chemical manufacturing, transportation, marketing, and uses of petroleum, natural gas, and their products in the industrial sector.



Grade Levels:



Intermediate



Secondary

Subject Areas:



Science



Social Studies



Language Arts



Public Speaking



National Energy Education Development Project



NEED Mission Statement

The mission of The NEED Project is to promote an energy conscious and educated society by creating effective networks of students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education programs.

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In support of NEED, the national Teacher Advisory Board (TAB) is dedicated to developing and promoting standards-based energy curriculum and training.

Energy Data Used in NEED Materials

NEED believes in providing teachers and students with the most recently reported, available, and accurate energy data. Most statistics and data contained within this guide are derived from the U.S. Energy Information Administration. Data is compiled and updated annually where available. Where annual updates are not available, the most current, complete data year available at the time of updates is accessed and printed in NEED materials. To further research energy data, visit the EIA website at www.eia.gov.

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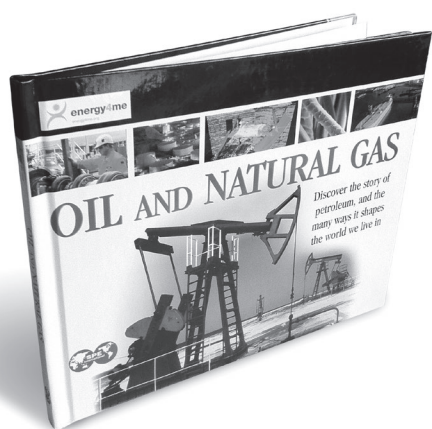


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Fossil Fuels to Products was developed by The NEED Project and the Center for the Advancement of Process Technology (CAPT) with funding from Shell Oil Company.

Special thanks to the Society of Petroleum Engineers for their assistance with teacher lessons for this guide. For more resources, visit www.energy4me.org.



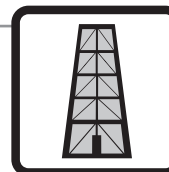
Oil and Natural Gas, from the Society of Petroleum Engineers, is a great resource that supplements the information and activities in *Fossil Fuels to Products*. Available in several languages, this book showcases the geology, technology, careers, and difficult concepts of oil and natural gas in a fun, colorfully illustrated, and informational way.

To order a free classroom copy, visit <http://www.energy4me.org/order/oil-and-natural-gas/>.

Fossil Fuels to Products

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Standards Correlation Information

www.NEED.org/curriculumcorrelations

Next Generation Science Standards


- This guide effectively supports many Next Generation Science Standards. This material can satisfy performance expectations, science and engineering practices, disciplinary core ideas, and cross cutting concepts within your required curriculum. For more details on these correlations, please visit NEED's curriculum correlations website.


Common Core State Standards

- This guide has been correlated to the Common Core State Standards in both language arts and mathematics. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED curriculum correlations website.

Individual State Science Standards

- This guide has been correlated to each state's individual science standards. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED website.





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Curriculum Correlations

NEED has correlated their materials to the Disciplinary Core Ideas of the Next Generation Science Standards. NEED has also correlated all of their materials to The Common Core State Standards for English/Language Arts and Mathematics. All materials are also correlated to each state's individual science standards. Most files are in Excel format. NEED recommends downloading the file to your computer for use. Save resources, don't print!

- [Navigating the NGSS? We have What You NEED!](#)
- [NEED alignment to the Next Generation Science Standards](#)
- [Common Core State Standards for English and Language Arts](#)
- [Common Core Standards for Mathematics](#)
- [Alabama](#)
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- [California](#)



NEED is adding new energy workshops all the time. Want to



Fossil Fuels to Products Materials

ACTIVITY	MATERIALS NEEDED
<i>Exploring Sound Waves</i>	<ul style="list-style-type: none"> ▪ Metal slinky spring ▪ Large foam cup ▪ Small foam cup
<i>Exploring Core Sampling</i>	<ul style="list-style-type: none"> ▪ 4 Colors of sand ▪ Clear plastic straws ▪ Opaque cups (bathroom-sized) ▪ Water in spray bottles ▪ Plastic spoons ▪ Rulers ▪ 1 Bag of small gravel (optional)
<i>Understanding Density</i>	<ul style="list-style-type: none"> ▪ 100 mL Graduated cylinders ▪ 600 mL Beakers ▪ Corn syrup ▪ Water, dyed with food coloring ▪ Vegetable oil ▪ Plastic buttons ▪ Grapes ▪ Small corks ▪ Pennies ▪ Glass marbles ▪ Wooden beads ▪ Ice cubes
<i>Exploring Porosity</i>	<ul style="list-style-type: none"> ▪ 1 Bag large gravel (coarse gravel) ▪ 1 Bag medium gravel (pea gravel) ▪ 1 Bag small gravel (aquarium size) ▪ Water (can be dyed with food coloring) ▪ 600 mL Beakers or tall clear cups or jars ▪ 100 mL Graduated cylinders
<i>Getting the Oil Out</i>	<ul style="list-style-type: none"> ▪ Clear drinking straws ▪ Masking tape ▪ Scissors ▪ Ruler ▪ Chocolate milk or other beverage (preferably a dark color so it can be seen through the straw)
<i>Distillation Products</i>	<ul style="list-style-type: none"> ▪ Refinery cards ▪ Projector ▪ White board ▪ Cardstock

ACTIVITY	MATERIALS NEEDED
<i>The Refining Process</i>	<ul style="list-style-type: none"> ▪ 2% Milk ▪ Vinegar ▪ Saucepans ▪ Wooden spoons ▪ Hot plates ▪ Pot holders ▪ Safety glasses
<i>Polymers</i>	<ul style="list-style-type: none"> ▪ Cornstarch ▪ Water ▪ Sealable plastic sandwich bags ▪ Measuring spoons ▪ Food coloring ▪ Paper plates ▪ White glue ▪ Borax ▪ Spoons or popsicle sticks ▪ Small paper cups ▪ Food coloring ▪ Graduated cylinder ▪ Rulers
<i>Slush Powder</i>	<ul style="list-style-type: none"> ▪ Sodium polyacrylate ▪ 400 mL Beakers ▪ 100 mL Beakers ▪ Water ▪ Salt (optional)
<i>Pretzel Power</i>	<ul style="list-style-type: none"> ▪ 3" x 5" Cards ▪ Internet access for students ▪ Large bag of pretzels ▪ Plastic sandwich bags ▪ Posterboard or sign paper
<i>Synthesis Activity</i>	<ul style="list-style-type: none"> ▪ Large piece of mural paper ▪ Colored markers

Dig up NEED's Oil and Natural Gas Kit!

NEED offers an oil and natural gas kit to support many of the activities in this guide. Visit shop.need.org for more information.



Teacher Guide

Grade Levels

- Intermediate, grades 6-8
- Secondary, grades 9-12

Time

Three to ten 45-minute class periods, depending on the number of activities you choose to conduct

Web Resources

The Virtual Chemical Plant Tour

www.chemalliance.org/tools/

Energize Your Future With Shell

www.shell.us/sustainability/energize-your-future-with-shell.html

Energy4Me

www.energy4me.org

EIA Kids Page

<http://www.eia.gov/kids/>

Energy Explained from the Energy Information Administration

<http://www.eia.gov/energyexplained/>

Additional Activities and Resources

NEED has several other guides and activities available at various levels to enhance your discussion about oil and natural gas. Download these guides and activities for free from shop.need.org:

- *Exploring Oil and Natural Gas*— Intermediate and Secondary
- *Transportation Guides*— All Levels

Background

The United States uses more petroleum than any other energy resource. Petroleum products are used to get us from “point A” to “point B” and are used to manufacture many of the plastics and other vital products we use every day to maintain our lifestyle and economy. In this student-centered unit, students will work cooperatively to explore fossil fuels, the products they make, and the careers associated with the related industries. Students “jigsaw” the content and activities and learn from each other.

Preparation

- Familiarize yourself with the information and activities in the guide. Read through the process of the unit before instruction.
- Make copies of the informational text and worksheets you are going to use for each student. You may also find it helpful to make copies of the *Fossil Fuels to Products Pre/Post Assessment* for use before and after the unit.
- Make a digital copy or projection of page 49 if you are conducting the *Distillation Products* activity.
- Make a copy of pages 72-74 on cardstock and cut out the cards if you are conducting the *Oil and Natural Gas Industry in the Round* activity.
- Gather the materials you need to conduct the hands-on activities, as listed in the table on page 5. The activities are designed so that the materials are inexpensive; most materials are available in the school science lab, or can be obtained at hardware, pet, and craft stores. If you have difficulty locating any of the materials you need, please email NEED at info@need.org for information on where you can purchase the materials.

Science Notebooks

Throughout this curriculum, science notebooks are referenced. If you currently use science notebooks or journals, you may have your students continue using them. A rubric to guide assessment of student notebooks can be found on page 9.

In addition to science notebooks, student worksheets have been included in the guide. Depending on your students’ level of independence and familiarity with the scientific process, you may choose to use these instead of science notebooks. Or, as appropriate, you may want to make copies of worksheets and have your students glue or tape the copies into their notebooks.

Procedure

Activity One: Introducing the Unit

1. Introduce the activity by asking the students the following questions:

- What are petroleum and natural gas?
- Where do they come from?
- How are they retrieved?
- How are they turned into useful products?
- What petroleum and natural gas products do we use every day?
- What impact do these products have on society in the U.S.?

CONTINUED ON PAGE 7

Fossil Fuels to Products

CONTINUED FROM PAGE 6

2. Explain to the students that they will be able to further answer these questions by taking on the roles of consumers and experts in the industry as they proceed through the jigsaw activity described below, as well as by participating in hands-on activities.
3. Have the students take the assessment on page 76 to establish baseline knowledge. Have the students self-grade the assessments, determine the average number of correct answers as a benchmark, mark the assessments as PRE, and save them.

Activity Two: Jigsaw

1. Divide the students into six groups. Assign each group one of six specific roles, as listed below. These groups are the role groups. Also assign the students to presentation groups, in which they will share their role expertise. Each presentation group should include at least one member from each role group.
 - Geologist
 - ROVER Operator
 - Lab Technician
 - Process Technician
 - Pipeline Inspector
 - Consumer
2. Explain the jigsaw assignment to the students. Give each student the list of questions for his/her role group found on page 38. Explain that the questions will guide their reading and research and that they will be answering the questions over several days as they participate in the readings and other activities. They will use the information they have gathered to design and present projects at the end of the unit in their presentation groups.
3. Instruct the students to use the included informational text, as well as outside research, to answer their questions as completely as possible. You may choose to conduct the hands-on activities after or concurrent to student research, in an effort to reinforce new information.
4. When the students have read all of the informational text and completed their research, have the role groups meet to discuss their findings. Instruct the students to add to their notes any additional information provided by group members.
5. After the students have met in the role groups and completed their discussions, assign them to their presentation groups. Explain that these groups will synthesize the information collected by the different role groups.
6. Distribute copies of all of the presentation questions to each student (page 38). Instruct the presentation groups to work together to answer the presentation questions, collecting members' ideas from each of the role areas.
7. After the groups have answered all of the presentation questions, instruct each presentation group to choose a medium with which to present their findings. Suggested work products include a digital presentation, a brochure, a movie, an expo display board, a song or rap, a school newspaper article, an advertisement, or any other format acceptable to the teacher.
8. Give the groups a timeframe in which to complete and present their projects.
9. Use the *Presentation Rubric* on page 9 to evaluate the projects.

Careers

1. An oil and natural gas industry career glossary, game, and questions and answers with industry professionals can be found on pages 26-33.

Organizers and Hands-on Activities

1. Review the lessons in the four sections listed below and choose those you wish to complete with the class. For each section, have the students read the informational text section listed and complete the graphic organizer for that section (pages 34-37).
2. Complete the hands-on activities for each section and discuss the background information and activities before proceeding to the next section. Activities are all labeled at the top with the section they fit into. Instructions for the hands-on activities and the materials needed are included with the activities. It is suggested that students record what they learn from the hands-on activities in science notebooks.

Section 1: What are petroleum and natural gas and how do we locate them? (Formation and Exploration)

Section 2: How do we retrieve petroleum and natural gas how do we move them? (Production)

Section 3: How do we refine and ship petroleum products? (Refining)

Section 4: What can we create with processed petroleum? (Manufacturing and Transportation).

3. Return to Step 4 of the jigsaw activity above and have students complete the jigsaw presentations.

CONTINUED ON PAGE 8

Vocabulary Reinforcement Activity: Oil and Natural Gas Industry in the Round

1. Follow the instructions on page 10 for *Oil and Natural Gas Industry in the Round*.

Synthesis Activity: Fossil Fuels to Products

1. Follow the instructions on page 11 for the *Synthesis Activity*.

Evaluation

- Evaluate individual student performance using the graphic organizers and science notebooks. A rubric for science notebooks can be found on page 9.
- Evaluate presentations for the jigsaw activity using the presentation rubric on page 9.
- Have the students take the assessment on page 75 again, self-grade, and determine the average number of correct answers to determine knowledge gain.
- Evaluate the entire unit with your students using the *Evaluation Form* on page 79 and return it to NEED.

Answer Keys

Fossil Fuels to Products Pre/Post Assessment, page 75

1. d 2. b 3. a 4. d 5. b 6. b 7. c 8. b 9. a 10. b 11. a 12. a 13. b 14. b 15. a 16. a

Production Activity—Understanding Density, page 43

Densities: Oil: 0.881 g/cm^3 Aluminum: 2.70 g/cm^3 Copper: 8.93 g/cm^3 Nickel: 8.90 g/cm^3

Chemical Manufacturing Activity—Identifying Chemical Hazard Placards, page 56

A: butane B: calcium C: benzene D: sulfuric acid E: phosphorus F: methane



Rubrics for Assessment

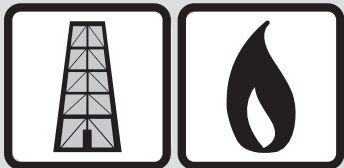
Inquiry Explorations Rubric

This is a sample rubric that can be used with inquiry investigations and science notebooks. You may choose to only assess one area at a time, or look at an investigation as a whole. It is suggested that you share this rubric with students and discuss the different components.

	SCIENTIFIC CONCEPTS	SCIENTIFIC INQUIRY	DATA/OBSERVATIONS	CONCLUSIONS
4	Written explanations illustrate accurate and thorough understanding of scientific concepts.	The student independently conducts investigations and designs and carries out his or her own investigations.	Comprehensive data is collected and thorough observations are made. Diagrams, charts, tables, and graphs are used appropriately. Data and observations are presented clearly and neatly with appropriate labels.	The student clearly communicates what was learned and uses strong evidence to support reasoning. The conclusion includes application to real life situations.
3	Written explanations illustrate an accurate understanding of most scientific concepts.	The student follows procedures accurately to conduct given investigations, begins to design his or her own investigations.	Necessary data is collected. Observations are recorded. Diagrams, charts, tables, and graphs are used appropriately most of the time. Data is presented clearly.	The student communicates what was learned and uses some evidence to support reasoning.
2	Written explanations illustrate a limited understanding of scientific concepts.	The student may not conduct an investigation completely, parts of the inquiry process are missing.	Some data is collected. The student may lean more heavily on observations. Diagrams, charts, tables, and graphs may be used inappropriately or have some missing information.	The student communicates what was learned but is missing evidence to support reasoning.
1	Written explanations illustrate an inaccurate understanding of scientific concepts.	The student needs significant support to conduct an investigation.	Data and/or observations are missing or inaccurate.	The conclusion is missing or inaccurate.

Presentation Rubric

	CONTENT	ORGANIZATION	ORIGINALITY	WORKLOAD
4	Project covers the topic in-depth with many details and examples. Subject knowledge is excellent.	Content is very well organized and presented in a logical sequence.	Project shows much original thought. Ideas are creative and inventive.	The workload is divided and shared equally by all members of the group.
3	Project includes essential information about the topic. Subject knowledge is accurate.	Content is organized in a logical sequence.	Project shows some original work. Work shows new ideas and insights.	The workload is divided and shared fairly equally by all group members, but workloads may vary.
2	Project includes essential information about the topic, but there are 1-2 factual errors.	Content is logically organized but may have a few confusing sections.	Project provides essential information, but there is little evidence of original thinking.	The workload is divided, but one person in the group is viewed as not doing a fair share of the work.
1	Project includes minimal information or there are several factual errors.	There is no clear organizational structure, just a compilation of facts.	Project provides some essential information, but no original thought.	The workload is not divided, or it is evident that one person is doing a significant amount of the work.



Oil and Natural Gas Industry in the Round Instructions

Oil and Natural Gas Industry in the Round is a quick, entertaining game to reinforce information about energy sources, forms of energy, and general energy information from the student informational text.

Preparation

- 5 minutes

Time

- 20–30 minutes

“In the Rounds” are available on several different topics. Check out these resources for more fun “In the Round” examples!

- Coal in the Round—Coal guides
- Conservation in the Round—*Monitoring and Mentoring, Learning and Conserving*
- Energy in the Round—*Energy Games and Icebreakers*
- Forms of Energy in the Round—*Science of Energy* guides
- Hydrogen in the Round—*H₂ Educate*
- Solar Energy in the Round—*Energy from the Sun*
- Transportation Fuels in the Round—Transportation guides
- Uranium in the Round—Nuclear guides

Get Ready

- Copy one set of the cards on pages 72-74 on cardstock and cut into individual cards.
- Make one extra copy of the cards to serve as your answer key. This does not need to be cut into cards.
- Have copies of the student informational text available for quick reference.

Get Set

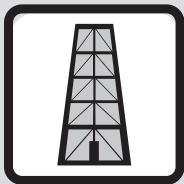
- Distribute one card to each student. If you have cards left over, give some students two cards so that all of the cards are distributed.
- Have the students look at their bolded words at the top of the cards. Give them five minutes to review the information about their words using the informational text.

Go

- Choose a student to begin the game and give the following instructions:
 - Read the question on your card. The student with the correct answer will stand up and read the bolded answer, “I have _____.”
 - That student will then read the question on his/her card, and the round will continue until the first student stands up and answers a question, signaling the end of the game.
- If there is a disagreement about the correct answer, have the students listen to the question carefully looking for key words (forms versus sources, for example) and discuss until a consensus is reached about the correct answer.
- Follow along with students using your answer key. Mark off the starting card, so you remember where you started and ended. The cards go in order vertically down each column.

Alternative Instructions

- Give each student or pair a set of cards.
- Students will put the cards in order, taping or arranging each card so that the answer is directly under the question.
- Have students connect the cards to fit in a circle or have them arrange them in a column.



Synthesis Activity (Teacher Instructions)

Objective

Students will create a flow chart mural of petroleum from formation to disposal, with each student representing a different product.

Materials

- Large piece of mural paper
- Colored markers

Procedure

1. Assign a product to each student, using the list below and/or any others you wish:
asphalt, aspirin, butane, carpeting, CD, coke, naphtha, contact lenses, cosmetics, crayon, credit card, diaper, diesel fuel, electricity, fertilizer, glue, grease, hand lotion, heating oil, industrial fuel, jet fuel, laundry detergent, ethane, lubricants, methane, milk jug, gasoline, motor oil, paint, pen ink, trash bag, plastic container, propane, prosthetic heart valve, soda bottle, tar, tire, toothbrush, toothpaste, tractor fuel, wax, shoe polish
2. Have each student prepare a flow chart of his/her product's lineage from formation to final product to use or disposal.
3. Explain to the students that after they create their personal flow charts, they will create a classroom flow chart that includes the lineage of every product in the class. Have the students brainstorm ideas for creating a combined flow chart. They will need to find out what the products have in common within each lineage and may find it helpful to group themselves by boiling point or some other characteristic. Once students have discovered and agreed upon patterns in their flow charts, sketch out a master flow chart on large chart paper at the front of the room.
4. All products started out as ancient sea plants and animals, so formation can go at the beginning of the flow chart. Offshore and onshore exploration and production can be divided into two areas, and then the flow chart can come back together after transportation to the refining phase. After refining, have the students begin to add their individual products to the flow chart. Some products will move straight to transportation and market, others to chemical processing, then to market. Have students add product uses to the flow chart.
5. Have the students add colored lines to the flow chart detailing the way their products are transported from origin to market; pipeline = red, truck = blue, ship = green, for example.
6. Brainstorm disposal methods for some products that are not consumed, such as plastic objects. See NEED's *Museum of Solid Waste and Energy* for information on preferred disposal methods for plastics and other waste products.
7. Have students answer the following discussion questions in their science notebooks.

Discussion Questions

1. What do DVDs and diesel fuel have in common?
2. What do you think is the most important product created from crude oil? Why do you think so?

Extension

Discuss question two as a group. List each student's opinion of the most important product derived from crude oil. Debate the choices. For example, which is more important, diesel fuel to ship goods, gasoline for personal transportation, medicines, or plastics for heart valves?



Introduction to Petroleum and Natural Gas

What is Petroleum?

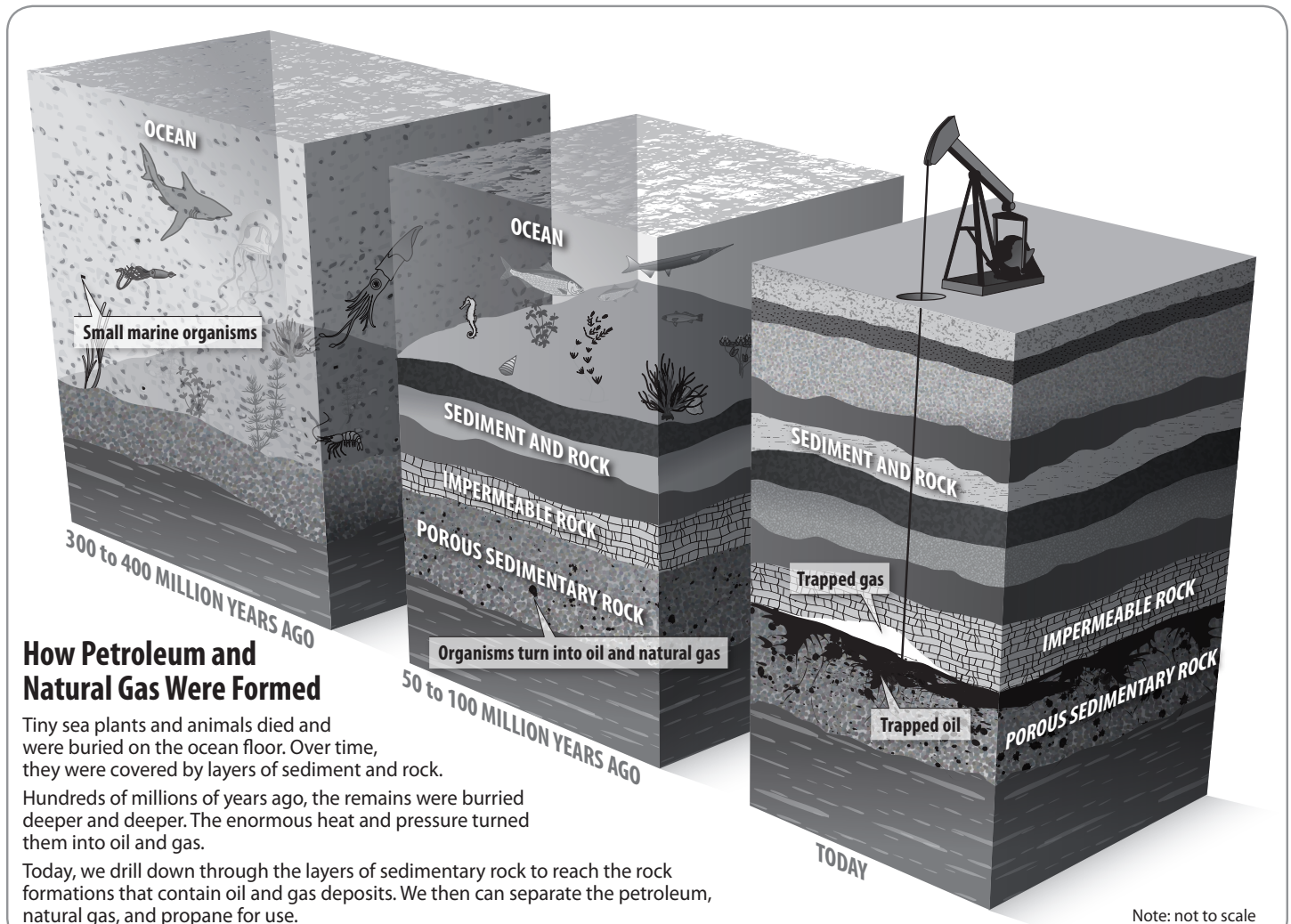
Petroleum is a fossil fuel. Petroleum is often called **crude oil**, or just oil. It is considered a **fossil fuel** because it was formed from the remains of tiny sea plants and animals that died hundreds of millions of years ago. When the plants and animals died, they sank to the bottom of the oceans. Over time, they were buried by thousands of feet of sand and sediment, which turned into **sedimentary rock**. As the layers increased, they pressed harder and harder on the decayed remains at the bottom. The heat and pressure eventually changed the remains into petroleum. Petroleum is classified as a **nonrenewable energy source** because it takes hundreds of millions of years to form. We cannot make new petroleum reserves in a short period of time.

Even though oil and natural gas come from ancient plant and animal matter, in geologic time, they are young. Most oil comes from rocks that are about 300–400 million years old. Scientists believe the Earth is over four billion years old, with life existing on Earth for about

3.7 billion years. Dinosaurs first roamed the Earth about 248 million years ago.

Like all once-living things, petroleum is a mixture made of several carbon compounds such as hydrogen butanes and **olefins**, and is an excellent source of energy. Because the living things that turned into petroleum did not have the opportunity to complete the decay process, there is a great deal of chemical energy held in their molecular bonds.

Petroleum deposits are locked in **porous** rocks like water is trapped in a wet sponge. Petroleum, just out of the ground, is called crude oil. When crude oil comes out of the ground, it can be as thin as water or as thick as tar. The characteristics of crude oil vary in different locations. Some crude is very clear and moves like water with a low **viscosity**. This is usually called light crude. Other crude is very dark, viscous, and even almost a solid at normal temperatures.



How Petroleum and Natural Gas Were Formed

Tiny sea plants and animals died and were buried on the ocean floor. Over time, they were covered by layers of sediment and rock.

Hundreds of millions of years ago, the remains were buried deeper and deeper. The enormous heat and pressure turned them into oil and gas.

Today, we drill down through the layers of sedimentary rock to reach the rock formations that contain oil and gas deposits. We then can separate the petroleum, natural gas, and propane for use.

Note: not to scale

History of Oil

People have used petroleum since ancient times. The early Chinese and Egyptians burned oil to light their homes. Before the 1850s, Americans used whale oil to light their homes. When whales became scarce, people skimmed the crude oil that seeped to the surface of ponds and streams. Did you know that oil floats on water? The density of oil is less than the density of water, allowing it to float to the top.

The demand for oil grew and in 1859, Edwin Drake drilled the first oil well near Titusville, PA. At first, the crude oil was refined into kerosene for lighting. Gasoline and other products produced during refining were thrown away because people had no use for them.

This all changed when Henry Ford began mass producing automobiles in 1908 with the invention of the assembly line. Everyone wanted automobiles, and they all ran on gasoline. Gasoline was the fuel of choice because it provided the greatest amount of energy relative to cost and ease of use.

Today, Americans use more petroleum than any other energy source, mainly for transportation. Petroleum provides more than 36 percent of the total energy we use. One-sixth of the oil the U.S. produces comes from offshore wells. Some of these wells are a mile under the ocean. Some of the rigs used to drill these wells float on top of the water. It takes a lot of money and technology to find, explore, produce, and transport oil from under the ocean.

Texas produces more oil than any other state, followed by North Dakota, California, Alaska, and Oklahoma. Americans use much more oil than we produce. Today, the U.S. imports 48% of the oil it consumes from foreign countries.

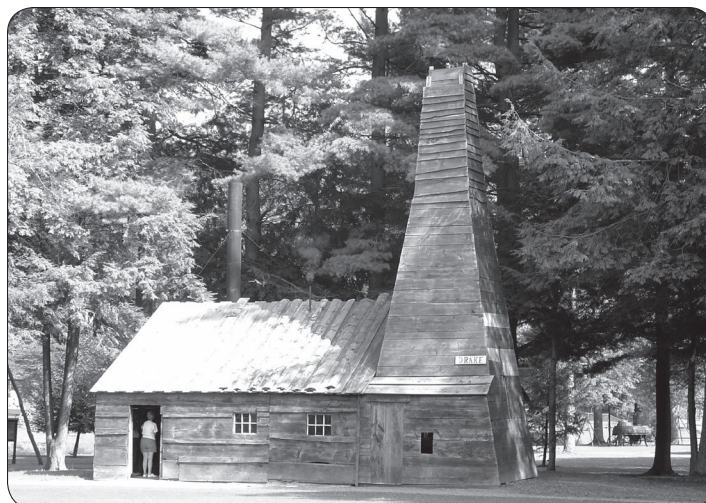
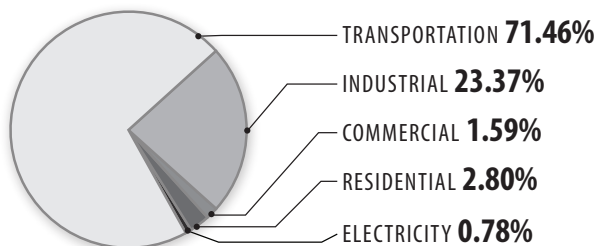


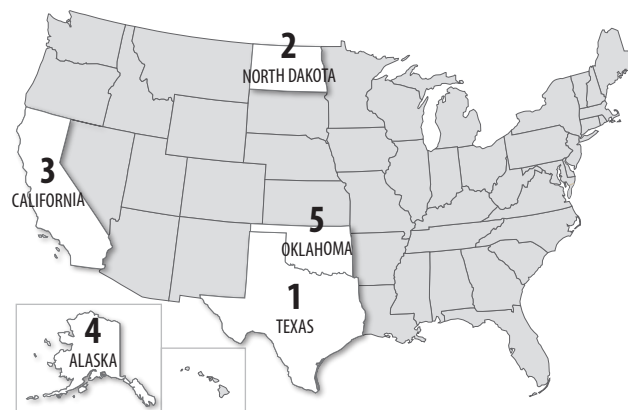
Image courtesy of Doug Stewart, contributor to Wikimedia Commons
A replica of the Drake Well in Titusville, PA.

U.S. Petroleum Consumption by Sector, 2015



Data: Energy Information Administration

Top Petroleum Producing States, 2015



Data: Energy Information Administration



Henry Ford began mass producing the automobile. His Model-T above started using gasoline as a fuel in its internal combustion engine.

What is Natural Gas?

Natural gas is a fossil fuel like petroleum and coal. Natural gas is considered a fossil fuel because most scientists believe that it was formed from the remains of ancient sea plants and animals like petroleum. When the plants and tiny sea animals died, they sank to the bottom of the oceans where they were buried by sediment and sand, which turned into sedimentary rock. The layers of plant and animal matter and sedimentary rock continued to build until the pressure and heat from the Earth turned the remains into petroleum and natural gas.

Natural gas is also trapped in underground rocks, much like water is trapped in the pockets of a sponge. Natural gas is really a mixture of gases. The main ingredient is **methane**. Methane has no color, odor, or taste. As a safety measure, gas companies add an odorant, **mercaptan**, to the natural gas that we use in our homes and buildings so that leaking gas can be detected. Mercaptan smells like rotten eggs. Natural gas should not be confused with gasoline, which is a petroleum product.

Natural gas from underground reservoirs is considered a nonrenewable energy source, which means we cannot make more in a short time.

History of Natural Gas

The ancient people of Greece, Persia, and India discovered natural gas many centuries ago. The people were mystified by the burning springs created when natural gas seeped from cracks in the ground and was ignited by lightning. They sometimes built temples around these eternal flames and worshipped the fire.

About 2,500 years ago, the Chinese recognized that natural gas could be put to work. The Chinese piped the gas from shallow wells and burned it under large pans to evaporate seawater to make salt.

In 1816, natural gas captured from a coal **coking** plant was first used in America to fuel street lamps in Baltimore, MD. Soon after, in 1821, William Hart dug the United States' first successful natural gas well in Fredonia, NY. It was just 27 feet deep, quite shallow compared to today's wells. Today, natural gas is the country's second largest source of energy, meeting nearly 29 percent of our total energy demand.

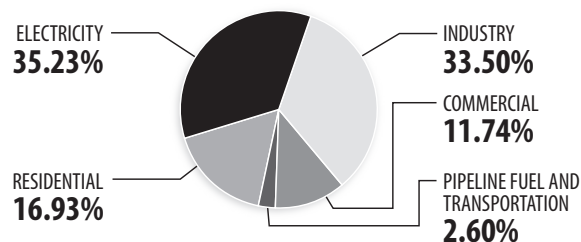
Who Uses Natural Gas?

Just about everyone in the United States uses natural gas. Natural gas can be used to generate electricity. Many utilities are building new power plants or converting old plants into sites that burn natural gas. It is cleaner burning than coal and can produce electricity quickly when it is needed for periods of peak demand. Electricity generation is the second largest user of natural gas today.

Industry burns natural gas to produce heat to manufacture many of the products we use every day. Natural gas is also used as an ingredient, or **feedstock**, in fertilizer, glue, paint, laundry detergent, and many other products.

Residences, or homes, are the third biggest users of natural gas. More than fifty percent of homes use natural gas for heating, and many also use it for cooking and heating water. Commercial buildings use natural gas too. Commercial users include stores, offices, schools, churches, and hospitals.

U.S. Natural Gas Consumption by Sector, 2015



Data: Energy Information Administration



Natural gas is used to power some fork lifts.

A small amount of natural gas is used as fuel for automobiles. Natural gas is cleaner burning than gasoline, but vehicles must have special equipment to use it. Many of the vehicles used by the government in national parks as well as public transportation vehicles operate on compressed natural gas.

Exploration

Geology

Oil and natural gas are buried beneath the Earth's crust, on land and under the oceans. To find it, geologists use their knowledge of land and rock formations, the geologic history of an area, and sophisticated technology. Combining all this information, geologists are more likely to be successful when they drill. Even with all this, not all wells produce oil or natural gas. **Exploratory wells** are drilled

if scientists think an area has oil. For every 100 exploratory wells drilled, only about 60 of them will find oil or natural gas.

By the time **production wells** are drilled, the success rate has risen to about 90 percent. To increase the success of drilling, petroleum geologists must be knowledgeable in a number of areas.

Rock Formation

The field of **stratigraphy** is the study of rock layers (or strata) to determine the type of rock formation, the age of the layers, the radioactivity of the formations, and other information to determine the composition, origin, and location of rock strata.

Compiling information on rock formations is an important part of oil and gas exploration. Different types of rock have varying potential for holding oil or gas in a reservoir. There are three different types of rock: sedimentary, metamorphic, and igneous. Every rock fits into one of these three categories.

Igneous rock is formed from hardened magma or lava— liquid rock that exists in the Earth's core or seeps to the surface through cracks in the Earth's crust. Igneous rock is usually the most dense of the three rock types. Igneous rock can have very few to many **pores**, depending on the rate at which it hardened.

Sedimentary rock is formed by the build-up of layers of sand and sediment over time. These layers are created as materials on the Earth's surface are eroded and washed downstream. Over thousands of years, these particles are compressed to create rock. Most oil is found in sedimentary rock because these rocks formed in the presence of ancient plant and animal life. Since sedimentary rock often has many pores, it is an ideal formation to contain oil and natural gas.

Metamorphic rock began as either sedimentary or igneous rock. The **protolith** was exposed to increased pressure and heat and eventually changed into metamorphic rock. Frequently, metamorphic rock is found near other types of rock. It is also usually more dense than sedimentary rock because the pores spaces were condensed or removed by heat and pressure.

Permeability and Porosity

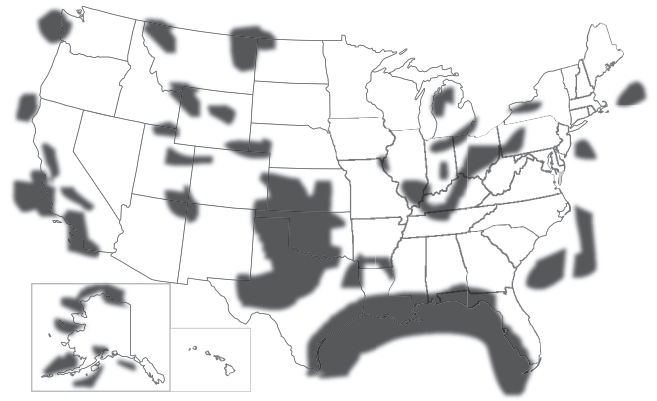
Oil and natural gas occur naturally in the Earth's layers, inside of rocks. Rocks are not completely solid; they have tiny holes, or pores, in which air or other fluids were trapped during formation. The **porosity** of a rock formation is a measure of the number and kind of pores it has. Pores can be various sizes and shapes and vary based on the rock's formation and changes over time.

Fluids can move between rock pores in varying degrees. **Permeability** is a measure of the ability of a rock to move fluids through its pores. Permeability is a very important feature for finding oil and gas. Being successful at finding oil is partially determined by locating porous rock, as well as locating other fluids, such as water, that are contained in rock formations. Geologists must look for rock that has good porosity but also has high permeability for easily recoverable resources.

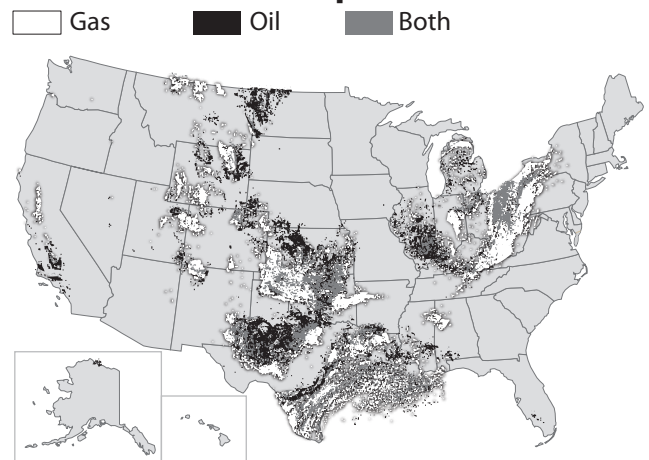
Geologic History

An important factor in finding oil and gas is understanding the environment that existed in an area millions of years ago. Since oil and natural gas are the remains of ancient sea life, the first step in locating oil is finding areas where ancient seas once existed.

Oil and Gas Basins

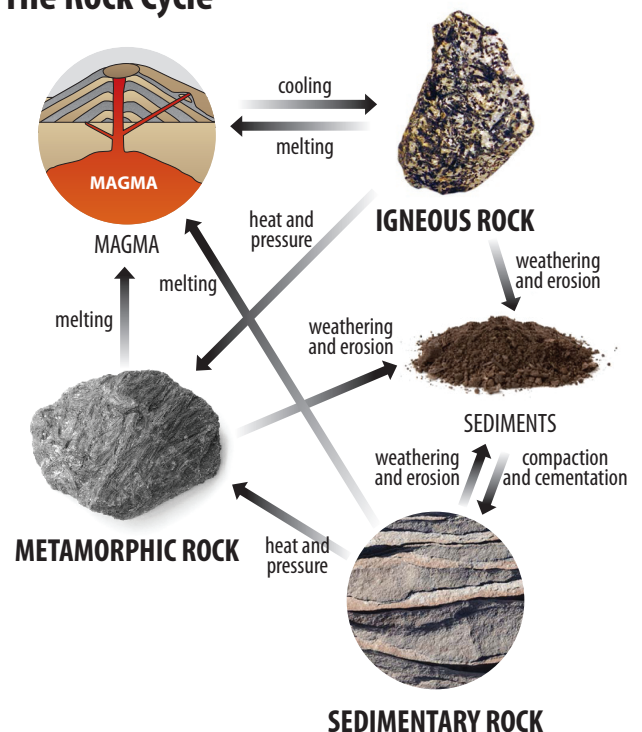


Oil and Natural Gas Exploration



Data: Energy Information Administration

The Rock Cycle



Seismic Technology

Seismic technology uses seismic waves to reveal what lies deep in the ground. Seismic waves can travel through some materials more easily than others. When these waves are directed into the ground and they hit something they cannot penetrate, they bounce back, returning to the surface. Equipment on the surface records the returning waves. Once the waves have all been recorded for an area, the information is taken back to a lab where geoscientists analyze the wave movement data. A map of the underground terrain can then be created.

The first seismic instruments were used in the mid-1800s to detect earthquakes. Seismic equipment began being used in the oil fields in the 1920s. In those days, dynamite was used to create the sound waves. The data collected had to be read by hand. In the 1960s, digital technology allowed the information to be read by machine. Three-dimensional seismic data was first used in the late 1960s and changed the way seismographs were used. Today, machines called **thumpers** are used to create shock waves or acoustic pulses instead of dynamite. To create a 3D image of the layer of ground, not one, but many seismic instruments are used. They are placed in holes around a site. Each of these instruments, called **geophones**, records the vibrations. Then scientists can combine all of these images to get a better understanding of what lies underground.

When searching for oil under the sea floor, seismic equipment must be adapted for the marine environment. Seismic systems are placed on ships and the listening devices are attached to long streamers. Many ships have four or five streamers, but some larger ships may have up to 16 streamers.

Another way scientists analyze the ocean floor is with ocean bottom cables. These cables are sent to the ocean floor from a stationary platform. Then, a ship towing air guns passes by. The air guns, directed down, are used to create the sound waves.

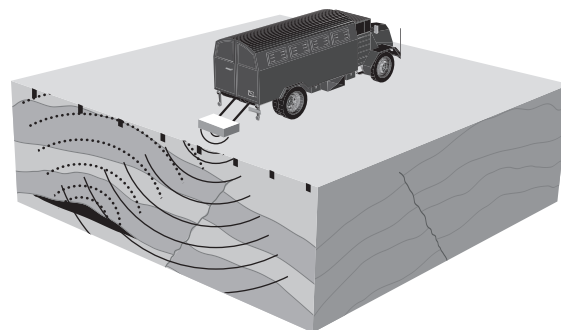
Interpreting Seismic Output

Today, seismic data is interpreted in high tech ways. 3D visualization puts seismic information into a three-dimensional format that people can more easily understand. One of the most advanced 3D visualization projects is known as the **CAVE** (Cave Automatic Virtual Environment). The CAVE is an entire room used for visualization. In this virtual reality environment, the walls and floor are used as projection surfaces, giving the appearance of filling the room and allowing scientists to walk into the data.

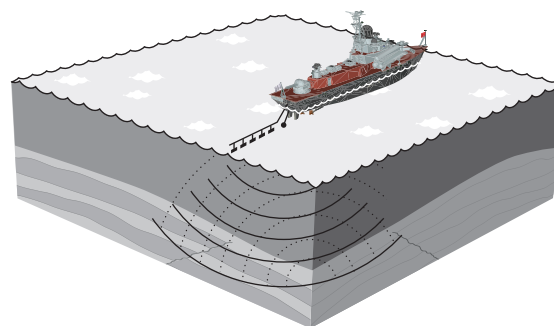
The newest type of seismic technology is 4D seismic. The fourth dimension is time. 4D seismic uses a number of 3D images taken over time to see how they change. This technology is often used in areas that are already producing oil to see how production is affecting the reserve.

Other surveying techniques include gravitational, magnetic, and radioactive processes, all of which measure physical properties of a site and use that information to determine whether oil or gas is present.

Land-based Seismic



Ocean-based Seismic



THE CAVE 3D SEISMIC VISUALIZATION ROOM



Retrieving the Oil

Permitting and Leasing Land

Once a site has the potential for oil extraction, companies must get permission to drill. In some areas, this means acquiring the needed permits from state government and leases from landowners to drill on private land. In other cases, the land is federal land and require leases and permits from the U.S. Bureau of Land Management (for onshore drilling) or the Bureau of Ocean Energy Management, and the Bureau of Safety and Environmental Enforcement. There are also environmental protection measures that must be in place before drilling can begin.

Drilling

Since the first oil well was drilled in 1859 by Edwin Drake, oil production has become an increasingly complex and precise process. The original methods of drilling for oil were based on ancient methods for finding water and salt. As wells have gotten deeper and more complex, drilling technology has also become more complex.

To drill a well, a large **drilling rig**, often called a **derrick**, is brought to the site. Once it is situated above the desired location, drilling can begin. **Roustabouts** work on the rig and handle many of the different elements of drilling.

Drill bits have sharp teeth that rotate to tear apart rock while the well is drilled. As the well gets deeper, lengths of 30-foot pipe are attached to the top of the drill. Each 30-foot section must be lifted above the last section into the sky and screwed onto the previous section. This is one of the reasons drilling platforms are very tall.

When drilling an oil well, the rock that is torn by the drill bit (called **debris**) does not come easily to the Earth's surface. As the hole gets deeper, debris can get in the way, blocking the hole. For this reason, drillers use mud to lift debris out of the well. **Drilling mud** originally was actual mud found on the drill site. Today, mud is a complex material specifically made for its drilling. Because it is so complex, mud is one of the biggest expenses in drilling.

Mud flow is controlled by the mud engineer. It is pumped down the hollow drilling pipe. It comes out near the drill bit, cooling the bit. The mud then carries debris up through the well as it is pumped, to be collected above ground. One of the reasons mud is so expensive is that it must be formulated with precise **density**. Since less dense materials float on top of more dense materials, the mud must have a greater density than the rock that is being cut. Drilling mud also keeps the formation, or walls of the well, from collapsing inward.

Once a well has been drilled to the depth of the oil reservoir, the workers move into the next stages—well **completion** and **production**. The drilling rig is removed from the site and the well is prepared to begin producing oil.

Well Completion

After a well is drilled, it must be completed before it can begin producing. There are three main steps in the completion process. The first step is allowing oil into the well so that it can be brought to the surface. The second is making sure that water does not get into the well, and the third is keeping underground rock out of the well.

Completion is not done the same way for all wells. Deciding what to do depends on a number of factors, including the size and shape of the oil reservoir, the surroundings of the reservoir, and the kinds of rocks and oil the reservoir contains.

Petroleum is contained within rock formations. The nature of these formations affects the way petroleum is pumped from the ground. There are two characteristics that are very important to predicting how the petroleum will flow—porosity and permeability. Knowing if the pores connect to each other is important, since these connections are what allow petroleum to flow to the well. Even though a rock formation is very porous, if it has no permeability, the petroleum will be difficult to extract.

Most petroleum formations also contain water near to or mixed in with the petroleum. The amount of water is often described as the **saturation** of the well. Producers must be sure to separate this water out of the crude oil. They must also be sure to avoid contaminating nearby ground water, land, and underground aquifers.

DRILL PIPE



ROUSTABOUTS



Image courtesy of StatOil

The amount of pressure in a formation is another factor that is very important. Since oil extraction removes mass from the Earth, the stability of the reserve is something that must be considered. While some formations can maintain their shape when oil is removed, others cannot. These formations must be stabilized, allowing them to remain open for fluids to flow.

The last issue to be considered is how well the **reserves** are connected. **Compartmentalization** is a situation in which the oil from one part of the reserve cannot flow to another part of the reserve. There may be faults in the ground that disconnect the layers, or pores from one section may not be connected to other sections because of low permeability. There can also be streaks of other types of rock that the oil cannot easily pass through between the well and the oil, or there may be other barriers in the way of the flow.

Once all these issues are taken into consideration, completing the well may begin. To start completion, the well must be open so that oil can flow into it.

Casing the Well

Drill pipe does not stay in the well after it is drilled. It is replaced with longer, wider casing pipe, which is used to line the well. Usually, **casing** a well begins before the end of the drilling process. There are often several layers of casing close to the top of the well. Casing the top of the well occurs as the drill continues to dig deeper into the ground. The final and deepest casing is placed in the well after drilling is complete.

The rock around the well is crushed to allow the petroleum to flow freely. Shooting nitroglycerin and shattering the rock in the immediate area can crush the rock. The side of the well, or the casing, blocks petroleum from getting into the well itself. At the levels where petroleum is present, the casing is perforated to let petroleum flow more easily into the well. **Perforating** the casing is done by shooting a very thin, fast jet of gas to penetrate and perforate the casing.

Cementing

Once casings are in place, cement is used to fill in the gap between each of the casing pipes and the well wall. Drilling mud is pumped out of the well as cement is pumped in. As the cement is pumped in, the casing is slowly rotated to create a better bond with the cement.

Production

Once the wells have been completed, they can go into production. Production wells do not have the complex, above ground structures that are in place during drilling. Instead, the wells are capped with smaller units. Ideally, oil is extracted using **natural drive**, which means there is enough pressure in the well to move the petroleum to the surface and no pumping is needed. Wells with natural drive have "**Christmas trees**" above ground. A Christmas tree, in the petroleum industry, is a series of valves and gauges used to measure and control the flow and pressure of the well.

Other wells do not have enough natural drive to move oil out of the ground. They must use pumps to artificially lift the oil to the surface. Typically, this is done with a **sucker-rod pump**, sometimes called a **horse head pump** because of its shape and motion. Using one-way valves underground near the oil formation, the pump draws, or sucks, oil to the surface. As the horse head pump above ground goes up and down, valves below lift the oil. Pumps may run for only a few hours each day to avoid distorting the way the fluids are distributed underground. Many wells produce only a few barrels of oil a day.

In a well that has a lot of pressure, a **blow out preventer**, or BOP, is used to avoid explosions. A BOP includes monitors to ensure the well is operating correctly and a set of controls that react to any unexpected pressure change. If there is too much pressure, the man-made elements of the well could be forced out the top of the well or fire could occur.

To monitor a well's progress, comprehensive **data logs** are kept that track a number of different factors. Radioactive, electric, mechanical, and sonic tools are just some of the ways wells are studied. If monitors indicate unusual well behavior, engineers investigate and attend to the problem.

CHRISTMAS TREE



HORSE HEAD PUMP



OFFSHORE RIG



Subsea Operations

In offshore operations, well completion and production are similar to onshore, but they take place below hundreds or thousands of feet of water. Well heads or caps must be resistant to corrosion by saltwater and must be able to withstand the pressure deep in the ocean. Well operators do not regularly visit the ocean floor to check on the well caps. Instead, sensors are placed on the well caps so that the wells can be monitored from the platform. Advanced technologies such as Remote Operating Vehicles, or **ROVERS**, can make robotic repairs to the well by operators on the platform using remote controls.

The petroleum is piped to an offshore **processing platform** where it is combined with oil from other wells before being cleaned and sent to a **refinery**. There is a limited amount of space on an offshore platform to store new oil, so all of the operations must be carefully coordinated. Production supervisors oversee the entire operation of an offshore rig to make sure operations are moving smoothly.

Cleaning the Petroleum

Once petroleum has been brought to the surface, it must be cleaned. Refineries have specific standards that they require suppliers to meet before they will accept the products. Producers usually clean their petroleum on site, near the pump. If a producer has multiple wells near each other, there may be one processing facility for a number of wells.

Field processing is used to separate out oil, natural gas, and water. All of these materials can come up through the well mixed together. The simplest way to separate out the different materials is in **settling tanks**. Oil from the ground is pumped into a tank through one pipe and allowed to settle. Each layer of oil, natural gas, and water is then pumped out through its own pipe. The downfall of this method is that settling can take a long time.

Pressurized separators that have a higher capacity and separate more quickly can also be used. Inside these separators, pressure and heat are used to collect liquids at the bottom, while oil and natural gas are piped out the side. Separators do a good job of separating oil and gas, but more processing is sometimes needed to remove all of the water from the petroleum, and impurities from the natural gas.

When oil and water are mixed together, they can be difficult to separate. This is true for household vegetable oil and tap water and it is true for crude oil and water. Refineries require that the oil contain no more than one percent water.

To remove excess water, heat is applied with a **heat-treater**. The heat-treater causes the droplets of water that are suspended in the oil to come together, creating larger drops that can be more easily removed from the oil. Water-free oil is removed from the top.

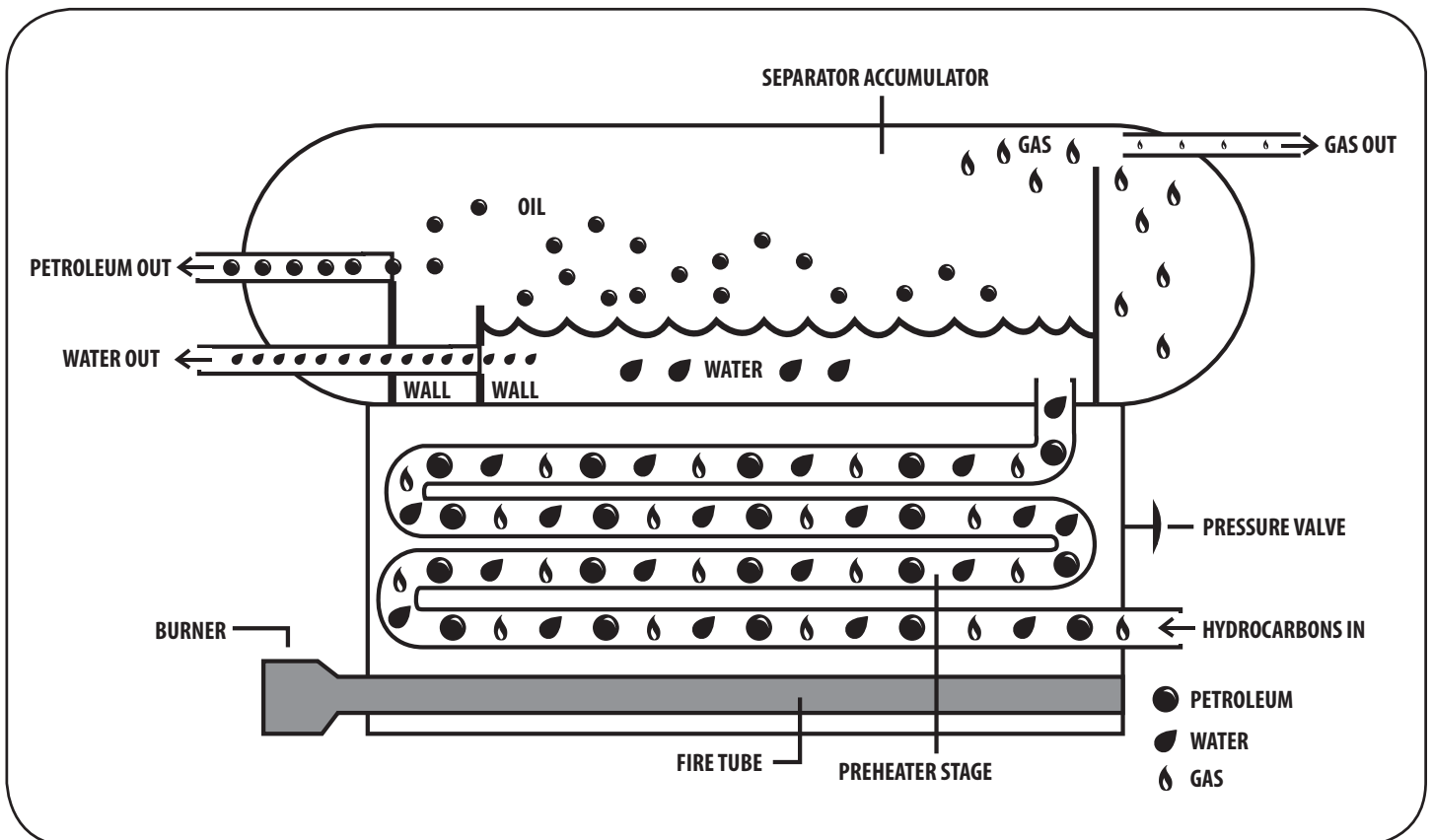
OIL TANKER



OIL PIPELINES



SEPARATOR



OFFSHORE PRODUCTION PLATFORM



STORAGE TANKS



Shipping Crude Oil

Petroleum wells are located above oil-bearing formations, wherever they are found. Refineries are usually near oil consumption markets, though many are located near major oil producing areas as well. There are different ways to get the oil from well to refinery.

Much of the petroleum we use is shipped via pipeline. These pipelines move crude oil from oil platforms offshore to refineries onshore. Pipelines can also move petroleum products between regions of the U.S. **Pumping stations** along the pipelines are located every 60 to 100 miles to keep the oil flowing.

A pipeline must be kept clean. To clean the inside of a pipeline, an instrument called a **pig** is used. This instrument is shaped like a bullet and scrubs the wall of the pipeline. More advanced pigs, called smart pigs, use cameras to monitor the pipe for flaws.

For longer distances, oil is put in tanker trucks or moved by sea on oil tankers. Crude oil produced in Venezuela, for example, is carried to the U.S. in oil tankers. This oil is off-loaded at a refinery to be turned into useful products. Oil tankers have two hulls, or shells, to help prevent oil spills.

In most cases when petroleum is shipped by tanker, the crude oil travels through both pipeline and tanker. One example is crude oil produced on the Northern Slope of Alaska. This oil field is very far north, near the Arctic Ocean. Instead of building a port to bring tanker ships into these treacherous waters, a pipeline was built to carry the oil to a more easily reached port in the southern part of Alaska.

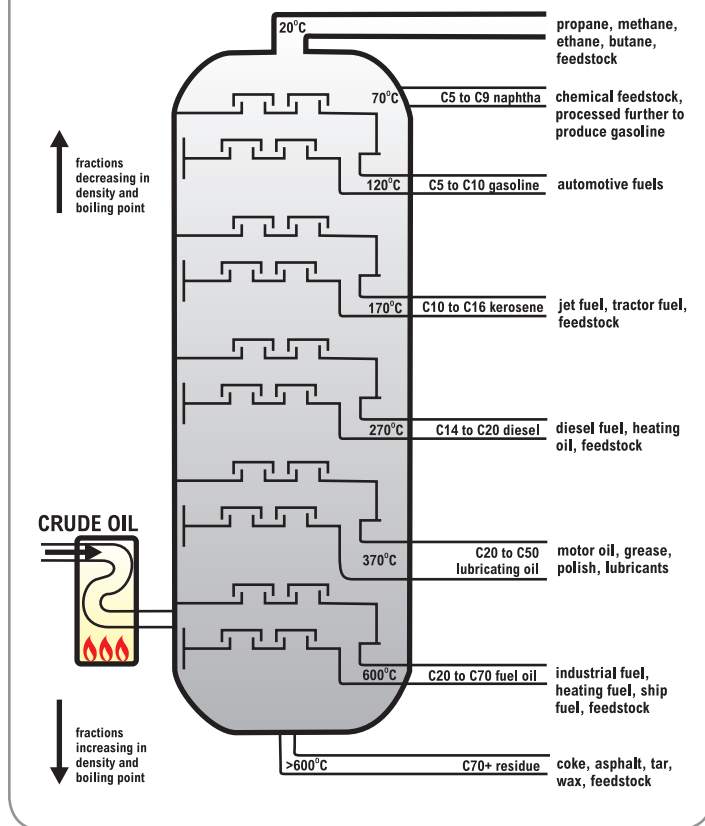
After transportation by oil tanker or pipeline to a refinery, much of the crude oil is placed in storage facilities or **tank farms**. These large cylinders hold the crude oil until the refinery is ready to process it.

Refining

Distillation

In its crude form, petroleum is of little use to us. To make it into products we know and use, petroleum must be **refined** or separated into its many parts. Those parts are what we use to fuel our world. Petroleum is made of **hydrocarbons**. Hydrocarbons are chemical compounds containing only hydrogen and carbon. These two elements combine in different ways to make hundreds of different compounds that we use to make thousands of products.

Fractionating Tower



The first and most important step in the refining process is **fractional distillation**. Distillation has been around since ancient times. Stills were set up by many cultures to produce alcohol. The first distillation of oil was done at the world's first oil refinery in Romania in 1856.

Fractional distillation is the separation of substances based on their boiling range. Petroleum is not the only thing that is distilled. The chemical industry and the beverage industry also distill their products. Basic distillation follows the same steps regardless of what is being separated.

A mixture is heated. As parts of the mixture begin to boil, they rise as gases. These gases are captured in a **fractionating tower**. While the bottom of the tower is very hot, the temperature at the top of the tower is cooler. Smaller molecules with lower densities and boiling points will move to the top of the column, while larger molecules with higher densities and boiling points will collect at the bottom. Trays or plates are placed at different levels inside the tower. These trays or plates have holes in them so that gases can pass through. But as the gas meets a plate that is cooler than the temperature of that gas, it **condenses**, or turns back into a liquid. The condensed liquid that forms on each plate is sent to a pipe. Each plate has its own pipe that carries only the liquids collected on it. The separated liquids move to other machines for further processing.

There are a number of products that come from the refining process. Hydrocarbons with simple molecular structures have lower boiling temperatures. As the molecular structures become more complex, the boiling temperature increases—more energy is required to break the intra-molecular forces between the molecules, which allows for the phase changes.

Once distillation is complete, the light, higher value products like propane, butane, and methane are cleaned and put to use. Heavy, lower value products, like fuel oil and lubricants, are subjected to additional processes to either extract higher value products or alter their chemical make-up to produce higher value products.

After transportation by petroleum tanker or pipeline to a refinery, much of the crude oil is placed in storage facilities or tank farms. These large cylinders hold the crude oil until the refinery is ready to process it.

Processing

These different parts are sent through chemical processing to be turned into useful products. There are three main types of processes.

Cracking breaks long hydrocarbon chains into smaller ones.

Unification combines small chains into longer ones. **Alteration** rearranges pieces of hydrocarbon chains to make different hydrocarbons.

Cracking can be done in a number of different ways. One method is **thermal cracking**. Thermal cracking uses very high temperatures to break apart long chains of hydrocarbons. This can be done using high temperature steam.

Cracking can also be done by heating the residue from distillation towers to very high temperatures until it separates into useful parts. This process is also known as **coking**, because the material that is left after all of the useful hydrocarbons are removed is **coke**, a hard, porous carbon material. Coke is used by heavy industry, such as iron and aluminum manufacturing.

Another way that long hydrocarbon chains are broken is through **catalytic cracking**. A catalyst is a material that increases the rate of reaction. Catalytic cracking is used to change heavy diesel oils into diesel oil and gasoline.

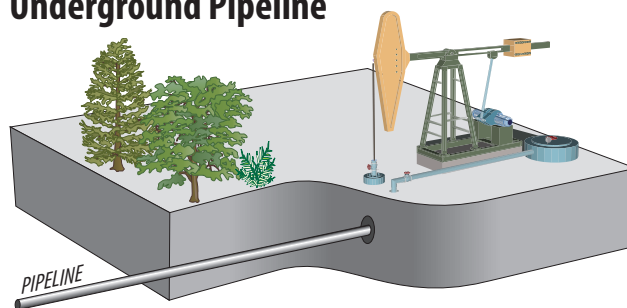
When smaller hydrocarbons are combined to make larger ones through unification, they usually undergo a process of **catalytic reforming**, a process that converts **naphtha** into **aromatics**. Aromatics are cyclic hydrocarbons—meaning the carbons form a ring rather than the simpler straight chain of hydrocarbons. They are named for their distinct “sweet” smell. Aromatics are a very important class of petrochemicals and are typically used to make chemicals and blend gasoline. The main by-product of catalytic reforming is hydrogen gas.

Alteration is the rearrangement of molecules in a hydrocarbon to create a more useful hydrocarbon. Usually this is done with **alkylation**, a process in which hydrocarbons are mixed with a catalyst and an **acid** to create hydrocarbons that are more branched rather than in straight chains. These are called high octane hydrocarbons that burn more smoothly and are often blended with gasoline.

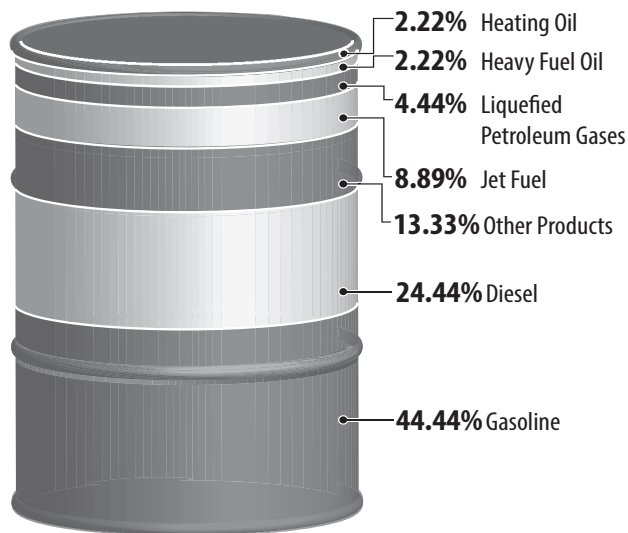
Preparation to Market

Once all the products have been separated from the crude oil that went into the refinery, the products must be prepared to go to market. This last step is known as **treatment**. Gasoline, for example, is treated with additives that help engines operate more smoothly and burn cleaner.

Underground Pipeline



Products Produced From a Barrel of Oil, 2015



* Total does not equal 100% due to independent rounding.
Data: Energy Information Administration

From the refinery, different petroleum products make their way to a variety of places. Just over forty-four percent of every barrel of oil is made into gasoline, and 24 percent is made into diesel fuel. Another 10–20 percent is refined into other transportation products such as jet fuel, motor oil, and liquefied petroleum gases. Many of these products are produced by further chemical processing.

Shipping Petroleum Products

After the refinery, most petroleum products are shipped to markets through pipelines. Pipelines are the safest and most cost effective way to move big shipments of petroleum. Gasoline is transported around the country through pipelines, most of which are buried underground. There are about 2 million miles of pipelines in the U.S. It takes about 15 days to move a shipment of gasoline from Houston, TX to New York City.

Special companies called **jobbers** buy petroleum products from oil companies and sell them to gasoline stations and to other big users such as manufacturers, power companies, and large farms.



Petroleum Based Transportation Fuels

Driving is an important part of Americans' daily lives. In fact, Americans drive their personal vehicles over 2.5 trillion miles a year. Commercial trucks drive 138.2 billion miles, public transit buses drive 2.4 billion, and school buses drive nearly 10 billion miles. There are a lot of vehicles racking up that kind of mileage—over 225 million personal vehicles, more than 100,000,000 commercial trucks, over 80,000 public transit buses, and almost 700,000 school buses.

Gasoline as a Transportation Fuel

Today, gasoline is the fuel used by a vast majority of passenger vehicles in the U.S. Americans use their gasoline powered vehicles to travel an average of roughly 12,000 miles per year. There are more than 150,000 fueling stations that provide convenient accessibility for consumers. The production and distribution infrastructures are in place. Most Americans consider gasoline the most sensible transportation fuel for today, even if it is not an ideal fuel.

Consumers are always concerned about price fluctuations. During World War I, the cost of gasoline was about \$0.25 a gallon. The price of gasoline averaged about \$2.00 or less a gallon in inflation-adjusted dollars for the last 80 years, until the shortages caused by Hurricanes Katrina and Rita, and the unrest in many oil producing areas, such as Iraq, Iran, and Nigeria. In 2014, the average cost for a gallon of gasoline was \$3.36. By January of 2016, that cost dropped to \$1.95 a gallon with a yearly average of \$2.25. Prices will continue to rise and fall. In June of 2017, prices had risen to \$2.35 per gallon.

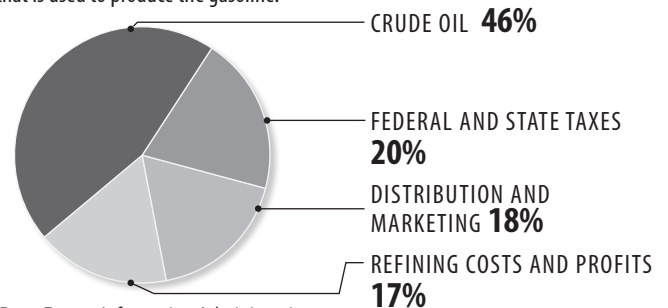
Diesel as a Transportation Fuel

Diesel fuel plays a vital role in America's economy, quality of life, and national security. As a transportation fuel, it offers a wide range of performance, efficiency, and safety features. Diesel fuel contains between 18 and 30 percent more energy per gallon than gasoline. Diesel technology also offers a greater power density than other fuels, so it packs more power per volume. Diesel prices used to be lower than or comparable to gasoline prices. However, in the last decade, diesel prices have been higher than gasoline prices. Diesel is more expensive due to higher refining costs and higher federal taxes. In 2016, the average retail price for diesel was \$2.30 per gallon, down from \$3.82 in 2014.

Diesel fuel has a wide range of applications. In agriculture, diesel powers more than two-thirds of all farm equipment in the U.S. because diesel engines are uniquely qualified to perform demanding work. The construction industry also relies heavily on diesel fuel to operate heavy machinery. Diesel power dominates the movement of America's freight in trucks, trains, boats, and barges; 94 percent of our goods are shipped using diesel-powered vehicles. No other fuel can match diesel in its ability to move freight economically. In addition, it is the predominant fuel for public transit buses, school buses, and intercity buses throughout the U.S.

Factors in Gasoline Pricing, 2017

In June 2017, the average retail price for a gallon of regular grade unleaded gasoline was \$2.35. The biggest factor in the total price is the cost of crude oil that is used to produce the gasoline.



Data: Energy Information Administration

*Total does not equal 100% due to independent rounding.

Diesel fuel is not just for large vehicles. There are more than five million diesel cars, pickups, and sport utility vehicles (SUVs) on the road today. A new generation of clean diesel cars, light trucks, and SUVs are now available and offer consumers a new choice in fuel-efficient and low-emissions technology. Clean diesel is a proven technology that is clean, quiet, and fun to drive. Many new diesel options are available for car consumers in every state. Thanks to their inherent fuel efficiency, diesel engines also offer a viable and readily available strategy for reducing **greenhouse gas** emissions as they produce 20 percent fewer carbon dioxide emissions than gasoline vehicles. American drivers who purchase cleaner-burning diesel cars, trucks, and SUVs are eligible for similar tax incentives as purchases of gasoline-hybrid electric vehicles.

Characteristics and Environmental Impacts of Gasoline and Diesel Fuels

Gasoline is a nonrenewable fossil fuel that produces criteria air pollutants—carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide—when it is burned. Since the 1960s, stricter environmental standards have led to gasoline formulations and vehicle designs that have reduced vehicle exhaust emissions by 95 percent.

The Clean Air Act Amendments of 1990 mandated that reformulated gasoline be used in areas of the country that do not meet air quality standards, as well as reductions in nitrogen compounds (NO_x) and volatile organic compounds (VOCs). More than a dozen different formulations of gasoline are now required by law in the U.S. Blending ethanol with gasoline was originally targeted in areas that did not meet air quality standards. Now, it is common to find up to 10 percent ethanol blended into gasoline.

Significant progress has been made in reducing emissions from diesel engines. With new clean diesel technologies, today's trucks and buses are eight times cleaner than those built just a dozen years ago. Since 2010, new trucks and buses have near-zero emission levels.

Chemical Manufacturing

Petroleum goes into much more than just the tanks of our cars and airplanes. Petroleum is part of many of the products we use every day. It is well known that plastics are made from petroleum products, but that is only the beginning. Your toothbrush, toothpaste, shampoo, and even your contact lenses contain petroleum, as do carpeting, CDs, the ink in your pen, and medical devices such as prosthetic heart valves.

Chemical plants take refinery products and turn them into the products we use. There are many different kinds of chemical plants. Some are small and produce one or two items. Some are very large and produce a number of items. The largest plants can produce over 5 billion pounds of product each year. Large chemical plants operate all the time. They run 24 hours a day, every day of the year. Many of these plants are automated with new technology and need fewer people than in the past to run them.

Plant Equipment and Processes

Cracking in a chemical plant is very similar to cracking in a refinery. Heat is used to break apart the chemical bonds of the hydrocarbon molecules in feedstocks. Feedstocks are the raw materials used to make products in chemical manufacturing plants.

Boilers and Furnaces

Both **boilers** and **furnaces** are important parts of chemical plants. Often feedstocks are brought to a chemical plant in solid form, such as powder or pellets. To work with these materials, they must be heated and melted into liquids or sometimes gases.

Cooling Towers

Cooling towers are used to return the water used in chemical processing back to a normal temperature before it is returned to the river or lake from which it was taken. To do this, water is sent through a maze-like structure that allows as much air as possible to come into contact with the water. Gravity pulls the water down through this maze, cooling it as it goes.

The air inside a cooling tower heats up as it comes into contact with the warm water being fed into the tower. The warming air rises, collecting a tiny bit of water vapor in the process, and is released from the top of the tower. As you drive by a chemical plant, you can sometimes see a cloud of water vapor rising from the cooling tower.

Heat Exchangers

Heat exchangers are devices that can speed up production and cut down on the need to process waste heat at the same time. Heat exchangers use fluids that contain waste heat, or heat that is no longer useful from a previous step, to heat materials that must be warmed in another step.

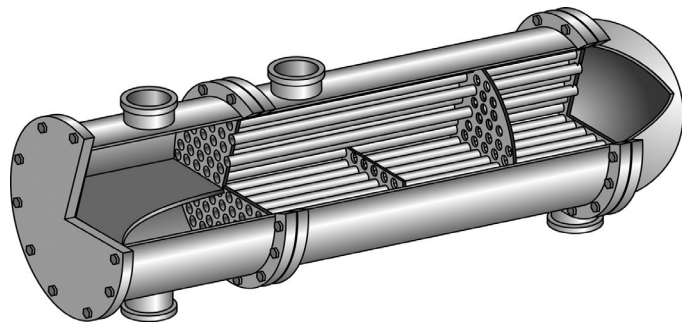
Heat exchangers are large pipes with smaller pipes inside. The small pipes carry cool liquids that need to be heated. The small pipes do not completely fill the large pipes, and the space around the small pipes is where the waste-heat fluid (liquid or gas) flows.

As the cool liquid and the hot fluid flow past each other, heat is transferred from the hot fluid to the cool liquid. At the end of the heat exchanger, the cool liquid has warmed in preparation for its next step. The hot fluid has cooled and requires less processing.

FURNACE



Heat Exchanger



Wastewater Treatment

Processing chemicals can use large quantities of water. Water is present in nearly every step. Boilers, cooling towers, and heat exchangers all use water. To ensure that the water leaving the plant is as clean as the water coming into the plant, **wastewater treatment** facilities are located on site.

Laboratory

One important part of a chemical plant is the laboratory. Chemists constantly monitor the product at each step to make sure it meets the required specifications. If the chemistry is not just right, plastic bags could be too weak to hold groceries or nylon thread too brittle to sew. Chemists also monitor waste products to make sure the land and water is not being polluted.

Loading Station

Once the final product is complete, it is stored in a warehouse or storage tank, depending on the type of product. When needed, the product is taken from the storage facility to a **loading station** to be transported to market or to another chemical plant for further processing. Depending on the product, it may be transported by road, rail, air, water, or pipeline.

Transportation

Refineries and chemical plants are located all over the country and feedstock is often moved long distances between the two. Sometimes, chemicals are moved in small 50-pound bags or 400-pound drums. Feedstocks that must be transported in large quantities may be moved by barge, ship, or pipelines, which can carry larger quantities of product.

Products

To get the products that are familiar to us, feedstocks must be processed. Different products have different steps that are needed. Many products are made from more than one feedstock, which are combined in different ways to produce a variety of products.

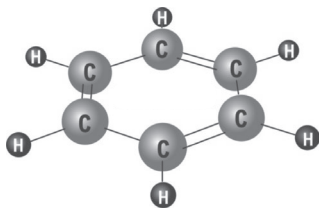
There are two general types of chemicals produced from petroleum that are used to create most everyday items—aromatics and olefins. Aromatics are a group of petrochemicals with a distinctive sweet smell that are characterized by ring structures, and are produced in refineries and petrochemical plants. The most common aromatics are benzene, toluene, and xylenes.

Aromatics are used for chemical production or as high-octane components for gasoline blending. Aromatics are also used to make plastics and **polymers**. These materials go into products such as paint, textiles, building materials, and leather alternatives.

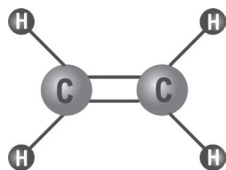
Olefins are a class of hydrocarbons recovered from petroleum that contain one or more pairs of carbon atoms linked by a double bond. Typical examples include ethylene and propylene. Olefins are obtained by cracking petroleum fractions at high temperatures. Another word for olefin is alkene.

The simplest olefins—ethylene, propylene, butylene, butadiene, and isoprene—are the basis of the petrochemicals industry. They are used to produce plastics, industrial solvents, and chemicals that are used in other applications. A number of familiar products come from these petrochemicals, including plastic bags, paint, tires, and plastic bottles.

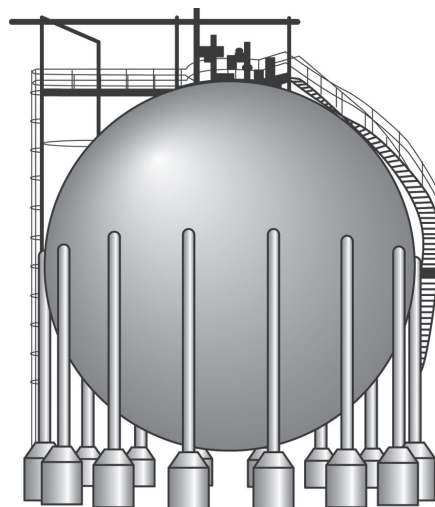
Benzene



Ethylene



Sphere Storage Tank



Products Made From Petroleum



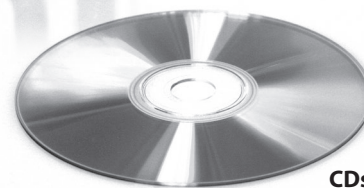
Lipstick



Action figures



Rubber bands



CDs



Tape



Pen

Health and Safety

Worker health and safety are top priorities in all process industry facilities. To help ensure that workers are safe on the job, all manufacturing plants follow OSHA (Occupational Safety and Health Administration) rules and guidelines. In many work settings, for example, OSHA guidelines require that workers wear hard hats, ear protection, eye protection, or other safety gear.

Chemical plants are continuously making their operations as safe as possible. Spill kits are located throughout a plant so that if there is a spill, clean-up can be accomplished quickly. Plants also work hard to replace any materials used in their processes that are toxic with alternatives that are safer for workers and for the environment.

One safety feature at a chemical plant is the fire pond. A pond of water is kept on site ready to be pumped if a fire were to erupt. There are usually a number of ponds scattered around each plant site so that one is never far away if it is needed. Since fire pond water does not need to be as clean as the water we use in our everyday lives, storm water is often collected to fill the ponds.

Environment

In the United States, we use more petroleum than any other energy source. Petroleum products—gasoline, fertilizers, plastics, and medicines—have brought untold benefits to Americans and the rest of the world. We depend on these products, and, as consumers, we demand them. However, these benefits are not without cost. Petroleum production, distribution, and combustion can also contribute to air and water pollution.

Drilling for, transporting, and improper disposal of petroleum can endanger wildlife and damage the environment. Leaking underground storage tanks can pollute groundwater and create noxious fumes. Processing petroleum at the refinery can contribute to air and water pollution. Burning gasoline and diesel to fuel our cars and other small engines such as lawn mowers contributes to air pollution. Even waste petroleum drained from the family car, if not properly recycled, can pollute rivers and lakes.

Many advances have been made in protecting the environment since the passage of the Clean Air Act in 1970. Petroleum companies have redesigned their refineries to reduce emissions into the air and water. Gasoline mixtures have been reformulated to burn cleaner, dramatically cutting the levels of nitrogen oxide, carbon monoxide, and hydrocarbons released into the air. Removing lead from gasoline has significantly reduced the amount of lead pollution in the last 30 years. Oil companies do everything they can to drill, process, and transport oil and gas products as safely as possible, as it is the key to their success.

Like petroleum, burning natural gas releases pollutants into the atmosphere when burned. However, natural gas is the least polluting fossil fuel. Burning natural gas produces less sulfur, carbon, and nitrogen than burning other fossil fuels. Natural gas also emits little ash particulate into the air when it is burned.

The production, transportation, distribution, and combustion of petroleum and natural gas are strictly regulated to minimize the negative effects on the environment and people. Our dependence on petroleum presents a continuing challenge. In the future we must balance the demand for petroleum products with protection of the global environment.

OIL WORKER

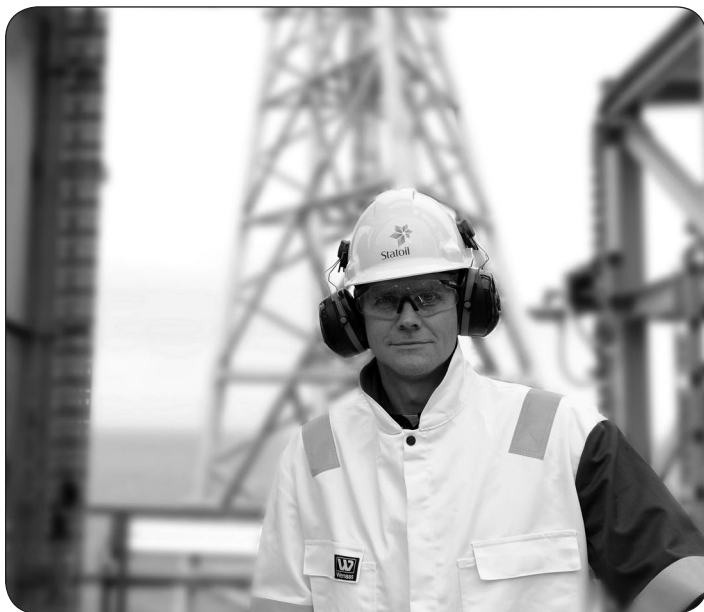


Image courtesy of StatOil

AIR POLLUTION



Petroleum fuels can contribute to air pollution.

Into the Future

As the demand for petroleum continues and the issues become more and more complex, energy companies are using advanced technologies to design and deliver next generation fuels and products. The skills used by all workers in the petroleum product industry are transferable to these new technologies. New opportunities are emerging every day.

Consumers can make a real difference by recycling petroleum-based products and buying products that conserve energy.

To take a tour of a chemical plant, go to the ChemStewards® Society of Chemical Manufacturers and Affiliates Virtual Plant Tour at www.chemalliance.org/tools/.



Careers in the Oil and Natural Gas Industry

The oil and gas industry offers a variety of careers for individuals to work at its refineries, chemical plants, or on exploration and production onshore/offshore facilities. The following are examples of some of the career options available:

Process Technicians - members of a team of people that control, monitor, and troubleshoot equipment and focus on safety and environmental considerations.

Instrumentation Technicians - maintain, calibrate, adjust, and install measuring and control instruments necessary to ensure the safe, efficient operation of equipment.

Electricians - read blueprints that show the flow of electricity and maintain and repair the electrical and electronic equipment and systems that keep the facilities up and running.

Machinists - install, maintain, repair, and test rotating mechanical equipment and systems.

Geologists - explore the nature and structure of rock layers to piece together a whole picture of the subsurface in order to determine the best possible places to drill for oil and natural gas.

Petroleum Geologists - gather, process, and analyze seismic data and well data in order to locate drill sites for their companies.

Geoscientists - study the composition, structure, and other physical aspects of the Earth and are involved in exploration and production of oil and natural gas.

Petroleum Engineers - play a key role in determining the reservoir capacity (how much oil it might hold) and productivity (how much it produces) to design systems that move the petroleum from the wells (production process) through refining, where it gets cleaned up and converted into the energy we use.

Chemical Engineers - design chemical plant equipment and develop processes for manufacturing chemicals and products like gasoline, detergents, and plastics.

Mechanical Engineers - deal with the design, manufacture, and operation of the machinery and equipment used to improve oil drilling, and the processing of petroleum or chemical products.



Image courtesy of Shell

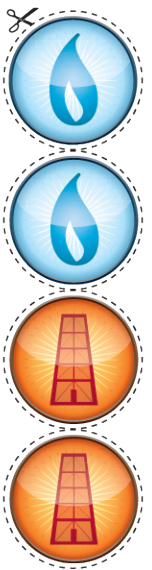


Image courtesy of Shell

Oil and Natural Gas Career Game

Imagine you are a drop of oil or a molecule of natural gas. Cut out the game pieces to the right and roll a die to follow the path from the ground to market. Along the way, you will meet many people who help you on your journey.

GAME PIECES



START

EXPLORATION
Geologists conduct many tests gathering information, such as seismic data, to determine if the geology holds oil or natural gas.

GEOSCIENTISTS AND HYDROLOGISTS
study the composition, structure, and other physical aspects of the earth to analyze the composition of earth, rock, and water.

PETROLEUM GEOLOGISTS
gather, process, and analyze seismic data and well data to locate drill sites.

PETROLEUM ENGINEERS
formulate the general plan for how the extraction operation will go. They help design the general structure of the well and the most efficient method of extraction.

DRILLING & PRODUCTION
Wells are drilled deep into the ground to bring oil and natural gas to the surface.

ROTARY-RIG ENGINE OPERATORS
are in charge of engines that provide the power for drilling and hoisting.

ROTARY DRILL OPERATORS
supervise the crew and operate machinery that controls drilling speed and pressure.

ENVIRONMENTAL ENGINEERS
ensure that well sites meet federal, state, and local regulations. They also plan reclamation projects when extraction is complete.

ELECTRICIANS
maintain and repair the electrical and electronic equipment and systems that keep the facilities up and running.

ROUGHNECKS
guide the lower ends of pipe to well openings and connect pipe joints and drill bits.

ROUSTABOUTS
are general laborers that do general oilfield maintenance and construction work, such as cleaning tanks and building roads.

MACHINISTS
install, maintain, repair, and test rotating mechanical equipment and systems.

INSTRUMENTATION TECHNICIANS
maintain, calibrate, adjust, and install measuring and control instruments necessary to ensure the safe, efficient operation of equipment.

REFINING & DISTRIBUTION
Crude oil and natural gas are refined into many different products and shipped to consumers.

ROUSTABOUTS
are general laborers that do general oilfield maintenance and construction work, such as cleaning tanks and building roads.

CHEMICAL ENGINEERS
design plant equipment and develop processes for manufacturing chemicals and products like gasoline, detergents, and plastics.

STOP!
Roll the die one last time to find out what kind of product you will become. If you are a drop of oil, follow the petroleum path. If you are a molecule of natural gas, follow the natural gas path.

PETROLEUM

- You are refined into gasoline for use in cars and trucks.
- You are made into plastic and become part of a toy.
- You are processed into the wax that becomes a crayon.
- You are part of medicine that helps save a person's life.
- You are used to make asphalt, which paves a new highway.
- You are refined into jet fuel and travel the world in first-class.

NATURAL GAS

- You are sent to a house and used to cook dinner on a stove.
- You are used as fuel in a power plant that generates electricity.
- You are compressed and used as an alternative fuel in a city bus.
- You are piped to a factory where you help make cars.
- You are a raw material used to make paint.
- You are sent to a house and used for space and water heating.

END-USE PRODUCTS

Q&A

NEED GETS TO KNOW INDUSTRY PROFESSIONALS

Adam Bell

Adam Bell is a marketing professional and former engineer with Schlumberger. He started out as a Field Engineer Trainee with a Bachelor's degree in Chemical Engineering. Schlumberger develops their Field Engineers through several steps of operational and technical schools combined with field work in advance. He participated in a Co-Op/Internship program in college, which he felt was especially useful in preparing for this challenging field.



TELL US A LITTLE ABOUT YOUR JOB AS AN ENGINEER.

I focused on developing our laboratories, facilities, and engineers in the Horseheads, NY district. I began my career working on field crews in South Texas, and moved into managing daily operations of well stimulation crews in Arkansas, Oklahoma, and New York. That included hiring and developing field crews, coordinating people, materials and equipment, and interfacing with clients both in preparation and following up on completed treatments.

HOW DID YOU DECIDE TO GO TO WORK IN THIS FIELD?

I have always been interested in math and science from a young age, which led me to wanting to become an engineer.

WHAT IS A TYPICAL DAY AT WORK LIKE FOR YOU?

When I worked in the field, I was at work before 5 a.m. preparing paperwork and then briefing the crew on the day's job. From there I would lead a convoy of up to 20 trucks to a well-site where we would rig up the equipment, pump the job, rig the equipment down, and move to the next well-site. All of this would happen before 7 p.m. that same day. Now, my day begins at the office at 8 a.m. and usually ends around 7 or 8 p.m.

COULD YOU DO YOUR JOB ANYWHERE IN WORLD?

The majority of well cementing and stimulation is performed on the oil and gas wells drilled in the United States. This covers a significant portion of the U.S. from California, the Rocky Mountains, Texas, Arkansas, Oklahoma, Louisiana, all the way to the Appalachian Mountains.

WHAT IS THE MOST CHALLENGING PART OF YOUR JOB?

The "24/7" nature of this fast-paced industry pushes everyone involved to their limit. To ensure that risks are managed and the correct decisions are made to perform the job safely and correctly is a constant challenge. In the Northeast part of the United States, one of the key challenges is to educate the public about our industry as well as ensure that all operations are conducted in accordance with established best practices in order to justify the public's trust.

ANY ADVICE FOR YOUNG PEOPLE CONSIDERING A CAREER IN THIS INDUSTRY?

Be ready to work harder than you ever thought was possible. You will always continue to learn in an industry that will always be challenging and changing at a dramatic pace—you will never be bored. If you are considering a career in this industry you cannot be afraid to get your hands dirty!



IMAGE COURTESY OF CHESAPEAKE/STATOIL

I have been able to see the sun rise and set across the countryside of America ...

ANY OTHER COMMENTS ABOUT PURSUING A CAREER IN THIS FIELD?

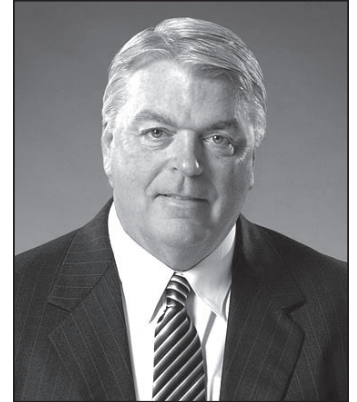
I have been able to see the sun rise and set across the countryside of America and have been able to work with an incredibly diverse, multi-national workforce. Abundant energy resources have enabled dramatic improvements in quality of life and advances in technology can never be predicted and should not be underestimated. Ensuring safe, reliable, and affordable energy for future generations is not only one of the greatest engineering challenges of today but also of primary concern for our society's future.

Q&A

NEED GETS TO KNOW INDUSTRY PROFESSIONALS

Pat Bond

Pat Bond is the Chief Operating Officer at Light Tower Rentals, Inc., an oilfield services company. He formerly was the Vice President of Sales for Drilling Tools and Remedial (DTR) at Schlumberger. Before and after graduating from The University of Texas with a B.S. in Petroleum Engineering, Mr. Bond spent years in the field working on rigs and running tools, building his understanding of the business literally from the ground up. That, along with his engineering degree, led to a technical career where he travels the world giving technical support and presentations.



HOW DID YOU DECIDE TO GO TO WORK IN THIS FIELD?

Growing up in Houston I was always around people in the energy business. I found the people to be daring and entrepreneurial (also known as “Wildcatters”) as they were taking risks and either hitting it big and driving fancy cars or going broke trying. That swashbuckling attitude was what first attracted me to the industry. From there I got hooked on the whole process of oil and gas extraction. We all use and depend on petroleum products so I figured the long term career prospects were good.

WHAT IS A TYPICAL DAY AT WORK LIKE FOR YOU?

Every morning I wake up thinking about how to get more business for my company. That includes calling on customers, evaluating new tools and processes that will assist our sales people, meeting with internal partners to discuss delivery, people, training, finances, and legalities. Fundamental questions we ask ourselves every day are “What do our customers need? What keeps them awake at night?” If you can solve those questions, and prove it, then sales will come.

HOW HAS YOUR FIELD CHANGED IN THE LAST 5-10 YEARS?

We are running tools in markets that did not exist 5-10 years ago. These new tools and markets now make up a large part of our annual revenue. The trick is adjusting to those needs and markets in time to capture a significant part of the business. If you stay still you will get run over in this industry. I think of it as—there are people who run the business and people who change the business. We always need a proper balance of people running today’s tools in today’s markets while we have people looking ahead at new tools and new markets.

WHAT IS THE MOST REWARDING PART OF YOUR JOB?

Like most competitive people I like to win. Gaining enough trust from our client so that they reward us with business is a fantastic feeling. Mentoring young or new team members is also very gratifying.

WHAT ARE SOME IMPORTANT ATTRIBUTES ONE MUST HAVE FOR THIS JOB?

Knowledge of the subject area and learning the art of public speaking have helped me tremendously in my role today. Obviously you never stop learning as I continue to take technical and leadership training classes to this day. I also have a personal objective on my annual performance review to take a certain amount of training classes every year.

WHAT CHALLENGES DO YOU FACE IN THE INDUSTRY?

Government regulations and negative public perceptions are constant challenges. In the aftermath of the oil spill in the Gulf of Mexico, these challenges have been magnified and of course in some ways justifiably so. But, regardless of perceptions and regulations the world still needs cars, trucks, planes, trains, ships, plastics, fertilizers, electricity, pharmaceuticals, cell phones, etc., made possible by petroleum products. I always wonder if the people who are down on the energy business know how much we contribute to society. And as a side note—I’m not sure how much more organic you can get than oil and gas—it comes from the EARTH.

WHAT ARE SOME BENEFITS TO WORKING IN THIS INDUSTRY?

Besides working with technology that rivals the space industry, there is camaraderie in this business that makes the whole thing fun to be in. On the technology side—think about drilling where the working platform is on water 2 miles above the sea floor and drilling a hole that is another 5 miles in length and hitting a target that is the size of a football field while dealing with all the challenges of pressure, temperature, and mechanical issues. The level of technology is actually quite amazing and really should be seen to understand.

WHAT ADVICE WOULD YOU GIVE TO A YOUNG PERSON WHO IS INTERESTED IN WORKING IN THE OIL AND NATURAL GAS FIELD?

I understand that there are some negative feelings about the energy business and relatively few people outside of the business truly understand what happens to get oil and gas out of the ground. I would say to anyone to take some time to understand the process and technology of oil and gas extraction and make up your own mind—don’t let outsiders who don’t know the business influence your decision.



Many people in the oil and gas industry, such as Mr. Bond, begin their careers in the field working as roughnecks or roustabouts before moving their way up through a company.

For those who are interested in a career in the energy industry there are plenty of opportunities for high energy people with or without a college degree. If in college, focus on math and science and take job shadowing and internships. These experiences and relationships will only help your career. If college is not in your plans, that's OK. Be flexible on where you want to live and work. There are oil and gas basins all over the world and all of them need good solid people to bring the oil and gas to surface, process it, and get it to market.

For any person interested in a career in the oil and gas business I would say keep your integrity. It's really the only thing anyone really has. Who wants a smart person that you can't trust? Say what you are going to do, then do it. This business is all about trust. There are always safety and financial risks in this business and trust is a necessity for a successful career.

ANY OTHER COMMENTS ON CAREER OPPORTUNITIES IN THE OIL AND GAS FIELD?

After nearly 30 years in this business I still wake up excited about my job. There are always new technologies, new markets, and challenges that keep this a very dynamic industry. On top of that, the industry is very social with plenty of technology conferences, industry associations, ties to universities, and affiliations with



charitable associations that constantly bring you in contact with customers and peers. I obviously have a very biased opinion, but I honestly don't see how people work in any other industry.

Q&A

NEED GETS TO KNOW INDUSTRY PROFESSIONALS

Galen Cobb

Galen Cobb is Vice President of Industry Relations for Halliburton and is responsible for the company's industry relations and global activities. As a graduate of Oklahoma Christian University with a degree in business, Mr. Cobb has been with Halliburton for over thirty-five years. Mr. Cobb serves on numerous industry, trade association, and civic boards throughout the industry, and was recently awarded the Spindletop Don E. Waggener-Butch Griffin Award as well as the NEED Distinguished Service Award.



TELL US A LITTLE ABOUT YOUR JOB AND WHAT YOU DO.

After working for Halliburton for almost 40 years I have had many different positions with the company. Currently I have broad responsibilities that include managing the company's industry relations, energy trade policy issues, executive client relations, and trade organizations oversight. Really my position is all of these things rolled into one. I am also very involved in our education component, which allows me to work with many K-12 schools and improve our relations with the future of our industry.

HOW DID YOU DECIDE TO GO TO WORK IN THIS FIELD?

Thirty-six years ago I was out of college, looking for a job, and found Halliburton. I started as most people do in this industry, at an entry level position doing field service work, export shipping, then working up to export sales. I have had various executive management positions in operations, marketing, and sales and business development. I was also the Director CIS in China with oversight in establishing Halliburton's presence and operations in these emerging markets.

WHAT IS A TYPICAL DAY AT WORK LIKE FOR YOU?

There is a lot of variety in my daily work schedule. Serving on 15 Boards and 32 Industry Committees I find myself traveling a lot, and doing many breakfasts, luncheons, and dinners that are all related to our industry. I have been fortunate enough to be able to spend a lot of time in Houston, Texas where I reside as well as traveling extensively throughout the world. I also spend many days working with schools and education programs to improve our educational institutions as well as our industry.

WHAT IS THE MOST REWARDING PART OF YOUR JOB?

The opportunity to meet such a wide variety of people is very enjoyable. I also feel that getting to know the different industry trade issues and working through those with various different people makes my job exciting. Another very enjoyable part of my job is focusing on enhancing our education programs. The future of our industry is in our youth, and educating them to be successful not only in their careers but to make a difference in their country.

WHAT CHALLENGES DO YOU FACE IN THE INDUSTRY?

The biggest challenge I face in our industry is the mindset and perception of the oil and gas industry. It is very important that we keep the price of our resources at an affordable range for our country. The oil and gas industry really affects our economy, which in turn has a huge influence on the future. We are very big fans of

renewable energy sources, and work with those industries as well. Everyone that is associated with energy is on the same team, and we enjoy working together. Oil and gas is not something that can go away quickly, and it is something in which the U.S. is the leader. Focusing on needing every energy source and producing them in a clean manner are the biggest challenges we face. I am a big proponent of the facts, which The NEED Project does a super job of delivering to schools and institutions across the country.

WHAT ARE SOME BENEFITS TO WORKING IN THIS INDUSTRY?

Our industry has some tremendous benefits. The oil and gas industry is going to be very strong throughout the next 30, 40, even 50 years. The upward mobility of this career path is endless. If you have talent and a willingness to learn and get better, you will advance very quickly. No matter what specific part of the energy industry you work in, if you are willing to do what it takes, you will have wonderful personal, financial, and industrial benefits.

WHAT ADVICE WOULD YOU GIVE TO A YOUNG PERSON WHO IS INTERESTED IN WORKING IN THE OIL AND NATURAL GAS FIELD?

Pay your dues. Be willing to get dirty, start in the field, and work your way up. The industry is always looking for leaders that are looking to manage parts of the job, and increase their knowledge and duties. For a very fast payback on your education, a technical degree is the best. Getting your engineering degree and being willing to learn four to five years of technical work, you will really be set in a wonderful career in a great industry. I would also like to encourage young people to give the oil and gas industry a fair evaluation and not exclude it from the decision of a career. The demand for young people in our industry is huge, and it is like that every year. I believe Halliburton hired close to 15,000 people last year and are going to need even more in the next year or so.

ANY OTHER COMMENTS ON CAREER OPPORTUNITIES IN THE OIL AND GAS FIELD?

Halliburton has started some Petroleum Academies in Houston area schools. This takes juniors and seniors interested in this industry and allows them to earn advanced credits to apply to college when they graduate high school. This also gives students the opportunity to receive mentoring from professionals. In the summer they spend three weeks at Halliburton and other companies and get to see a live look at the industry, career outlook, and physically get to work in the field and simulate all aspects of this career. I am also a huge fan of The NEED Project and the information they provide as well as the opportunities.

Q&A

NEED GETS TO KNOW INDUSTRY PROFESSIONALS

Ashley Lantz

When interviewed, Ashley Lantz was an Operations Engineer for Encana in Colorado. She graduated with a Bachelor of Science in Petroleum Engineering from the Colorado School of Mines. Ashley now works for a private oil company in New Zealand.



TELL US A LITTLE ABOUT YOUR JOB AND WHAT YOU DO.

I work for our exploration team as an Operations Engineer. In our exploration group, operations engineers are involved in all aspects of well planning for new areas. We work with state and local officials to plan well locations, design and complete wellbores, and evaluate well performance when the wells begin producing. I spend one to two weeks per month in the field and at the well site during the drilling and completion phases. Field work is critical to the success of projects and the development of my engineering skills.

WHAT IS THE MOST REWARDING PART OF YOUR JOB?

I enjoy being involved in both the project planning and execution phases. It is exciting to be able to start with designing a project on paper and to also have the opportunity to implement designs and actually see the work take place.

WHAT IS THE HARDEST PART OF YOUR JOB?

One of the biggest hurdles is to anticipate future challenges and successfully design projects that mitigate or avoid those potential issues.

COULD YOU DO YOUR JOB ANYWHERE IN THE COUNTRY?

Our industry has both location and work schedule flexibility and as a result, engineers have many career path choices. Depending on the company, operations engineers typically have the opportunity to work from either corporate or field offices. Operations engineers also have flexibility in work schedules such as rotational work within the United States and throughout the world.

WHAT TYPE OF TRAINING OR EDUCATION IS REQUIRED?

Obtaining an engineering position at Encana required a Bachelor of Science degree; specifically I received a Bachelor of Science in Petroleum Engineering from the Colorado School of Mines. Even though I pursued a degree specific to the energy industry, engineers of other disciplines also qualify for various positions. In addition, many engineers elect to pursue graduate degrees; however, that is not required in most engineering disciplines.

While in college, I took advantage of the many internship opportunities our industry provides. I was fortunate to work three different summer internships in college. This was an excellent way to gain experience and find employment after college. My internships helped me secure a full time position with Encana early in my senior year of college.



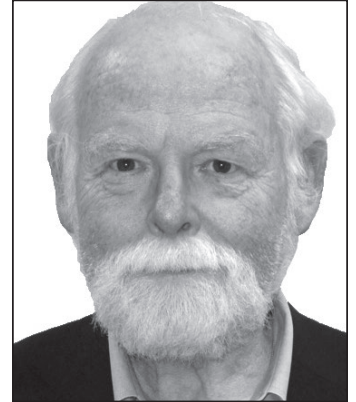
Much of Ashley Lantz's time with Encana was spent in the field at drilling sites.

Q&A

NEED GETS TO KNOW INDUSTRY PROFESSIONALS

William Pike

Dr. William Pike is currently a Senior Consultant within Leonardo Technologies Inc. (LTI) and works under contract in the National Energy Technology Laboratory (NETL), a division of the U.S. Department of Energy. Dr. Pike holds a Ph.D. from the University of Aberdeen. He has contributed to several books on oil and gas technology and energy economics and has authored technical papers on offshore drilling and production.



TELL US A LITTLE ABOUT YOUR JOB AND WHAT YOU DO.

I work under contract to the National Energy Technology Laboratory (NETL), a division of the U.S. Department of Energy. The Department of Energy conducts and funds research and development for oil and gas, and other energies including wind, solar, and nuclear through NETL. My work is undertaken, primarily, for the Strategic Center for Natural Gas and Oil (SCNGO) within NETL, although I occasionally work in other areas (particularly nuclear) where oil and gas technology can be applied. NETL's mission is to conduct research and development that contributes directly to the enhancement of the nation's energy supply in an environmentally safe manner.

HOW DID YOU DECIDE TO GO TO WORK IN THIS FIELD?

This field of work found me. A friend called to ask if I knew anyone who might be interested in the job. After he described it, I determined I was. The job allows me to bring my 20 odd years of experience in oil and gas exploration and production, plus a number of years as editor of technical publications, to bear on research and development that I believe is vitally important for our nation.

WHAT IS A TYPICAL DAY AT WORK LIKE FOR YOU?

In a typical day I will work at three to four tasks. These normally include: conducting research and creating recommendations for future research projects within NETL based on current technological gaps, and emerging energy options; assessing the progress and results of ongoing research and development programs within NETL; interacting with industry and academia to determine non-governmental research foci and coordinate research efforts; and, managing an outreach program to inform industry and the public of NETL research and development projects and their availability for external applications. To do this, I work closely, through conversations, meetings and correspondence, with NETL researchers in the national energy laboratories system and with individual researchers in industry and academia. A significant portion of my work day is also spent planning and writing research recommendations for future NETL projects.

WHAT TYPE OF TRAINING OR EDUCATION IS REQUIRED?

The job I do requires at least a bachelor's degree, preferably in engineering or the geosciences. More importantly, it requires a great deal of experience on the ground in the technical sector of the oil and gas industry.

WHAT IS THE BIGGEST CHALLENGE THAT YOUR INDUSTRY FACES?

I face the same challenge that everyone in our industry faces - the provision of energy to sustain and build the nation's economy and infrastructure in a prudent, safe, and environmentally friendly manner.

WHAT ARE THE BIGGEST BENEFITS TO WORKING IN YOUR INDUSTRY?

The primary benefit of working in the upstream oil and gas industry is getting to work with people you like and respect. The upstream industry is global but the workforce is not large by most industry standards. Over the course of your career, you make lasting friendships around the globe. The second benefit that I have found in this industry is the knowledge that what you are working on is important to the entire global community.

WHAT ARE SOME OF THE OPPORTUNITIES YOU HAVE HAD THROUGHOUT YOUR CAREER?

Some opportunities that I have had include the ability to work at jobs I enjoy, the opportunity to advance in these jobs, and most importantly to me, the opportunity to live in foreign countries with my family and travel a good bit of the globe.

ANY OTHER COMMENTS OR ADVICE FOR THOSE INTERESTED IN A CAREER LIKE YOURS?

Despite a lot of rhetoric floating around today, the oil and gas industry will be a healthy industry for many decades to come. If you are interested in working in the industry, the first key to success is education. The technologies we use are extremely sophisticated. A bachelor's degree in a technical subject related to the industry is the entry card for a successful career. Past that, creating a successful career requires a lot of flexibility. There will be a lot of moves, a lot of travel and a lot of 16-18 hour days as you build your career in the industry. In the end however, it is worth it!

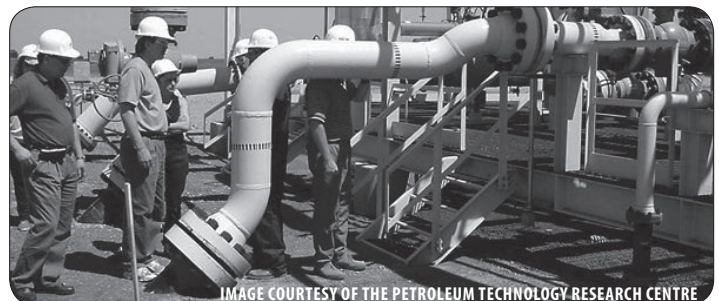


IMAGE COURTESY OF THE PETROLEUM TECHNOLOGY RESEARCH CENTRE

Some of Dr. Pike's work with NETL focuses on researching new carbon capture and storage technologies.

FORMATION

GEOLOGY

TECHNOLOGIES

CHALLENGES

EXPLORATION

CAREERS



FACTS

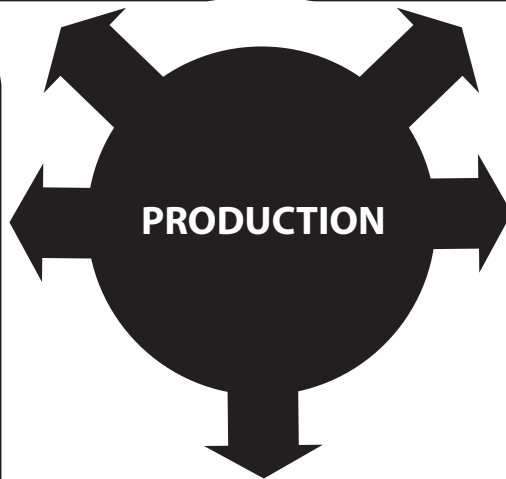
PROCESSES

TECHNOLOGIES

CHALLENGES

PRODUCTION

CAREERS



FACTS

PROCESSES

TECHNOLOGIES

CHALLENGES

REFINING

CAREERS

FACTS

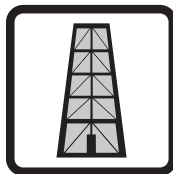
PROCESSES

TECHNOLOGIES

CHALLENGES



CAREERS



Jigsaw Role Questions and Presentation Questions

Exploration: Geologist

1. Why is an understanding of geologic and fossil fuel formation helpful in locating oil and natural gas reservoirs?
2. What geological characteristics are associated with oil and natural gas reservoirs?
3. What technologies are used to locate oil and natural gas reservoirs?
4. What types of careers are available in oil and natural gas exploration?

Production: ROVER Operator

1. What technologies are used to drill for oil and natural gas?
2. What physical characteristics of rock formations are important when drilling for oil and natural gas?
3. How does offshore drilling differ from drilling on land?
4. What types of careers are available in oil and natural gas production?

Refining: Lab Technician

1. What are the important characteristics of hydrocarbons?
2. What are the processes involved in refining crude oil?
3. What products come from refining crude oil and how are they used?
4. What types of careers are available in oil refining?

Manufacturing: Process Technician

1. What are feedstocks and how are they used?
2. What equipment and processes are involved in chemical manufacturing?
3. What are some of the important products of chemical manufacturing?
4. What types of careers are available in chemical manufacturing?

Transportation: Pipeline Inspector

1. What types of transportation are used in oil production?
2. What are the hazards of transporting petroleum and its products?
3. How are pipelines maintained?
4. What types of careers are available in petroleum transportation?

Consumer

1. What petroleum products do average Americans use every day?
2. Where does the U.S. get its crude oil?
3. What are current economic trends in the oil industry?
4. What are the environmental impacts of petroleum production and consumption?

Presentation Questions

1. What are the advantages of using petroleum?
2. What are the disadvantages of using petroleum?
3. Does the use of petroleum provide more benefits or risks to society?
4. How would a sharp increase in the price of crude oil affect the standard of living in the U.S.?
5. What can consumers do to ensure that future generations will receive the benefits of petroleum products?



INTRODUCTION ACTIVITY

Formation of Oil and Natural Gas

Activity courtesy of SPE

Oil and Natural Gas Formation

Materials

- 8 ½" x 14" Sheets of paper (one per student)
- Colored pencils and markers

Procedure

1. Divide an 8 ½-inch x 14-inch sheet of paper into three equal parts. Label the sections: Scene 1, Scene 2, and Scene 3.
2. Clear everything off of your desk except for colored pencils and the piece of paper. You will be listening to your teacher read the story and drawing your explanation.
3. Listen carefully the first time, and begin drawing the second time it is read. You may draw while you are listening or at the end of each scene.

Scene One

570 million years ago—during a period known as the “Paleozoic Era” [paley-uh-zo-ik]—a large sea covered the area we now recognize as the southern part of the United States. In this sea lived a vast number of microscopic plants and animals called plankton. This microscopic plankton drifted on or near the surface of the water and became so numerous that it could actually be seen with the naked eye. Throughout the Paleozoic Era the sea was also alive with trilobites, corals, crinoids, brachiopods, and many other plants and animals that evolved over millions of years. A trilobite was a strange-looking little creature. Small grooves divided its body and hard-segmented shell into three vertical parts. A semicircular shield covered its head. Coral, which still exists today, came in many different sizes, shapes, and colors. The coral polyps were simple animals that were able to take calcium out of saltwater and convert it into a rock-like shelter in which they lived. Crinoids anchored themselves to rocks on the sea floor with a root-like structure that supported a stalk or column topped by a cup-like cavity, which formed a protective case for a flower. Brachiopods were clam-like animals. Their two-piece dorsal and ventral shells enclosed and protected their soft body parts. Due to their ability to reproduce quickly, the plankton, along with other sea life, were abundant. As these carbon-containing organisms went through their extremely short life cycles and died, their remains sank to the deep sea floor and became covered with the mud, sand, and sediment from the eroding mountains and surrounding areas. Because they were buried so quickly on the deep sea floor, the plankton and other sea creatures lacked oxygen, which is necessary for decay or decomposition. Draw a picture that shows this scene on the first section of your paper.

Scene Two

320 million years passed, and layers of sediment on the sea floor became thousands upon thousands of feet deep. These layers were filled with dead plankton, fossilized sea creatures, and eroded rock. During the time period known as the “Mesozoic Era” [mez-uh-zo-ik], dinosaurs began to roam the Earth and swim in the sea. More than half of the great sea had disappeared because of evaporation, earthquakes, and the filling and layering of sediments on the sea floor. This heat and pressure was responsible for changing the dead organic material into hydrocarbons (substances containing hydrogen and carbon) and causing the remaining inorganic material to change into sedimentary rock. Draw a picture that shows this scene on the second section of your paper.

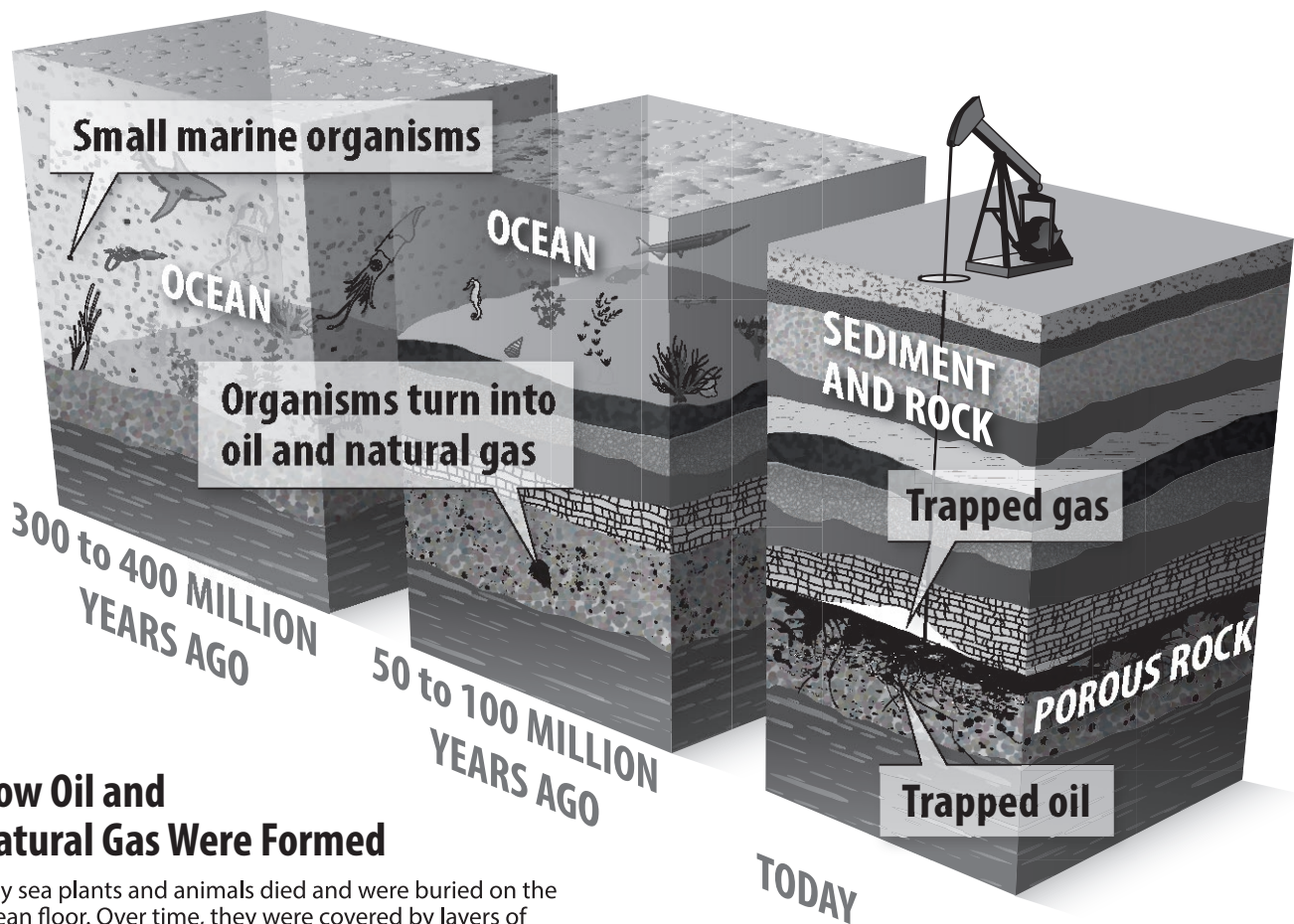
Scene Three

250 million years later brings us to present day—the “Cenozoic Era” [sen-uh-zo-ik]. People now walk the Earth and the dinosaurs have long since disappeared. Erosion and other sediments have now completely filled the ancient seas. The heat and pressure have formed many layers of sedimentary rock, and deep source rock—rock where oil and natural gas form. Much of the water that was in the sea is now in the pore spaces of the sedimentary rock. The remaining water evaporated or was pushed into areas where seas or oceans now exist. Over millions of years, temperatures ranging from 150-300 degrees Fahrenheit (66-149 degrees Celsius) have “cooked” the organic materials causing a complex chemical change, creating hydrocarbons called oil and natural gas. These hydrocarbons, also known as fossil fuels, have been discovered in many parts of the country and all over the world. Texas produces the most of these fuels. Can you picture this scene? Draw a picture that shows this scene on the third section of your paper.

As you finish the last scene, keep in mind that there are several theories concerning the formation of oil and natural gas. What you have just heard and drawn is the most widely accepted scientific theory.

Teacher Information

Oil and natural gas are often found together. Petroleum is a mixture of hundreds of different hydrocarbons. Hydrocarbons are molecules containing hydrogen and carbon—that exist sometimes as a liquid (crude oil) and sometimes as a vapor (natural gas). Natural gas can also be a mixture of hydrocarbons but is mostly methane. Hydrocarbons are typically made from the remains of tiny sea plants and animals that died and were buried on the ocean floor for hundreds of millions of years. Layer upon layer of the plant and animal remains built up. This pressure combined with heat from the Earth's processes slowly “cooked” the plant and animal remains into hydrocarbons. These hydrocarbons flowed into empty spaces in the surrounding rocks, called traps. Finally, an oil-soaked rock—much like a wet sponge—was formed. The traps were covered with a layer of solid rock, or a seal of salt or clay, that kept the oil and gas from escaping to the surface. Crude oil is held inside the rock formation, similar to how a sponge holds water.



How Oil and Natural Gas Were Formed

Tiny sea plants and animals died and were buried on the ocean floor. Over time, they were covered by layers of sediment and rock.

Over hundreds of millions of years, the remains were buried deeper and deeper. The enormous heat and pressure turned them into oil and gas.

Today, we drill down through the layers of sedimentary rock to reach the rock formations that contain oil and gas deposits.



EXPLORATION ACTIVITY

Exploring Sound Waves

Question

How do sound waves travel?

Hypothesis

Draft a hypothesis to answer the question using an “If...then...because...” format.

Materials

- Metal slinky spring
- Large foam cup
- Small foam cup

Procedure *LONGITUDINAL WAVES*

1. Place the slinky on the floor so the coils are all together facing up. Place the large foam cup inside of the slinky coils and press in gently.
2. Lift the cup straight up. The end coils should come up around the center of the cup.
3. Place your hand around a few coils in the cup's middle to hold the slinky in place.
4. Bounce your hand up and down to create longitudinal waves and observe the sound vibrations echoing from the cup.
5. Repeat your hand motions at different heights—low and high—to hear the different sound vibrations and see the longitudinal waves produced.
6. Remove the large cup and repeat the investigation with the small cup.

Conclusions

1. Was there a difference in longitudinal waves produced from the trials at different heights? Describe.

2. What was the difference in the two sounds you heard from the two different cups?

3. Sound waves and seismic waves are both longitudinal waves. Explain how you think seismic technology might be helpful to locate specific geologic formations underground.



EXPLORATION ACTIVITY

Exploring Core Sampling

Question

Are all core samples the same?

Hypothesis

Draft a hypothesis to answer the question using an “If...then...because...” format.

Materials

- 4 Colors of sand
- 1 Clear plastic straw per student
- 1 Opaque cup per student (bathroom size)
- Water in a spray bottle
- Plastic spoons
- Ruler
- Small gravel (optional)

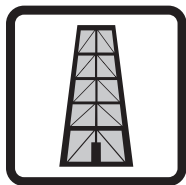
NOTE: When layering the sand in cups, you can arrange the colors in any order.

Procedure

1. Using the ruler to measure, place a 1 cm layer of one of the sand colors in the cup with a spoon. Mist with the spray bottle of water until damp, but not soaking.
2. Place another colored layer on top of the first layer. Mist with water until damp.
3. Continue alternating layers of sand and water. The total height of the layers stacked in the cup should be at least 4 cm deep.
4. Trade cups with someone else so you are not pulling a core sample from your own cup.
5. Use a straw to extract a core sample by pushing the straw straight down through the layers in the cup.
6. Place your finger tightly over the top end of the straw and withdraw it from the cup. Observe the layers in the straw core sample.
7. Lay several core samples from different cups side by side. Compare results.

Conclusions

1. What are core samples?
2. Did you encounter any challenges when pulling up your core sample? If so, what was the challenge? How does this relate to real world drilling?
3. What are petroleum geologists looking for when they examine core samples?
4. What about your core sample might be similar or different from an actual core sample?



PRODUCTION ACTIVITY

Understanding Density

Question

Do all liquids have the same densities?

Hypothesis

Draft a hypothesis to answer the question using an "If...then...because..." format.

Materials

- 100 mL Graduated cylinder
- 600 mL Beaker
- Corn syrup
- Water, dyed with food coloring
- Vegetable oil
- Plastic button
- Grape
- Small cork
- Penny
- Glass marble
- Wooden bead
- Ice cube

Procedure

1. Pour 100 mL each of corn syrup, vegetable oil, and water into the beaker.
2. Let the liquids settle for a few minutes. Observe what happens.
3. One at a time, gently drop each object into the container.
4. Observe where the objects settle.

Conclusions

1. What did you learn about the densities of liquids?
2. What did you learn about the densities of objects?

Extension

ELEMENT	DENSITY AT 20 °C
Hydrogen	0.00008 g/cm ³
Carbon	2.25 g/cm ³
Oxygen	.00131 g/cm ³
Sodium	0.97 g/cm ³
Chlorine	.00295 g/cm ³
Calcium	1.54 g/cm ³
Zinc	7.14 g/cm ³
Bromine	3.12 g/cm ³
Gold	19.32 g/cm ³

Density is defined as mass per unit volume ($D = m/v$). The density of water is the standard at 1.00 g/cm³. Discuss the densities of the elements in the chart above. Use the formula for density to calculate the following densities:

- 1000 cm³ of oil with a mass of 881 g: _____
- 100 cm³ of aluminum with a mass of 270 g: _____
- 10 cm³ of copper with a mass of 89.3 g: _____
- 200 cm³ of nickel with a mass of 1780 g: _____



Exploring Porosity

Questions

Which size gravel will have the greatest porosity? Why is this?

Hypothesis

Draft a hypothesis to answer the questions using an “If...then...because...” format.

Materials

- 350 cm³ Large gravel
- 350 cm³ Medium gravel
- 350 cm³ Small gravel
- Water (can be dyed with food coloring to enhance activity)
- 3 600 mL Beakers
- 100 mL Graduated cylinder

Procedure

1. Fill one beaker to the 350 cm³ mark with the large gravel. Fill the second beaker with 350 cm³ of medium gravel. Lastly, fill the third beaker with 350 cm³ of small gravel (Remember, one cm³ is equal to one mL).
2. Fill the graduated cylinder with 100 mL of water.
3. Slowly pour water into the first beaker until the water reaches the top of the rocks. Record exactly how much water you poured into the beaker. If you need more than 100 mL of water, fill the graduated cylinder again.
4. Follow Step 3 again for the other two beakers filled with gravel.
5. Calculate the porosity of the three materials using this formula:

$$\text{Porosity} = \frac{\text{Volume of Water}}{\text{Volume of Material}} \times 100$$

TYPE OF MATERIAL	VOLUME (mL) OF WATER POURED	VOLUME (cm ³) OF MATERIAL	PERCENTAGE OF PORE SPACE IN MATERIAL
Large gravel			
Medium gravel			
Small gravel			

Conclusions

1. Which size of gravel has the greatest porosity? Explain why.

2. Explain porosity's importance in determining the best location for an oil well.



PRODUCTION ACTIVITY

Getting the Oil Out

Activity courtesy of SPE

Background

Artificial lifting systems, or pumping units, are used to help pull the oil out of the reservoir rock and pump it up the well. A down hole pump in the well is connected to the pumping unit by steel rods, which are screwed together. The pump is activated from the up and down movement of the pumping unit on the surface. As the pump plunges down, fluid from the rock formation flows into the pump chamber. On the upstroke, the fluid in the chamber is forced up the tubing, to the surface.

Question

Will it be easier to bring up liquid with a long tubing system, or a short tubing system?

Hypothesis

Draft a hypothesis to answer the question using an "If...then...because..." format.

Materials FOR EACH STUDENT OR PAIR

- 8-10 Drinking straws
- Masking tape
- Scissors
- Ruler
- Carton of chocolate milk or dark-colored, low viscosity beverage (that can be seen through the straw)

Procedure

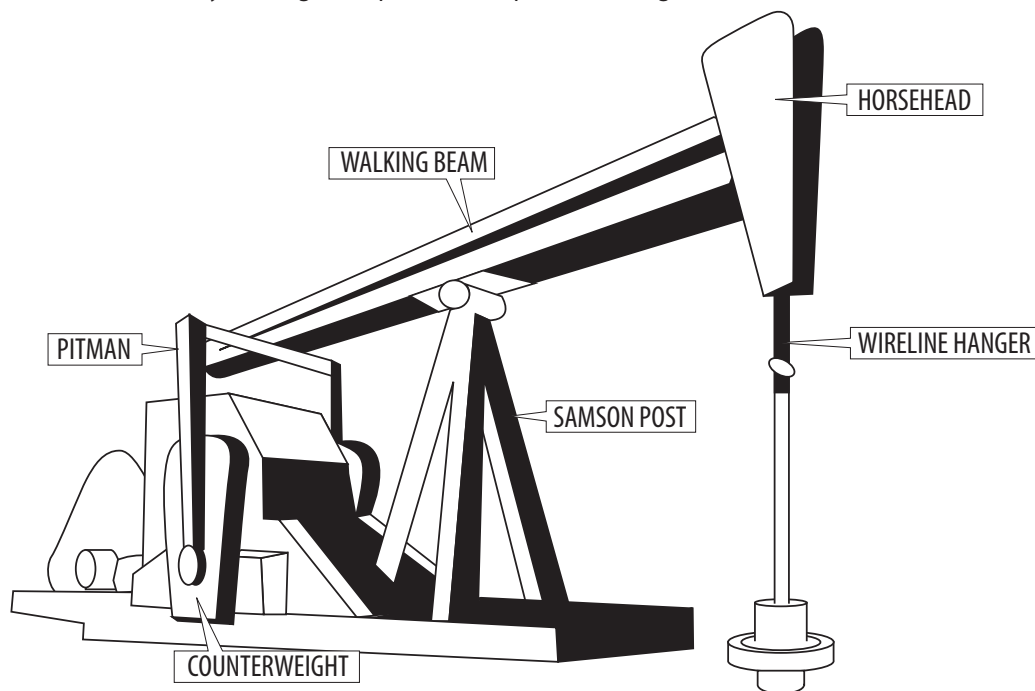
1. Using the scissors, cut a 1 cm slit at one end of each straw.
2. Join the straws end to end to form one long tube. Place the slit end of the straw into the inside of the adjoining straw.
3. Place masking tape over each connected end to secure the joint and create an air tight seal.
4. Place beverage on the floor. One member of the group stands up and inserts the extended straw "tubing" into the beverage trying to bring the liquid to the top of the "tubing" using his/her suction.
5. Now, decrease the number of straws used for the "tubing" by cutting off one straw. The same student tries to bring the liquid to the top.
6. Continue cutting off one straw at a time. After each cut try to bring the liquid to the top of the tubing.

** Conclusions

1. Which length of straw required the most effort to bring the liquid to the top? Which length of straw required the least effort to bring the liquid to the top? Explain why.

Extensions

- Try to pull up liquids of different viscosities and densities.
- Try using straws of different diameters to make your tubing.
- Study the diagram of the artificial lift system. Use the diagram to estimate how the system works to retrieve oil. Record your thoughts in your notebook. Using the *Oil and Natural Gas* book by the Society of Petroleum Engineers, or internet sources, research how a horsehead pump actually works.





REFINING ACTIVITY

Refinery Maze

Background

After crude oil is brought to the surface, it is transported in order to be separated into its many products. The first step to separating the crude oil into its components is distillation. This takes place in a refinery where a fractional distillation tower, or fractioning tower, is used to separate the products by boiling them. The crude oil is pumped into the tower and heated. Parts of the crude oil mixture turn into gases as the crude boils. The bottom of the tower is very hot, while the top of the tower is allowed to be much cooler. The gas molecules of the crude oil move up the tower based on their boiling points. Larger molecules with higher boiling points and higher densities will collect at the bottom, while smaller molecules with lower boiling points and lower densities will try to push their way to the top. As gas molecules meet an area of the tower that is cooler than their boiling temperature, these gases will condense. There are plates staged throughout the tower that the gases condense onto and then are pumped out of the tower with the materials of similar molecular makeup. Each material can then be further processed into other products. This game enables students to visualize how larger molecules are trapped in certain areas while smaller, lighter molecules can move higher in the tower for separation.

Question

How are different products made from crude oil?

Materials FOR THE TEACHER

- Enough quarters, nickels, pennies, and dimes for the class
- Straws or pipe cleaners (optional)
- Scissors and glue (optional)
- *Refinery Maze Game Board*, page 47
- *Fractional Distillation* master, page 49

Preparation

- Make copies of the game board for each student or group.
- Make a copy of the *Fractional Distillation* master to project for the class.
- Gather enough coins so that each student or group has one of each type of coin.

Procedure

1. Observe the coins and explain or identify the physical characteristics that are different about each coin.
2. Review the process of distillation using the background above, or pages 20-21 of the *Fossil Fuels to Products* informational text.
3. Pretend each coin is a hydrocarbon molecule found in a mixture of crude oil. The coins will all enter the fractioning tower for processing together. They will then move through the tower, attempting to get as high as they may travel in the tower before being pumped out.

OPTIONAL: Cut straws or pipe cleaners and glue them onto the borders (plates) of the game board to create more rigid borders on which the “molecules” can condense. This ensures coins are not squeezed higher than intended. Be sure students match the edges of all borders and black lines as exactly as possible.

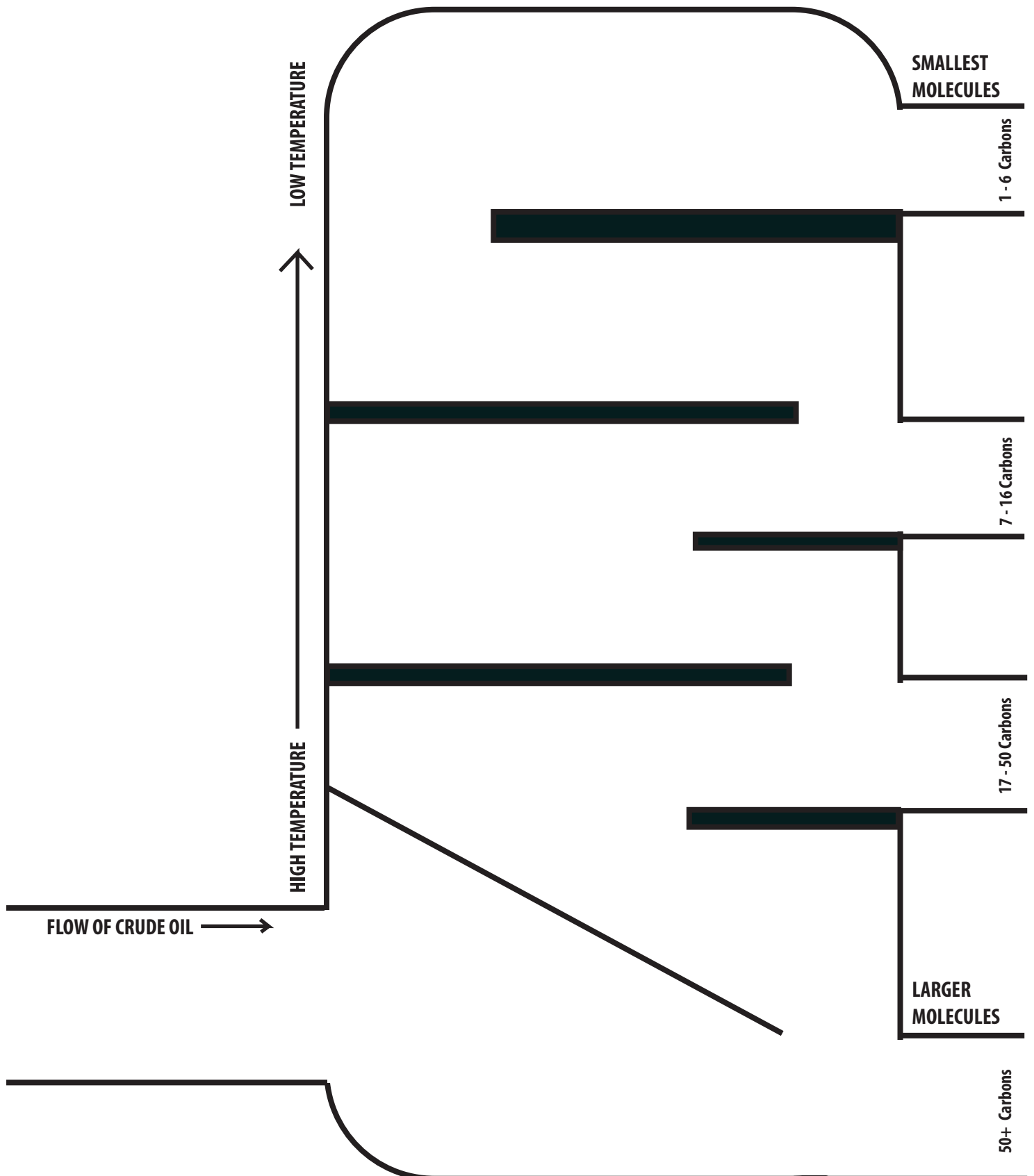
4. Look at the *Fractional Distillation* master. Review the process of fractional distillation. Identify which coins might represent certain petroleum products. How does this game board differ from an actual tower? How might you redesign the board to be a better model of the technology and process?

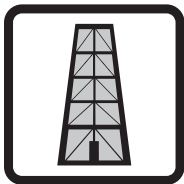
Extensions

- Provide students with a game board that does not have the levels or molecule information (use white-out). Have students construct their own model of the tower prior to playing the game. Have them compare their tower to the game board after learning about the process. What are the successes and challenges with each version?
- Have students redesign the game board to more closely represent the processes used at a refinery.
- Have students create a life-sized demonstration of this concept using props.
- Calculate the densities of each of the coins. Ask students to explain why the coins are both a good prop and a poor prop to use in this model of distillation.



Refinery Maze Game Board





REFINING ACTIVITY

Distillation Products

Question

What products are made from crude oil?

Materials

- Projector
- White board
- Cardstock
- Internet access (optional)
- *Fractional Distillation* master, page 49
- *Refinery Product Cards*, page 50

Preparation (FOR THE TEACHER)

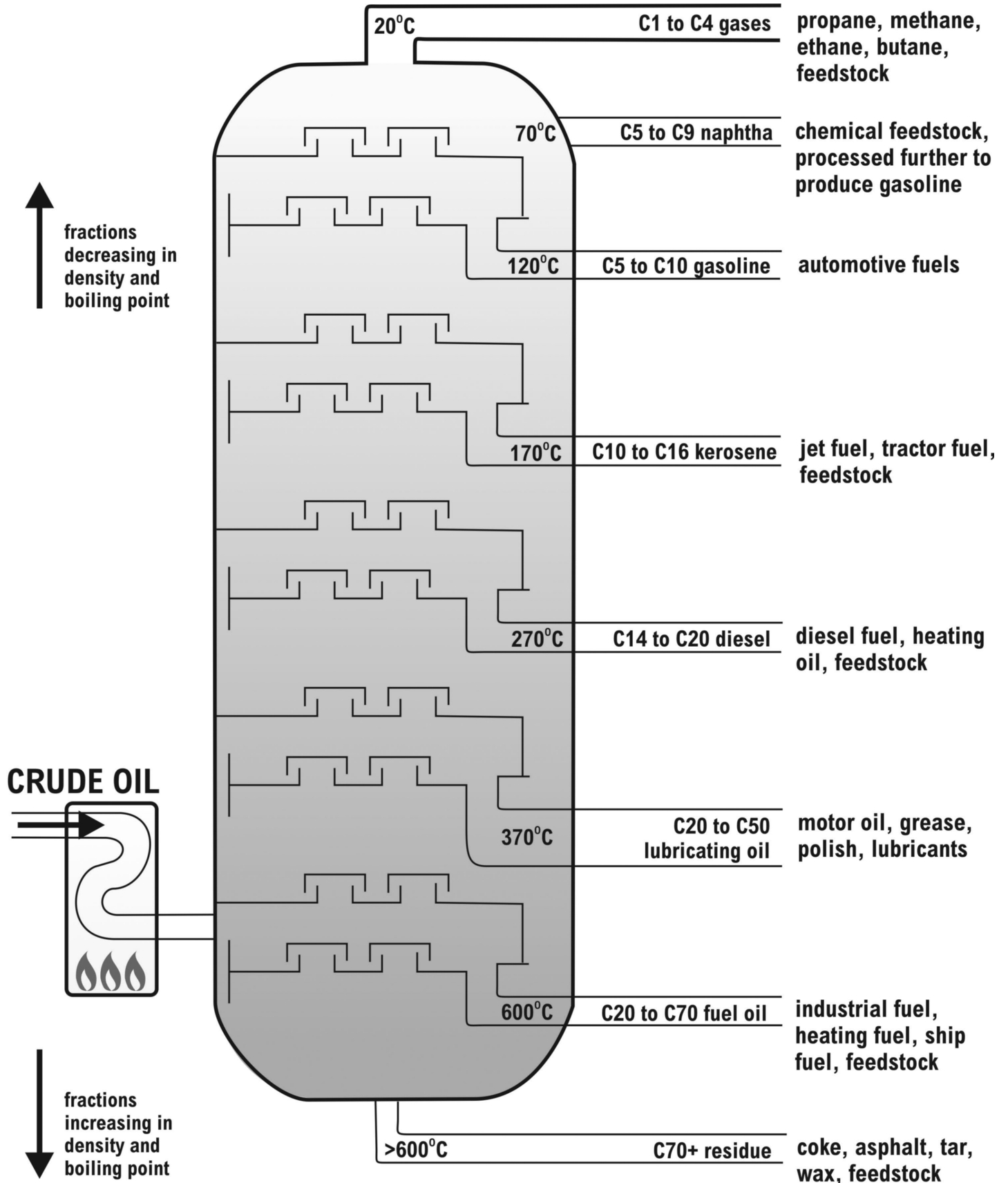
- Make a master of the *Fractional Distillation* graphic that you can share with your class using an LCD or overhead projector.
- Copy the *Refinery Product Cards* on cardstock and cut out each product. Hand a card to each student.
- Draw or display a thermometer on the board with a range of 0 to 700°C.

Procedure

1. Look at your *Refinery Product Card*. Write any uses, important facts, and the importance of the product on the back of the card.
2. Look at the *Fractional Distillation* master. Find your product on the graphic and note the boiling point.
3. Note that the density of the products increases as the number of carbon atoms in the products increases.
4. This activity involves heating crude oil as shown on the diagram and thermometer on the board. As the temperature of the crude oil decreases by 10°C at a time, hold up your hand as your product is separated out from the crude oil.
5. Stand up and tell the class the uses and important facts about your product.

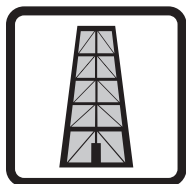


Fractional Distillation



Refinery Product Cards

propane	jet fuel	industrial fuel oil
methane	tractor fuel	heating fuel oil
ethane	kerosene	feedstock from fuel oil
butane	feedstock from kerosene	coke
petroleum gas feedstock	diesel fuel	asphalt
chemical feedstock	heating oil	tar
gasoline from processed naphtha	feedstock from diesel	wax
high octane gasoline	motor oil	feedstock from residue
mid octane gasoline	grease	fuel for ships
regular octane gasoline	lubricants	shoe polish



REFINING ACTIVITY

The Refining Process

Question

How can different products be separated out of one solution?

Hypothesis

Draft a hypothesis to answer the question using an "If...then...because..." format.

Materials

- 400 mL 2% Milk
- 100 mL Vinegar
- Saucepan
- Wooden spoon
- Hot plate
- Pot holder
- Safety glasses

Safety

This activity or demonstration uses a hot plate and liquid that will become hot. Review safety guidelines, and remember - do not touch the hot plate, even after it is turned off. Everyone should wear safety glasses to protect themselves against potential spatter.

Procedure

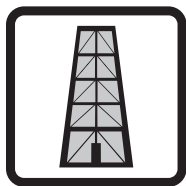
1. This activity uses a solution of milk and vinegar as a model for crude oil.
2. Brainstorm products that are made from milk. Do you know how those products are made? What do you think we do with milk to make most of these items?
3. Turn on the hot plate. Pour in the milk and vinegar into the saucepan. Stir until the substances have separated into curds and whey. (Approximately 1-3 minutes.)

Conclusions

1. What caused the milk solution to change forms and separate?

2. Explain how the milk solution is like crude oil during the refining process.

3. How does the oil and gas industry use this science in the refining process?



Polymers

Background

During fractional distillation crude oil is separated into useful parts. A petrochemical is a product of the fractional distillation process. Usually consisting of long chains, a monomer is a link in the chain. All of the monomer links connected together make a polymer chain.

Chemically bonded monomers form polymers in a process called polymerization. Polymers created from petrochemicals are synthetic or man-made polymers. We use many of these polymers, such as plastics, everyday.

Polymer One

Questions

- How do polymers behave?
- Do they have the same properties?

Materials

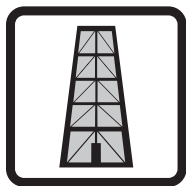
- Cornstarch
- Water
- Sealable plastic sandwich bags
- Measuring spoons
- Food coloring
- Paper plates

Procedure

1. Put 6 tablespoons of cornstarch in a plastic bag.
2. Add 5 drops of food coloring.
3. Add 4 tablespoons of water.
4. Close the bag and mix together by kneading.
5. If the polymer seems too runny (you cannot pick it up), add a spoonful of cornstarch to thicken. If the polymer seems too thick or crumbly (dry), add a spoonful of water to make it thinner.
6. Open the bag and pour the polymer onto the plate.
7. Use your finger to gently poke the polymer. What happens?
8. Now quickly poke the polymer. What happens?
9. Pick the polymer up. What happens?
10. Roll the polymer in a ball. What happens?

**** Conclusion**

1. Is this polymer a liquid or a solid? Explain.



Polymers

Polymer Two

Questions

- How do polymers behave?
- Do they have the same properties?

Materials

- White glue
- Borax
- Water
- Spoon or popsicle stick to stir
- Small paper cups
- Food coloring
- Graduated cylinder
- Ruler
- Sealable plastic sandwich bags

Preparation

- Your teacher may have pre-prepared a borax solution. If not, prepare a borax solution: about 6 mL of borax to 235 mL of water.

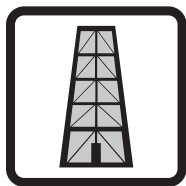
Procedure

1. Use the ruler to measure and mark 1 cm from the bottom of the small paper cup.
2. Add white glue to the 1 cm mark.
3. Add a few drops of food coloring and mix.
4. Measure 7 mL of water in the graduated cylinder and add to the glue. Mix well and pour into a plastic bag.
5. Measure 8 mL of the borax solution using the graduated cylinder and add it to the glue solution in the plastic bag. Mix well by kneading.
6. If it is too sticky, add borax solution one drop at a time. If it is too stringy, add glue one drop at a time.
7. Once the polymer is formed, you may remove it from the cup and knead it.
8. Pull your polymer apart, string it out, twist it, and roll it into a ball.
9. Write your observations about your polymer.

**** Conclusions**

1. What happened when you combined the glue solution and the borax solution?

2. Explain how this is a polymer.



CHEMICAL MANUFACTURING ACTIVITY

Slush Powder

Vocabulary

Polymer: a large organic molecule formed by combining many smaller molecules (monomers) in a regular pattern.

Monomer: a molecule that can combine with other molecules to form a polymer.

Dissociate: to split into simpler groups of atoms, single atoms, or ions.

Background

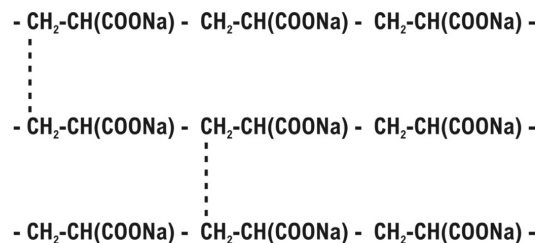
The chemical name for slush powder is sodium polyacrylate. It is a polymer containing many repeating molecules called acrylate monomers connected end-to-end in a large chain. Sodium acrylate is a chain made of carbon, oxygen, hydrogen, and sodium. Cross-links between the sodium acrylate chains (-----) tether the chains together into sodium polyacrylate. These repeating molecules can be thousands to millions of units long.

Sodium polyacrylate, nicknamed the “super slurper,” is called a superabsorber because it has the ability to absorb large quantities of water. It can absorb 400-800 times its mass in water, but does not dissolve into a solution because of its three-dimensional network structure. Its liquid-like properties result from the fact that the polymer is composed almost entirely of water. Its solid-like properties are due to the network formed by the cross-links.

Sodium polyacrylate is called a hydrophilic or “water-loving” polymer because of its great affinity for water. So how does this polymer work? In its dry powdered state, the chains of the polymer are coiled and lined with carboxyl groups (–COOH). When water is added, the carboxyl groups dissociate into negatively charged carboxylate ions (COO^{-1}). These ions repel one another along the polymer chain, widening the polymer coils and allowing water to move into contact with more carboxyl groups. As the polymer continues to uncoil, it becomes a gel.

Sodium polyacrylate is used as an absorbent material in disposable diapers and to retain water around plants. It is considered non-toxic, but inhalation of airborne particles of the powder or contact with the eye can cause serious adverse reactions. It is for this reason that using a disposable diaper to obtain the powder is discouraged.

To dispose of the gel, add salt. The presence of salt in the solution greatly decreases the ability of the polyacrylate to absorb and retain water. Once the gel has liquefied, it can be safely poured down a drain.



Materials

- Sodium polyacrylate
- 400 mL Beaker
- 100 mL Beaker
- Water
- Salt (optional)

Procedure

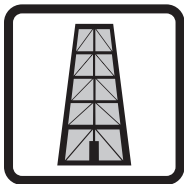
1. Place 1 cc (mL) of sodium polyacrylate in the 400 mL beaker.
2. Add 10 mL of water to the beaker. Observe.
3. Continue adding water 10 mL of water at a time until the sodium polyacrylate absorbs no more water.

Conclusions

1. Describe what happened to the polymer as you added water.
2. Why does the polymer stop absorbing water?
3. Explain how polymers like this one fit into the refining process.

Extension

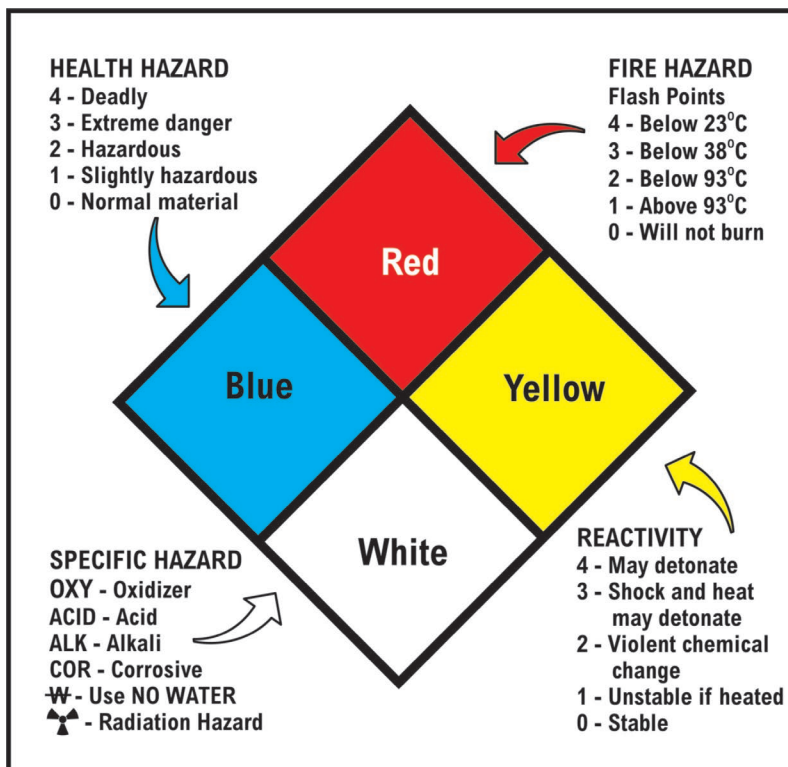
- Experiment with varying strengths of saltwater solution to determine how much a given amount of sodium polyacrylate can absorb. Use a one percent saltwater solution for this experiment. Diapers are known to trap or retain urine. Urine is approximately one percent saline (4.5 mL of salt to 1 liter of water).



CHEMICAL MANUFACTURING ACTIVITY

Chemical Hazard Placards

Chemical hazard placards are placed on laboratories and rooms in which specific chemicals are used and stored to let safety personnel know of the dangers. They are also used on vehicles that transport chemicals. The placards have four squares—three colored squares and one open square that represent different types of hazards. The levels of the hazards are written in the squares, as defined in the placard below.



Defining Terms

Define the following words using the *Fossil Fuels to Products Glossary*, a textbook, or a dictionary:

Acid:

Alkali:

Corrosive:

Detonate:

Oxidizer:

Unstable:

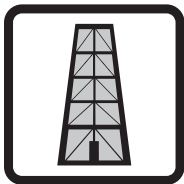
Temperature Conversions

Convert the flash points on the Fire Hazards from Celsius to Fahrenheit using the formula: $F = \frac{9}{5} C + 32$

23°C =

38°C =

93°C =



CHEMICAL MANUFACTURING ACTIVITY

Identifying Chemical Hazard Placards

Below are six chemical hazard placards and six descriptions of different chemicals. Read the chemical descriptions and match each chemical to its chemical hazard placard.

_____ **CALCIUM** is a silvery, moderately hard, metallic element that constitutes about three percent of the Earth's crust and is a basic component of most animals and plants. It occurs naturally in limestone, gypsum, and fluorite, and its compounds are used to make plaster, quicklime, Portland cement, and metallurgic and electronic materials. It can be slightly hazardous to human health, and is slightly flammable. It can produce a violent reaction when it comes into contact with water.

Physical State: solid **Boiling Point:** 1,487°C **Appearance:** silver-white **Odor:** odorless

_____ **METHANE**, CH₄, is an odorless, colorless, flammable gas that is the major constituent of natural gas. It is used as a fuel and is an important source of hydrogen and a wide variety of organic compounds. It is hazardous to human health and is an extreme fire hazard. It is a stable gas.

Physical State: gas **Flash Point:** -188°C **Appearance:** colorless **Odor:** odorless

_____ **BENZENE** is a colorless, very flammable, toxic, liquid, aromatic hydrocarbon, C₆H₆, derived from petroleum and used in or to manufacture a wide variety of chemical products, including solvents, detergents, insecticides, and motor fuels. It can be hazardous to human health. It is a stable compound.

Physical State: liquid **Boiling Point:** 80°C **Appearance:** colorless **Odor:** gasoline-like

_____ **BUTANE** is either of two isomers of a gaseous hydrocarbon, C₄H₁₀, produced from petroleum and used as a household fuel, refrigerant, aerosol propellant, and in the manufacture of synthetic rubber. It can be slightly hazardous to human health and is an extreme fire hazard. It is a stable compound.

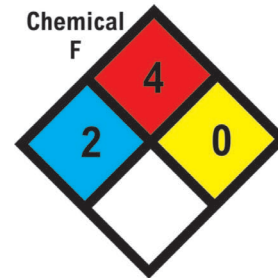
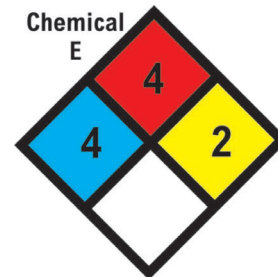
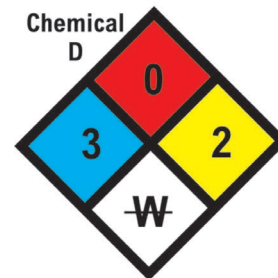
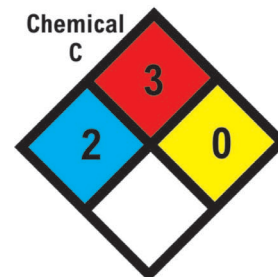
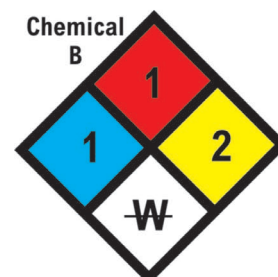
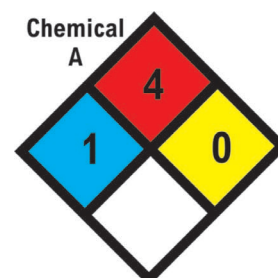
Physical State: gas **Flash Point:** -76°C **Appearance:** colorless **Odor:** faint, disagreeable

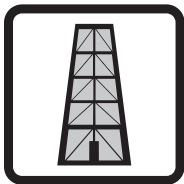
_____ **SULFURIC ACID** is a highly corrosive, dense, colorless, oily liquid, H₂SO₄, used to manufacture a wide variety of chemicals and materials including fertilizers, paints, detergents, and explosives. It can pose an extreme danger to human health and is unstable, capable of causing violent chemical change. Reacts violently with water.

Physical State: liquid **Boiling Point:** 290°C **Appearance:** colorless **Odor:** sulfurous

_____ **PHOSPHORUS** is a highly reactive, deadly poisonous, nonmetallic element occurring naturally in phosphates. It is used in safety matches, pyrotechnics, fertilizers, and to protect metal surfaces from corrosion. It is extremely flammable and is unstable, capable of violent chemical change.

Physical State: solid **Boiling Point:** 280°C **Appearance:** white-to-yellow **Odor:** odorless

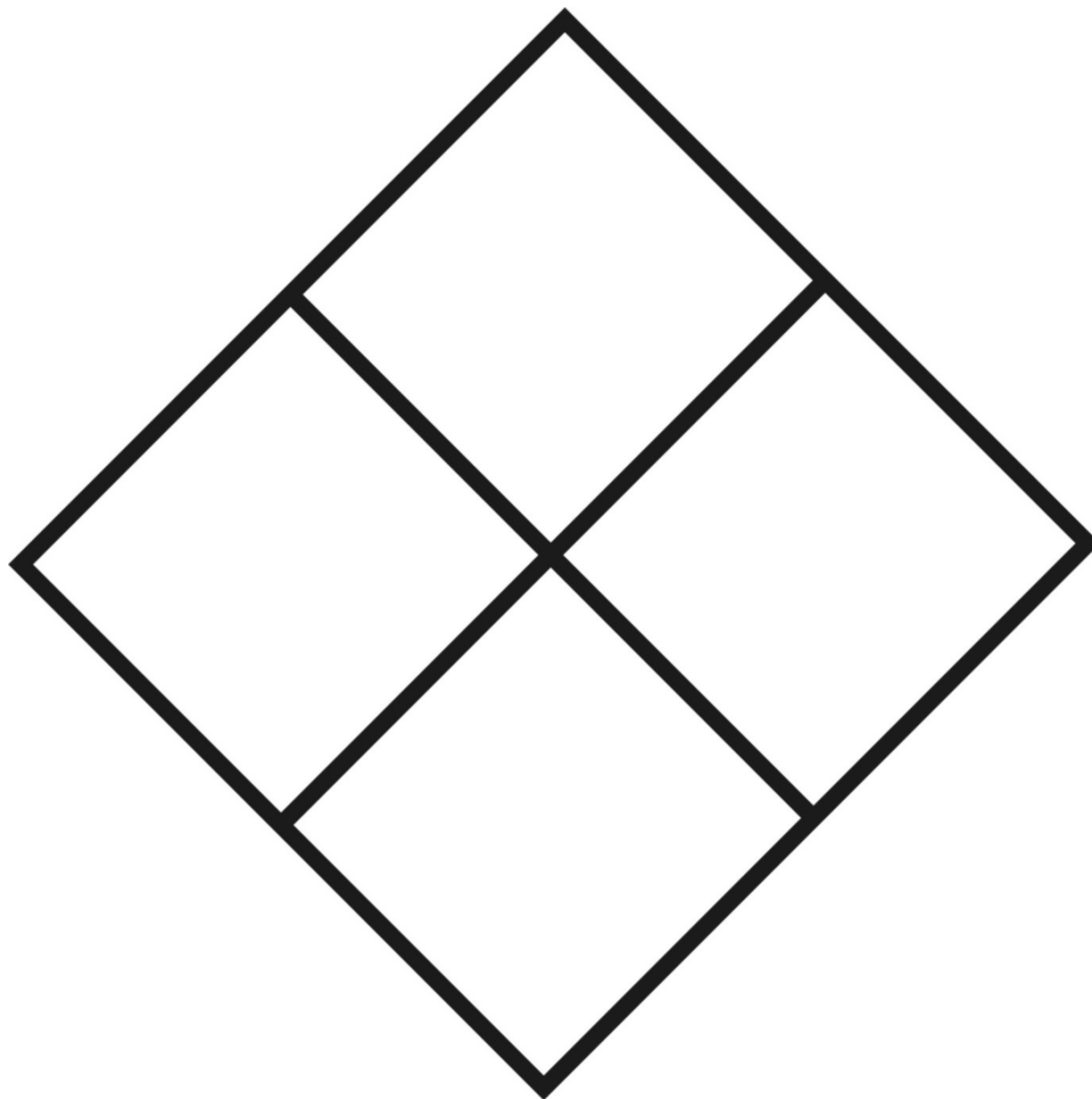




CHEMICAL MANUFACTURING ACTIVITY

Make a Chemical Hazard Placard

Make your own chemical hazard placard. Choose a chemical you've heard about and research its characteristics and uses, then draw a placard for the chemical using the blank placard below. Display your placard and tell your classmates about the characteristics and uses of your chemical.



Chemical:

Chemical Formula:

Characteristics:

Uses:



TRANSPORTATION ACTIVITY

Pretzel Power Teacher Instructions

Background

Oil and natural gas are widely used as transportation fuels. Most of our cars run on petroleum. Some vehicles are more efficient than others and allow us to go farther with less fuel while being kind to the environment.

Objective

- Students will be able to define “miles per gallon” and explain why this rating is important.

Materials

- 3” x 5” Cards
- Internet access for students (see optional note below)
- Bag of pretzels
- Plastic sandwich bags
- Three signs (Home, Near Town, Far Town)

Preparation

- Prepare a plastic bag with ten pretzels for each student.
- Make three signs, one labeled “Home”, one labeled “Near Town”, and one labeled “Far Town.” The signs should be large enough to see from across the room.
- Select a large area and place the Home, Near Town, and Far Town signs on poles or walls. The distance from Home to Near Town should be 50 steps. The distance from Home to Far Town should be 100 steps. (Do not give these distances to students.)

Procedure

1. Have students look up a car they would like to drive on www.fueleconomy.gov. On 3” x 5” cards, students should record the car’s name, model year, miles per gallon, and the number of passengers the car holds. If students are selecting a vehicle that operates on flex-fuel (FFV), have them select the fuel they will use - gasoline or E-85 - prior to recording mileage ratings and game play.

OPTIONAL: If you would prefer, you can use the pre-made automobile cards on pages 59-71. If you would like to print the cards on adhesive labels use Avery 5392. When handing out cards for vehicles using a Flex Fuel, instruct them to pick or assign the fuel choice to students.

2. Distribute a bag of pretzels to each student. Tell students not to eat the pretzels until they are instructed to begin.
3. Explain to the students that each pretzel represents one gallon of gasoline, and each step (heel-to-toe) the student takes represents one mile traveled.
4. Students eat a pretzel and take the appropriate number of steps before eating the next pretzel. All steps are heel-to-toe.

Round One

- Use only 5 pretzels for this round. Each person will drive his/her car to work in Near Town and return Home. If anyone runs out of fuel (pretzels), he/she must stay at that point until round one is over. Line up at Home and start stepping!

DISCUSS: Which cars got you to work and home? Which didn’t?

- Did anyone have extra fuel remaining?
- What alternatives to driving your own car are there?

Round Two

- Use the remaining five pretzels and try some of the alternative suggestions discussed above. Everyone will travel to Far Town and return Home. Expect “negotiations”. Suggest students carpool to work. Drivers may eat each passenger’s pretzels as fuel. Line up at Home and start stepping!

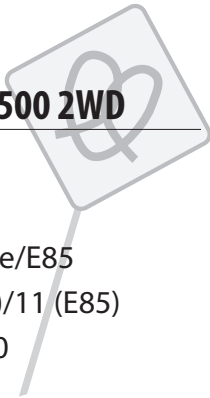
DISCUSS: Who made it to Far Town and back? How did you do this?

- Who did not make it to Far Town and back? Why not?

NOTE: If using pre-made cards, some of the vehicles use flex-fuel blends. These run on gasoline blended with higher amounts of ethanol than regular gasoline. E-85, for example, is a blend of 15 percent gasoline and 85 percent ethanol.

2006 Chevrolet Suburban 1500 2WD

CLASS	SUV
NUMBER OF PASSENGERS	7
FUEL	Gasoline/E85
COMBINED MPG	14 (gas)/11 (E85)
MAXIMUM RANGE	430/340



2007 Honda Accord

CLASS	Midsize
NUMBER OF PASSENGERS	5
FUEL	Gasoline
COMBINED MPG	25
MAXIMUM RANGE	428



2006 Dodge Caravan

CLASS	Minivan
NUMBER OF PASSENGERS	7
FUEL	Gasoline
COMBINED MPG	20
MAXIMUM RANGE	400



2007 Hyundai Santa Fe 2WD

CLASS	SUV
NUMBER OF PASSENGERS	5
FUEL	Gasoline
COMBINED MPG	21
MAXIMUM RANGE	416



2006 Ford Focus

CLASS	Compact
NUMBER OF PASSENGERS	4
FUEL	Gasoline
COMBINED MPG	25
MAXIMUM RANGE	350



2008 Ford Escape Hybrid 4WD

CLASS	SUV
NUMBER OF PASSENGERS	5
FUEL	Hybrid
COMBINED MPG	28
MAXIMUM RANGE	420



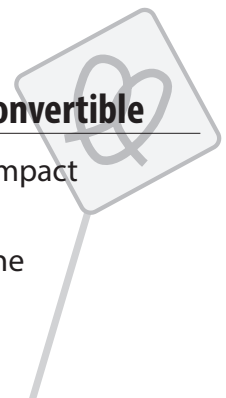
2007 Toyota Camry

CLASS	Midsize
NUMBER OF PASSENGERS	5
FUEL	Gasoline
COMBINED MPG	24
MAXIMUM RANGE	444



2008 BMW 335ci Manual Convertible

CLASS	Subcompact
NUMBER OF PASSENGERS	4
FUEL	Gasoline
COMBINED MPG	20
MAXIMUM RANGE	322



2008 Cadillac Escalade AWD

CLASS	SUV 4WD
NUMBER OF PASSENGERS	8
FUEL	Gasoline
COMBINED MPG	14
MAXIMUM RANGE	364



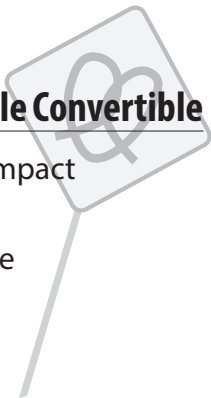
2009 Jeep Liberty 2WD

CLASS	SUV 2WD
NUMBER OF PASSENGERS	5
FUEL	Gasoline
COMBINED MPG	18
MAXIMUM RANGE	351



2008 Volkswagen New Beetle Convertible

CLASS	Minicompact
NUMBER OF PASSENGERS	4
FUEL	Gasoline
COMBINED MPG	23
MAXIMUM RANGE	334



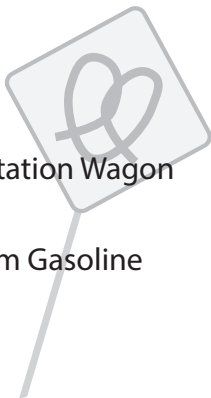
2009 Saturn Vue Hybrid

CLASS	SUV 2WD
NUMBER OF PASSENGERS	5
FUEL	Hybrid
COMBINED MPG	28
MAXIMUM RANGE	504



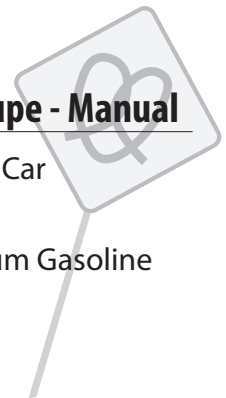
2008 Volvo V50 AWD

CLASS	Small Station Wagon
NUMBER OF PASSENGERS	5
FUEL	Premium Gasoline
COMBINED MPG	21
MAXIMUM RANGE	332



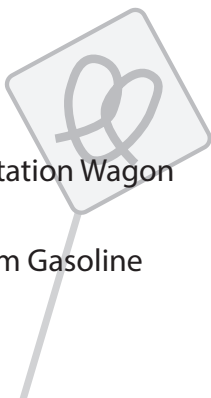
2009 Aston Martin DBS Coupe - Manual

CLASS	Sports Car
NUMBER OF PASSENGERS	2
FUEL	Premium Gasoline
COMBINED MPG	13
MAXIMUM RANGE	266



2009 Dodge Caliber

CLASS	Small Station Wagon
NUMBER OF PASSENGERS	5
FUEL	Premium Gasoline
COMBINED MPG	22
MAXIMUM RANGE	299



2009 Nissan Xterra 4WD

CLASS	SUV 4WD
NUMBER OF PASSENGERS	5
FUEL	Gasoline
COMBINED MPG	17
MAXIMUM RANGE	359



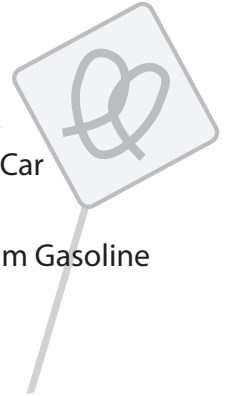
2010 Acura RL

CLASS	Midsize
NUMBER OF PASSENGERS	5
FUEL	Gasoline
COMBINED MPG	18
MAXIMUM RANGE	349



2010 Dodge Viper Coupe

CLASS	Sports Car
NUMBER OF PASSENGERS	2
FUEL	Premium Gasoline
COMBINED MPG	16
MAXIMUM RANGE	256



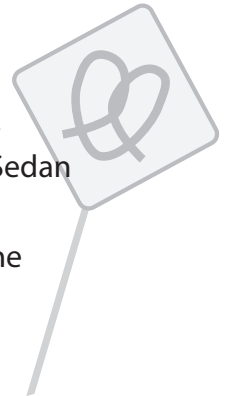
2010 Bentley Continental GT

CLASS	Luxury Compact
NUMBER OF PASSENGERS	4
FUEL	Gasoline
COMBINED MPG	13
MAXIMUM RANGE	309



2010 Ford Taurus FWD

CLASS	Large Sedan
NUMBER OF PASSENGERS	5
FUEL	Gasoline
COMBINED MPG	22
MAXIMUM RANGE	418



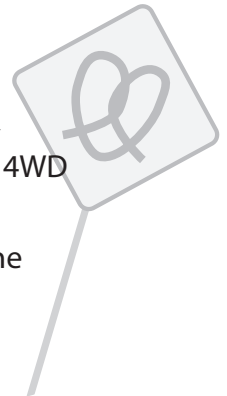
2010 Buick Lucerne FFV

CLASS	Large Sedan
NUMBER OF PASSENGERS	5
FUEL	Gasoline/E85
COMBINED MPG	20 (gas)/15 (E85)
MAXIMUM RANGE	370/278



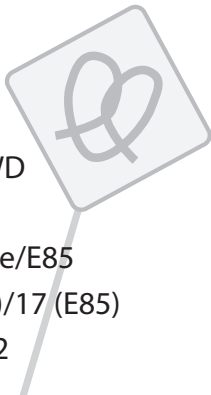
2010 Hummer H3T4WD

CLASS	Pickup 4WD
NUMBER OF PASSENGERS	5
FUEL	Gasoline
COMBINED MPG	16
MAXIMUM RANGE	432



2010 Chevrolet HHR FFV

CLASS	SUV 2WD
NUMBER OF PASSENGERS	5
FUEL	Gasoline/E85
COMBINED MPG	25 (gas)/17 (E85)
MAXIMUM RANGE	400/272



2010 Hyundai Elantra

CLASS	Midsize
NUMBER OF PASSENGERS	5
FUEL	Gasoline
COMBINED MPG	29
MAXIMUM RANGE	406



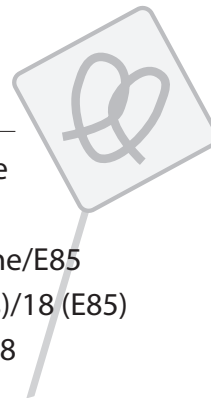
2010 Mazda 6

CLASS	Midsize
NUMBER OF PASSENGERS	5
FUEL	Gasoline
COMBINED MPG	24
MAXIMUM RANGE	444



2011 Chevrolet Malibu FFV

CLASS	Midsize
NUMBER OF PASSENGERS	5
FUEL	Gasoline/E85
COMBINED MPG	26 (gas)/18 (E85)
MAXIMUM RANGE	416/288



2010 Toyota Prius

CLASS	Midsize
NUMBER OF PASSENGERS	5
FUEL	Hybrid
COMBINED MPG	50
MAXIMUM RANGE	595



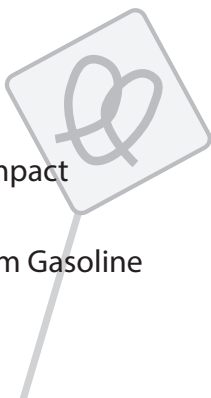
2011 Honda Fit

CLASS	Small Station Wagon
NUMBER OF PASSENGERS	4
FUEL	Gasoline
COMBINED MPG	30
MAXIMUM RANGE	318



2011 Audi S5 Cabriolet

CLASS	Subcompact
NUMBER OF PASSENGERS	4
FUEL	Premium Gasoline
COMBINED MPG	20
MAXIMUM RANGE	338



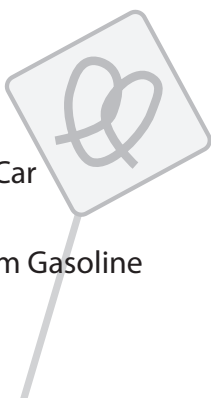
2011 Kia Forte Eco

CLASS	Midsize
NUMBER OF PASSENGERS	5
FUEL	Gasoline
COMBINED MPG	3
MAXIMUM RANGE	411



2011 Bugatti Veyron

CLASS	Sports Car
NUMBER OF PASSENGERS	2
FUEL	Premium Gasoline
COMBINED MPG	10
MAXIMUM RANGE	264



2011 Lexus RX 450h

CLASS	SUV
NUMBER OF PASSENGERS	5
FUEL	Hybrid
COMBINED MPG	30
MAXIMUM RANGE	516



2011 Mini Cooper Convertible

CLASS	Minicompact
NUMBER OF PASSENGERS	4
FUEL	Premium Gasoline
COMBINED MPG	30
MAXIMUM RANGE	396

2012 Azure Dynamic Transit Connect

CLASS	Van, Special Purpose
NUMBER OF PASSENGERS	2
FUEL	Electric
COMBINED MPG	62e
MAXIMUM RANGE	56

2011 Porsche 911 Carrera 4S Targa

CLASS	Sports Car
NUMBER OF PASSENGERS	2
FUEL	Premium Gasoline
COMBINED MPG	20
MAXIMUM RANGE	354

2012 BMW Active Hybrid 7

CLASS	Midsize
NUMBER OF PASSENGERS	5
FUEL	Hybrid
COMBINED MPG	20
MAXIMUM RANGE	434

2011 Subaru Outback AWD

CLASS	SUV 4WD
NUMBER OF PASSENGERS	5
FUEL	Gasoline
COMBINED MPG	24
MAXIMUM RANGE	444

2012 Cadillac CTS Supercharger

CLASS	Midsize
NUMBER OF PASSENGERS	5
FUEL	Premium Gasoline
COMBINED MPG	14
MAXIMUM RANGE	252

2011 Toyota Yaris

CLASS	Subcompact
NUMBER OF PASSENGERS	4
FUEL	Gasoline
COMBINED MPG	31
MAXIMUM RANGE	344

2012 Coda

CLASS	Subcompact
NUMBER OF PASSENGERS	4
FUEL	Electric
COMBINED MPG	73e
MAXIMUM RANGE	88

2012 Ferrari 458 Italia Spider

CLASS	Sports Car
NUMBER OF PASSENGERS	2
FUEL	Premium Gasoline
COMBINED MPG	14
MAXIMUM RANGE	318

2012 Land Rover Range Rover Sport

CLASS	SUV 4WD
NUMBER OF PASSENGERS	5
FUEL	Premium Gasoline
COMBINED MPG	15
MAXIMUM RANGE	345

2012 Fiat 500 Abarth

CLASS	Minicompact
NUMBER OF PASSENGERS	4
FUEL	Gasoline
COMBINED MPG	31
MAXIMUM RANGE	326

2012 Lincoln MKT FWD

CLASS	SUV 2WD
NUMBER OF PASSENGERS	7
FUEL	Gasoline
COMBINED MPG	20
MAXIMUM RANGE	372

2012 GMC Acadia AWD

CLASS	SUV 4WD
NUMBER OF PASSENGERS	8
FUEL	Gasoline
COMBINED MPG	19
MAXIMUM RANGE	418

2012 Maserati Quattroporte

CLASS	Large Luxury Sedan
NUMBER OF PASSENGERS	5
FUEL	Premium Gasoline
COMBINED MPG	15
MAXIMUM RANGE	357

2012 Jaguar XJ LWB

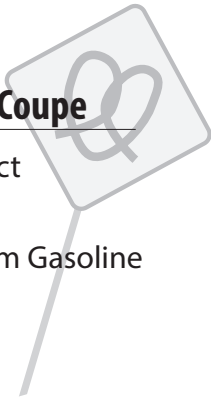
CLASS	Large Luxury Sedan
NUMBER OF PASSENGERS	5
FUEL	Gasoline
COMBINED MPG	18
MAXIMUM RANGE	391

2012 Mitsubishi i-MiEV

CLASS	Subcompact
NUMBER OF PASSENGERS	4
FUEL	Electric
COMBINED MPG	112e
MAXIMUM RANGE	52

2012 Rolls-Royce Phantom Coupe

CLASS	Compact
NUMBER OF PASSENGERS	4
FUEL	Premium Gasoline
COMBINED MPG	14
MAXIMUM RANGE	369



2013 BYD e6

CLASS	Small SUV
NUMBER OF PASSENGERS	5
FUEL	Electric
COMBINED MPG	63e
MAXIMUM RANGE	127



2012 Scion XD

CLASS	Subcompact
NUMBER OF PASSENGERS	4
FUEL	Gasoline
COMBINED MPG	29
MAXIMUM RANGE	322



2013 Chevrolet Volt

CLASS	Compact
NUMBER OF PASSENGERS	5
FUEL	Plug-in Hybrid
COMBINED MPG	98e/37 (gas)
MAXIMUM RANGE	38e/380



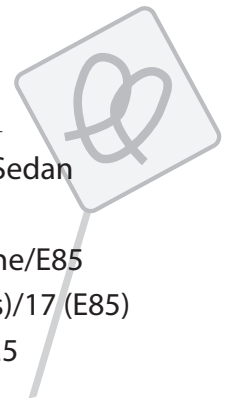
2013 Honda Civic CNG

CLASS	Compact
NUMBER OF PASSENGERS	4
FUEL	CNG
COMBINED MPG	31e
MAXIMUM RANGE	193



2013 Dodge Charger FFV

CLASS	Large Sedan
NUMBER OF PASSENGERS	5
FUEL	Gasoline/E85
COMBINED MPG	23 (gas)/17 (E85)
MAXIMUM RANGE	439/325



2013 Nissan Leaf

CLASS	Midsize
NUMBER OF PASSENGERS	5
FUEL	Electric
COMBINED MPG	115e
MAXIMUM RANGE	75



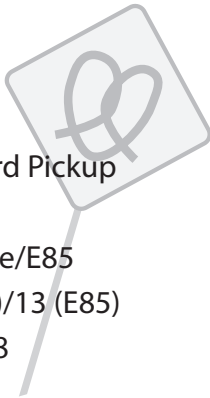
2013 Ford E350 Wagon

CLASS	Van, Passenger
NUMBER OF PASSENGERS	12
FUEL	Gasoline
COMBINED MPG	11
MAXIMUM RANGE	396



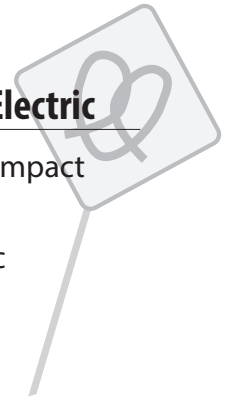
2013 GMC Sierra C15 XFE

CLASS	Standard Pickup
NUMBER OF PASSENGERS	3
FUEL	Gasoline/E85
COMBINED MPG	18 (gas)/13 (E85)
MAXIMUM RANGE	468/338



2013 smart fortwo Coupe Electric

CLASS	Minicompact
NUMBER OF PASSENGERS	2
FUEL	Electric
COMBINED MPG	107e
MAXIMUM RANGE	68



2013 Jeep Wrangler Unlimited

CLASS	Small SUV
NUMBER OF PASSENGERS	4
FUEL	Gasoline
COMBINED MPG	18
MAXIMUM RANGE	405



2013 Toyota Rav 4

CLASS	Small SUV
NUMBER OF PASSENGERS	4
FUEL	Gasoline
COMBINED MPG	26
MAXIMUM RANGE	413



2013 Mercedes-Benz S400 Hybrid

CLASS	Large Sedan
NUMBER OF PASSENGERS	5
FUEL	Hybrid
COMBINED MPG	21
MAXIMUM RANGE	500



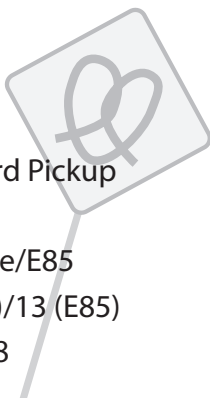
2014 Audi Q5

CLASS	Small SUV
NUMBER OF PASSENGERS	5
FUEL	Diesel
COMBINED MPG	27
MAXIMUM RANGE	535



2013 Ram 1500 4WD

CLASS	Standard Pickup
NUMBER OF PASSENGERS	3
FUEL	Gasoline/E85
COMBINED MPG	19 (gas)/13 (E85)
MAXIMUM RANGE	494/338



2014 Buick LaCrosse eAssist

CLASS	Midsize
NUMBER OF PASSENGERS	5
FUEL	Hybrid
COMBINED MPG	29
MAXIMUM RANGE	458



2014 Chrysler 300 FFV

CLASS	Large Sedan
NUMBER OF PASSENGERS	5
FUEL	Gasoline/E85
COMBINED MPG	23 (gas)/17 (E85)
MAXIMUM RANGE	439/325



2014 Mini JCW Countryman

CLASS	Compact
NUMBER OF PASSENGERS	4
FUEL	Gasoline
COMBINED MPG	26
MAXIMUM RANGE	322



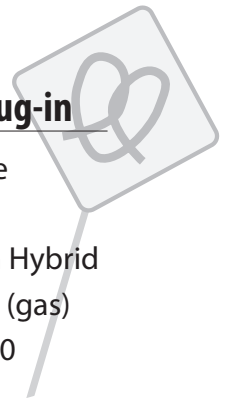
2014 Ford Edge

CLASS	Small SUV
NUMBER OF PASSENGERS	5
FUEL	Gasoline
COMBINED MPG	22
MAXIMUM RANGE	403



2014 Ford C-max Energy Plug-in

CLASS	Midsize
NUMBER OF PASSENGERS	5
FUEL	Plug-in Hybrid
COMBINED MPG	88e/38 (gas)
MAXIMUM RANGE	20e/550



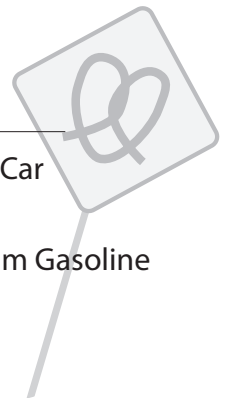
2014 Honda Accord

CLASS	Midsize
NUMBER OF PASSENGERS	5
FUEL	Plug-in Hybrid
COMBINED MPG	115e/46 (gas)
MAXIMUM RANGE	13e/570



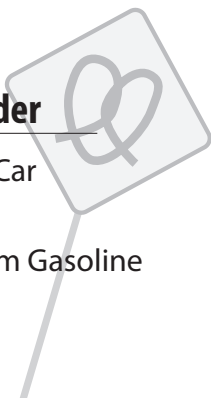
2014 Pagani Huayra Coupe

CLASS	Sports Car
NUMBER OF PASSENGERS	2
FUEL	Premium Gasoline
COMBINED MPG	13
MAXIMUM RANGE	250



2014 McLaren MP4-12C Spider

CLASS	Sports Car
NUMBER OF PASSENGERS	2
FUEL	Premium Gasoline
COMBINED MPG	18
MAXIMUM RANGE	250



2014 Subaru Forester AWD

CLASS	Small SUV
NUMBER OF PASSENGERS	5
FUEL	Gasoline
COMBINED MPG	27
MAXIMUM RANGE	429



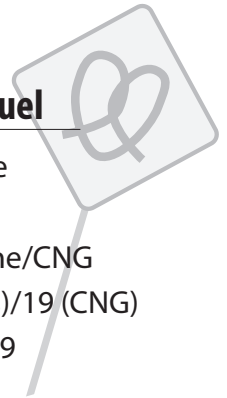
2014 Kia Soul

CLASS	Small Station Wagon
NUMBER OF PASSENGERS	5
FUEL	Gasoline
COMBINED MPG	26
MAXIMUM RANGE	369



2015 Chevrolet Impala bi-fuel

CLASS	Midsize
NUMBER OF PASSENGERS	5
FUEL	Gasoline/CNG
COMBINED MPG	20 (gas)/19 (CNG)
MAXIMUM RANGE	368/119



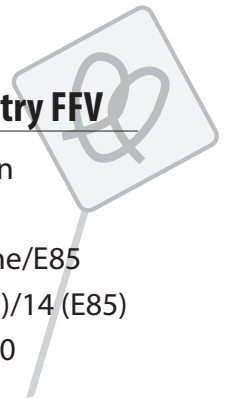
2014 Volkswagen Passat

CLASS	Midsize
NUMBER OF PASSENGERS	5
FUEL	Diesel
COMBINED MPG	34
MAXIMUM RANGE	629



2015 Chrysler Town & Country FFV

CLASS	Minivan
NUMBER OF PASSENGERS	7
FUEL	Gasoline/E85
COMBINED MPG	20 (gas)/14 (E85)
MAXIMUM RANGE	400/280



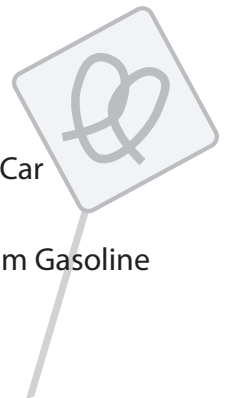
2014 Volvo XC60

CLASS	Small SUV
NUMBER OF PASSENGERS	5
FUEL	Gasoline
COMBINED MPG	21
MAXIMUM RANGE	388



2015 Dodge Viper SRT

CLASS	Sports Car
NUMBER OF PASSENGERS	2
FUEL	Premium Gasoline
COMBINED MPG	15
MAXIMUM RANGE	240



2015 Acura TLX

CLASS	Compact
NUMBER OF PASSENGERS	4
FUEL	Premium Gasoline
COMBINED MPG	28
MAXIMUM RANGE	482



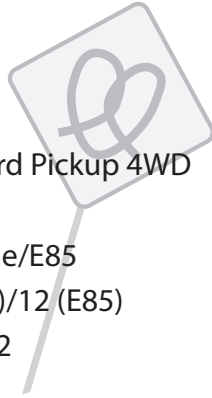
2015 Fiat 500e

CLASS	Minicompact
NUMBER OF PASSENGERS	5
FUEL	Electric
COMBINED MPG	116e
MAXIMUM RANGE	87



2015 GMC Sierra K15 FFV

CLASS	Standard Pickup 4WD
NUMBER OF PASSENGERS	4
FUEL	Gasoline/E85
COMBINED MPG	17 (gas)/12 (E85)
MAXIMUM RANGE	442/312



2015 Lincoln MKS

CLASS	Large Sedan
NUMBER OF PASSENGERS	5
FUEL	Gasoline
COMBINED MPG	22
MAXIMUM RANGE	418



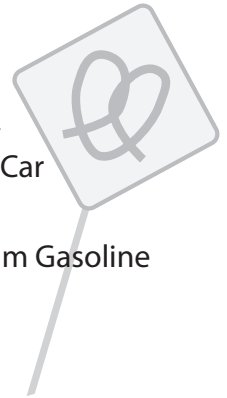
2015 Hyundai Veloster

CLASS	Compact
NUMBER OF PASSENGERS	4
FUEL	Gasoline
COMBINED MPG	30
MAXIMUM RANGE	396



2015 Mazda MX-5

CLASS	Sports Car
NUMBER OF PASSENGERS	2
FUEL	Premium Gasoline
COMBINED MPG	23
MAXIMUM RANGE	292



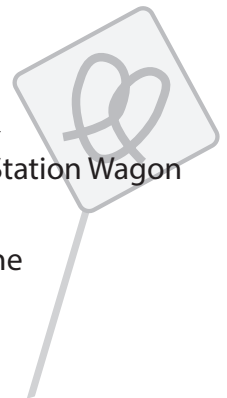
2015 Infiniti Q50 Hybrid

CLASS	Compact
NUMBER OF PASSENGERS	4
FUEL	Hybrid
COMBINED MPG	31
MAXIMUM RANGE	552



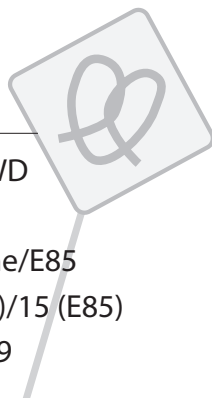
2015 Nissan Juke

CLASS	Small Station Wagon
NUMBER OF PASSENGERS	4
FUEL	Gasoline
COMBINED MPG	30
MAXIMUM RANGE	396



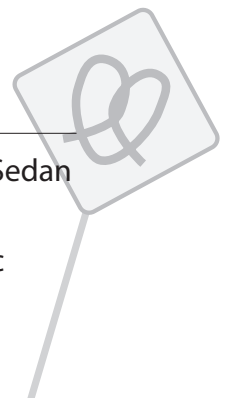
2015 Jeep Grand Cherokee

CLASS	SUV 4WD
NUMBER OF PASSENGERS	5
FUEL	Gasoline/E85
COMBINED MPG	19 (gas)/15 (E85)
MAXIMUM RANGE	467/369



2015 Tesla Model S 90 kWh

CLASS	Large Sedan
NUMBER OF PASSENGERS	5
FUEL	Electric
COMBINED MPG	89e
MAXIMUM RANGE	265



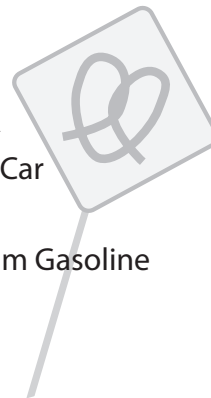
2015 Toyota Prius Plug-in

CLASS	Midsize
NUMBER OF PASSENGERS	5
FUEL	Plug-in Hybrid
COMBINED MPG	95e/50 (gas)
MAXIMUM RANGE	11e/450



2016 Chevrolet Corvette

CLASS	Sports Car
NUMBER OF PASSENGERS	2
FUEL	Premium Gasoline
COMBINED MPG	21
MAXIMUM RANGE	388



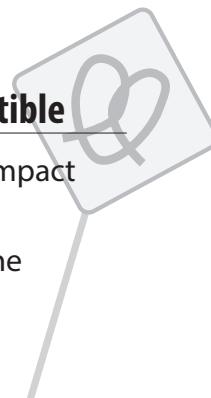
2015 Volkswagen Jetta

CLASS	Compact
NUMBER OF PASSENGERS	4
FUEL	Diesel
COMBINED MPG	36
MAXIMUM RANGE	522



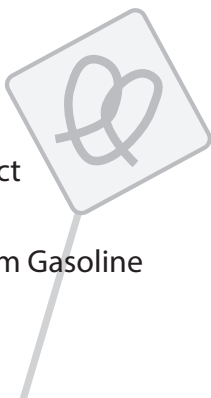
2016 Ford Mustang Convertible

CLASS	Subcompact
NUMBER OF PASSENGERS	4
FUEL	Gasoline
COMBINED MPG	24
MAXIMUM RANGE	372



2016 Audi S4

CLASS	Compact
NUMBER OF PASSENGERS	4
FUEL	Premium Gasoline
COMBINED MPG	21
MAXIMUM RANGE	338



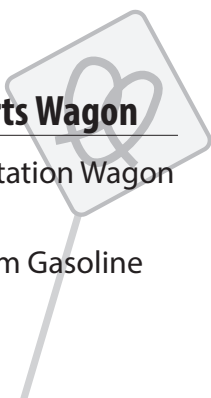
2016 Kia Optima Hybrid

CLASS	Midsize
NUMBER OF PASSENGERS	5
FUEL	Hybrid
COMBINED MPG	38
MAXIMUM RANGE	703



2016 BMW 328i XDrive Sports Wagon

CLASS	Small Station Wagon
NUMBER OF PASSENGERS	4
FUEL	Premium Gasoline
COMBINED MPG	26
MAXIMUM RANGE	411



2016 Porsche Cayenne Diesel

CLASS	SUV
NUMBER OF PASSENGERS	5
FUEL	Diesel
COMBINED MPG	23
MAXIMUM RANGE	607



2016 smart fortwo Coupe Electric

CLASS	Minicompact
NUMBER OF PASSENGERS	2
FUEL	Gasoline
COMBINED MPG	36
MAXIMUM RANGE	277

2016 Ford Escape Hybrid 4WD

CLASS	Small SUV
NUMBER OF PASSENGERS	5
FUEL	Gasoline
COMBINED MPG	26
MAXIMUM RANGE	403

2016 Toyota Sienna

CLASS	Minivan
NUMBER OF PASSENGERS	7
FUEL	Gasoline
COMBINED MPG	21
MAXIMUM RANGE	420

2016 Volvo XC90 PHEV

CLASS	SUV
NUMBER OF PASSENGERS	5
FUEL	Plug-in Hybrid
COMBINED MPG	53e/25 (gas)
MAXIMUM RANGE	14e/350



Oil and Natural Gas Industry in the Round Cards

<p>I have Alteration. Who has a name for fuels formed from the remains of ancient sea plants and animals?</p>	<p>I have Petroleum. Who has the area that produces one-sixth of all crude oil in the U.S.?</p>
<p>I have Fossil Fuel. Who has the term for energy sources that take hundreds of millions of years to form and can not be easily replenished?</p>	<p>I have Offshore. Who has the sector of the economy that uses almost three-fourths of U.S. oil?</p>
<p>I have Nonrenewable. Who has the name of the main component of natural gas?</p>	<p>I have Transportation. Who has the type of rock that is formed from magma?</p>
<p>I have Methane. Who has the type of rock made from layers of sand and sediment?</p>	<p>I have Igneous. Who has the type of gases that keep the Earth warm enough for life?</p>
<p>I have Sedimentary. Who has the energy source consumed the most in the U.S.?</p>	<p>I have Greenhouse. Who has the type of rock made from extensive heat and pressure on other rocks?</p>

<p>I have Metamorphic. Who has the study of rock layers to determine the origin and composition of rocks?</p>	<p>I have CAVE. Who has a new type of seismic technology that measures changes over time?</p>
<p>I have Stratigraphy. Who has the measure of a rock's ability to hold and move fluids?</p>	<p>I have 4D Seismic. Who has the structure used to drill for underground oil with an exploratory well?</p>
<p>I have Permeability. Who has the technology that uses sound waves to explore underground rock formations?</p>	<p>I have Drilling Rig. Who has the term for petroleum products that are used to make other products in chemical plants?</p>
<p>I have Seismic. Who has a device used to create underground shock waves?</p>	<p>I have Feedstocks. Who has the term for the rock that is disturbed by the drilling process?</p>
<p>I have Thumper Trucks. Who has an advanced visualization technology used to understand seismic data?</p>	<p>I have Debris. Who has the term for the material used to lift debris from a well?</p>

<p>I have Drilling Mud. Who has the term used to describe the gaps or pores where oil is stored?</p>	<p>I have Blow Out Preventor (BOP). Who has the term used when a well has enough pressure to lift the oil?</p>
<p>I have Porosity. Who has the process used to turn an exploratory well into a production well?</p>	<p>I have Natural Drive. Who has the process of separating crude oil into its major components using boiling range?</p>
<p>I have Completion. Who has the term used to indicate the amount of water in an oil deposit?</p>	<p>I have Distillation. Who has the process of using heat to break long hydrocarbon chains into smaller chains?</p>
<p>I have Saturation. Who has the term that describes nearby oil reserves that are not connected to each other?</p>	<p>I have Thermal Cracking. Who has the process of combining short hydrocarbon chains into longer chains?</p>
<p>I have Compartmentalization. Who has the device used to regulate high pressure in a production well?</p>	<p>I have Unification. Who has the process of rearranging the molecules in hydrocarbon chains?</p>



Fossil Fuels to Products Pre/Post Assessment

- Petroleum and natural gas are:**
a. fossil fuels b. nonrenewables c. hydrocarbons d. all three
- Which energy source meets more total energy demand than any other in the United States?**
a. natural gas b. petroleum c. solar d. coal
- Petroleum and natural gas are usually found in which type(s) of rock formations?**
a. sedimentary b. metamorphic c. igneous d. all three
- Which sector of the economy uses the highest percentage of petroleum products?**
a. industrial b. residential c. commercial d. transportation
- Geologists using advanced technologies to explore for oil are successful what percentage of the time?**
a. 20 percent b. 60 percent c. 80 percent d. 100 percent
- What percentage of oil does the U.S. import from other countries?**
a. 20-30 percent b. 40-50 percent c. 60-70 percent d. 80-90 percent
- What percentage of oil does the industrial sector in the U.S. use for energy and to manufacture products?**
a. < 5 percent b. 5-15 percent c. 15-25 percent d. 25-35 percent
- How much U.S. oil production comes from offshore wells?**
a. 5-10 percent b. 15-25 percent c. 40-60 percent d. over 75 percent
- Crude oil must be processed before it can be used.**
a. true b. false
- Most crude oil is processed into diesel fuel for trucks, boats, trains, and other heavy vehicles.**
a. true b. false
- Crude oil must be processed before it is usable by consumers.**
a. true b. false
- Refineries separate petroleum products according to their boiling point by distillation.**
a. true b. false
- Crude oil contains only liquid products.**
a. true b. false
- Most petroleum products in the United States are transported by large oil tankers.**
a. true b. false
- Chemical plants make thousands of different chemicals, plastics, medicines, cosmetics, clothing, tires, and other products we use every day from petroleum products.**
a. true b. false
- The price of oil affects all sectors of the U.S. economy.**
a. true b. false



Glossary

acid	any of various water-soluble compounds having a sour taste and capable of turning litmus red and reacting with a base to form a salt
alkali	any substance having basic (as opposed to acidic) properties
alkylation	mixing a hydrocarbon with a catalyst and an acid to create different hydrocarbons
alteration	a process that rearranges pieces of hydrocarbon chains into different hydrocarbons
aromatic	cyclic hydrocarbon in the shape of a ring rather than a chain; often known for their "sweet" odor
blow out preventer (BOP)	a device that controls the pressure of a well
boiler	equipment used to process petroleum products with heat
casing	process of lining a production well with pipe before production can begin
catalytic cracking	using a catalyst to break long hydrocarbon chains
catalytic reforming	using a catalyst to rearrange hydrocarbon chains
CAVE	Cave Automatic Virtual Environment; sophisticated technology for visualizing data from seismic systems
cementing	stabilizing a casing pipe in a production well with cement
Christmas tree	a series of valves and gauges that control the flow of a well with natural drive
coke	a carbon-rich substance used by heavy industry
coking	heating the residue from the distillation process to produce useful products such as coke
compartmentalization	a situation in which oil from one part of a reserve cannot flow to another part of the reserve because of characteristics of the rock formation
completion	preparing an exploratory well for production
condense	to change state from gas to liquid
cooling tower	equipment used to cool water that has been heated during chemical processing
corrosive	having the capability or tendency to cause corrosion or gradual destruction
cracking	a process that breaks long hydrocarbon chains into shorter chains
crude oil	also called crude, oil, or petroleum; a fossil fuel made of hydrocarbons formed from the remains of ancient marine plants and animal organisms
data log	comprehensive information about a well's production data over time
debris	the rock that is torn up by a drill bit and must be removed from a well
density	a measure of the amount of mass contained in a given volume
derrick	the large tower that houses all of the drilling equipment above the drilling site
detonate	to set off an explosion
dissociate	to split into simpler groups of atoms or ions
distillation	separation of substances based on their boiling range
drilling mud	the substance used to lift debris from a well during drilling
drilling rig	the equipment used to drill a well
exploratory well	a well dug to find out if oil or natural gas is present in a location
feedstock	raw material used in processing and manufacturing
field processing	processing of crude oil at an offshore production site to separate the crude oil, natural gas, and saltwater
fossil fuel	energy-rich hydrocarbon made from the ancient remains of organic matter
fractional distillation	the process of separating petroleum into its useful components based on density and boiling point by applying heat
fractioning tower	equipment in which distillation takes place
furnace	device used as the heat source for creating chemical processes or reactions like cracking
geophone	an electronic receiver that picks up seismic vibrations

greenhouse gas	any gas in the atmosphere that contributes to the greenhouse effect
heat exchanger	a device that uses waste heat from one chemical process in another process
heat-treater	a device used to remove water from crude oil
horse head pump	a pump with a crank arm that lifts oil to the surface of a production well
hydrocarbon	a chemical compound containing only hydrogen and carbon
igneous rock	rock formed from magma or liquid rock that exists inside the Earth
jobber	a company that buys and sells petroleum products
loading station	an area where products are stored until shipped to market
mercaptan	an odorant added to natural gas as a safety feature
metamorphic rock	rock with few pores made from sedimentary or igneous rock under intense pressure
methane	the main ingredient in natural gas
monomer	a molecule that can combine with other molecules to form a polymer
naphtha	a flammable hydrocarbon mixture with between 5-12 carbons; used as a feedstock for gasoline in catalytic reforming
natural drive	pressure in a production well with enough force to lift the crude oil to the surface
nonrenewable energy source	an energy source that takes millions to hundreds of millions of years to form
olefin	a hydrocarbon that contains one or more pairs of carbon atoms linked by a double bond
organic compound	a compound containing hydrogen and carbon made of once living material
oxidizer	a substance that gives up oxygen easily to stimulate combustion of organic material
perforating	making holes in the bottom portion of a casing pipe so that oil can flow into it
permeability	a measure of the ability of a rock to hold and move fluids
petroleum	a liquid mixture of hydrocarbons formed from the decay of ancient sea life
petrochemical	substance that is derived from processing petroleum or natural gas
pig	a device used to clean a pipeline
polymer	a large organic molecule formed by combining many smaller molecules (monomers) in a regular pattern
pores	openings or spaces within a rock that can hold fluids
porosity	relating to the pores or gaps between the grains of rock in which oil is stored
porous	filled with holes or pores allowing fluids to permeate
pressurized separator	a device that uses pressure to quickly separate crude oil, natural gas, and saltwater during field processing
processing platform	an offshore platform where oil is cleaned and combined with oil from other wells before it is sent to a refinery
production	describes oil and natural gas that is being brought to the surface
production well	a well that has proven and retrievable oil or natural gas
protolith	original source rock that metamorphosed when exposed to heat and/or pressure; can originally be sedimentary or igneous in type
pumping station	a device along a pipeline with pumping equipment to keep the product flowing through the pipeline
refined	term used to describe products that have been separated and through one or more processes to create an end use product
refinery	a facility where petroleum is separated into useable by-products
renewable energy source	an energy source that can be replenished in a short period of time
reserves	resources that have not been accessed or used
roustabout	a worker on a drilling rig
ROVER	a Remote Operating Vehicle used to maintain and repair undersea drilling equipment
saturation	the amount of water contained in crude oil

sedimentary rock	rock formed from layers of sand and sediment under pressure
seismic technology	equipment that bounces sound waves off of underground rock to determine the characteristics of rock formations
settling tank	a tank used to separate crude oil, natural gas, and saltwater on a processing platform
stratigraphy	the study of rock layers to determine data about the rock formation, the age of the layers, the radioactivity, and other information
sucker-rod pump	a pump that draws crude oil to the surface of a production well
tank farm	a group of oil storage tanks
thermal cracking	a process that uses very high temperatures to break apart long hydrocarbon chains
thumper	a device that produces sound waves in seismic technology
treatment	process of removing impurities from petroleum products before they are shipped to market
unification	a process that combines smaller hydrocarbon chains into longer chains
unstable	having a tendency to react easily with other substances
viscosity	the tendency of a liquid to resist flowing; thicker liquids have higher viscosities
wastewater treatment	processes that ensure that the water leaving a chemical plant is as clean as when it entered the plant



Fossil Fuels to Products Evaluation Form

State: _____ Grade Level: _____ Number of Students: _____

- 1. Did you conduct the entire unit? Yes No

- 2. Were the instructions clear and easy to follow? Yes No

- 3. Did the activities meet your academic objectives? Yes No

- 4. Were the activities age appropriate? Yes No

- 5. Were the allotted times sufficient to conduct the activities? Yes No

- 6. Were the activities easy to use? Yes No

- 7. Was the preparation required acceptable for the activities? Yes No

- 8. Were the students interested and motivated? Yes No

- 9. Was the energy knowledge content age appropriate? Yes No

- 10. Would you teach this unit again? Yes No

Please explain any 'no' statement below.

How would you rate the unit overall? excellent good fair poor

How would your students rate the unit overall? excellent good fair poor

What would make the unit more useful to you?

Other Comments:

Please fax or mail to: The NEED Project
8408 Kao Circle
Manassas, VA 20110
FAX: 1-800-847-1820



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American Electric Power
American Fuel & Petrochemical Manufacturers
Arizona Public Service
Armstrong Energy Corporation
Barnstable County, Massachusetts
Robert L. Bayless, Producer, LLC
BG Group/Shell
BP America Inc.
Blue Grass Energy
Cape Light Compact–Massachusetts
Central Falls School District
Chugach Electric Association, Inc.
CITGO
Clean Energy Collective
Colonial Pipeline
Columbia Gas of Massachusetts
ComEd
ConEdison Solutions
ConocoPhillips
Constellation
Cuesta College
David Petroleum Corporation
Desk and Derrick of Roswell, NM
Direct Energy
Dominion Energy
Donors Choose
Duke Energy
East Kentucky Power
Energy Market Authority – Singapore
Escambia County Public School Foundation
Eversource
Exelon Foundation
Foundation for Environmental Education
FPL
The Franklin Institute
George Mason University – Environmental Science and Policy
Gerald Harrington, Geologist
Government of Thailand–Energy Ministry
Green Power EMC
Guilford County Schools – North Carolina
Gulf Power
Hawaii Energy
Idaho National Laboratory
Illinois Clean Energy Community Foundation
Illinois Institute of Technology
Independent Petroleum Association of New Mexico
James Madison University
Kentucky Department of Energy Development and Independence
Kentucky Power – An AEP Company
Kentucky Utilities Company
League of United Latin American Citizens – National Educational Service Centers
Leidos
Linn County Rural Electric Cooperative
Llano Land and Exploration
Louisville Gas and Electric Company
Mississippi Development Authority–Energy Division
Mississippi Gulf Coast Community Foundation
Mojave Environmental Education Consortium
Mojave Unified School District
Montana Energy Education Council
The Mountain Institute
National Fuel
National Grid
National Hydropower Association
National Ocean Industries Association
National Renewable Energy Laboratory
NC Green Power
New Mexico Oil Corporation
New Mexico Landman’s Association
NextEra Energy Resources
NEXTracker
Nicor Gas
Nisource Charitable Foundation
Noble Energy
Nolin Rural Electric Cooperative
Northern Rivers Family Services
North Carolina Department of Environmental Quality
North Shore Gas
Offshore Technology Conference
Ohio Energy Project
Opterra Energy
Pacific Gas and Electric Company
PECO
Pecos Valley Energy Committee
Peoples Gas
Pepco
Performance Services, Inc.
Petroleum Equipment and Services Association
Phillips 66
PNM
PowerSouth Energy Cooperative
Providence Public Schools
Quarto Publishing Group
Read & Stevens, Inc.
Renewable Energy Alaska Project
Rhode Island Office of Energy Resources
Robert Armstrong
Roswell Geological Society
Salt River Project
Salt River Rural Electric Cooperative
Saudi Aramco
Schlumberger
C.T. Seaver Trust
Secure Futures, LLC
Shell
Shell Chemicals
Sigora Solar
Singapore Ministry of Education
Society of Petroleum Engineers
Society of Petroleum Engineers – Middle East, North Africa and South Asia
Solar City
David Sorenson
South Orange County Community College District
Tennessee Department of Economic and Community Development–Energy Division
Tesla
Tesoro Foundation
Tri-State Generation and Transmission
TXU Energy
United Way of Greater Philadelphia and Southern New Jersey
University of Kentucky
University of Maine
University of North Carolina
University of Tennessee
U.S. Department of Energy
U.S. Department of Energy–Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy–Wind for Schools
U.S. Energy Information Administration
United States Virgin Islands Energy Office
Wayne County Sustainable Energy
Western Massachusetts Electric Company
Yates Petroleum Corporation