Natural Gas: Safety & Science
Teacher's Guide

Introduction
Natural Gas Safety and Science describes how to safely use natural gas in daily life and explains natural gas science concepts. The booklet supports *Next Generation Science Standards* for both Earth & Space Sciences and Physical Sciences, along with *Common Core State ELA Standards* for Reading Informational Text.

This teacher's guide provides the objective for each page of the booklet along with background information, puzzle answers, and ideas for classroom discussion and follow-up activities. Some activities require only a pencil or pen and the booklet itself. Others call for everyday items that are on hand in most homes and classrooms or obtainable outdoors. If completed in its entirety, this booklet serves as a two-week interactive unit of study on natural gas. If time is limited, teachers are free to pick and choose from the activities presented. Teachers should preview all materials before assigning for student use.

Page 2: Natural Gas as an Energy Source
Objectives: Introduce natural gas as an energy source in our lives. Get students thinking about gas safety.

Background: We need energy to move, work, and play in our lives. Our own bodies get energy from food. Some appliances in our homes get energy from natural gas; these include clothes dryers, stoves and ovens, furnaces, water heaters, pool or spa heaters, barbecue grills, and fireplaces.

Discussion: Explain to students that natural gas is a fuel that can be burned in appliances to produce heat. Ask: What other kinds of fuels can you think of that produce heat? *(Oil, wood, gasoline, charcoal, propane.)* What other sources of energy can run the appliances in our homes? *(Electricity.)*

Natural Gas Safety Activity: Step 2 in this activity asks students to search online or ask a chatbot for age-appropriate natural gas safety tips. Be sure to remind students to work with an adult on this step. After all students complete this activity, have each student share one of their natural gas safety tips as a full-group exercise. Chart each tip on a grid on a white board, with two columns beside the listed tips: one headed "Student," for if the student thought of it, and another, "Researched," for if the tip came from an online resource or chatbot. Put a check mark beside the appropriate column for the source of each tip, with the student's name in the student column if they thought of the tip. No student should state a tip that has already been stated.

Page 3: Understanding Our Energy Use
Objective: Consider all the ways we use energy in our lives.

Background: Energy is the ability to change or move matter. Without energy there would be no motion, no light, and no heat, and life would not exist. Most of the energy on earth comes from the sun.

Explain to students that natural gas comes to our homes and schools through pipelines that run under streets, sidewalks, yards, and homes, and that their local utility monitors, maintains, and repairs the gas distribution system for safety.
Discussion: Ask students to list common activities they do that require energy from the food they eat. *(Reading, doing homework, walking, bike riding, etc.)* Then ask them to distinguish between those types of activities and activities that require other sources of energy. *(Taking a shower requires energy to heat the water; running appliances or electronic devices like the TV, computers, and clothes dryers requires energy sources like electricity or natural gas.)*

Energy Use Chart: Invite students to consider whether they did any of the following the previous day: took a bath or shower, ate home-cooked food, watched a TV show or video, listened to music, were driven to school, enjoyed a warm home, played a computer game. Ask students what appliance or equipment was used for each activity. Have them record their answers in the chart. If students are not aware of the energy sources that run the appliances and equipment they used, ask them to check with their families and fill out the third column at home. *(Tips for recognizing energy sources: Appliances and equipment that use natural gas or other fuels have a flame inside when they are on. Electrical appliances plug into a wall outlet, and portable electric devices run on batteries.)*

Going Further: Ask students to imagine living for a day without using any energy sources at all. In groups of two or three, have them explain to each other how they would keep warm or cool, what they would eat, and what they would do for transportation. Also, what would they do for fun?

Pages 4-5: Natural Gas Geology
Objectives: Understand that natural gas comes from fossil remains, and the nature of reservoir rock, where natural gas is trapped and held. Demonstrate the decay of organic materials through a simulation activity.

Background: Using the illustration on page 4, explain that reservoir rock is the layer of the earth's crust where natural gas is trapped, along with oil and water. Beneath the reservoir rock is source rock, where trapped fossils are converted to natural gas. Reservoir rock is porous, meaning it allows the gas to seep up into it, propelled by pressure from below. The layer of cap rock above it forms a seal, which keeps the gas from escaping.

Natural gas is known as a fossil fuel because it was formed from the fossilized remains of organic materials that were present on earth long ago and buried under lakes and oceans. Fossils are the naturally preserved remains or traces of animals or plants that lived in the geologic past. For natural gas to be formed from them, fossils undergo heat, shifting, and pressure that create gas in the porous pockets within sedimentary rock, which is a type of source rock.

Discussion: Ask students to name the three kinds of fossil fuels. *(Natural gas, oil or petroleum, coal).*

Make A Reservoir Activity: Setup: When students pour the water into the oil, remind them to do so very slowly. Questions: 1) Where did the liquid go? *(The water went between the grains of sand.)* 2) What substance did the liquid replace? *(Air, between the grains of sand.)* 3) Where did the substance go? (*The air came bubbling up when the water was poured in).* 4) How do the substances behave like the reservoir rock as shown in the illustration? *(The sand in the jar is like the reservoir rock in a gas trap. The water in the jar models the water in the trap, and the oil is like the oil in the trap, which floats on top of the water. The air is like the natural gas in the trap, which rises above both the water and oil. However, while the air escaped from the jar in this experiment, in a gas trap there is an impermeable rock seal above that keeps the gas from escaping.)*

Make Your Own Fossil Activity: If you don't have toothpicks, a hole can be poked in the moist dough with a sharp pencil or compass end. Before letting students bring their fossils home, consider displaying all of them together at the front or back of the classroom on some nylon fishing wire. Beads may need to be placed between the fossils to keep them separate, or else hang the wire very taut.
Going Further: Ask students to bury organic (*plant food waste*) and nonorganic (*plastic, metal*) materials in soil placed in a large jar or plastic bin, or in an outdoor compost pile. Have students record observations of these materials at two- or three-day intervals over a week or two. They will observe decay of the organic materials.

Page 6: Our Energy Comes from Natural Resources
Objectives: Describe the multiple types of natural resources we use in our lives and distinguish between renewable and nonrenewable resources. Explain how natural gas gets to us.

Background/Discussion: Wells are drilled through deep holes in the earth to bring natural gas to the earth's surface. The gas is pumped to processing plants, where it is cleaned and then pumped through pipelines to power plants, factories, businesses, and homes.

Discuss the meaning of the word *replenished*—to make full or complete again by supplying what has been used up. Explain to students that no matter what fuels produce the energy they use, their clothes get washed, their water heats up, and their computers run in the same way. Explain that the fuels used to generate most of the electricity used in this country include fossil fuels—coal, oil, and natural gas. Here is some more background on various fuel sources and how they are used to produce electricity:

Fossil Fuels: Coal, oil, and natural gas are burned to heat water into steam, which is pressurized and used to turn a turbine. They are called fossil fuels because they were formed millions of years ago, when plants and tiny sea creatures were buried by sand and rock. Their bodies decomposed and, as a result of the earth's heat and pressure, they turned into fossil fuels. These fuels are considered nonrenewable because they will some day be used up.

Hydropower: Hydropower plants rely on falling water to turn turbines. The most common form of hydropower uses dams on rivers to create large reservoirs. Water in rivers is continually replenished, so hydropower is renewable. In fact, hydropower is currently one of the largest sources of renewable power.

Solar Energy: Solar energy captures radiant energy from the sun and converts it into electricity. The sun's energy will never run out (at least not for several billion years), so solar energy is considered renewable.

Biomass: Like fossil fuels and nuclear energy, biomass is used to heat water into steam, which is pressurized and used to turn a turbine. Wood is the largest source of biomass energy, followed by corn, sugarcane wastes, straw, and other farming byproducts. Although it is possible to use biomass faster than we produce it, more can be grown, so biomass is renewable.

Wind Power: Wind power relies on moving air to turn turbines, which are connected to windmills. The wind will be around as long as the earth is, so wind power is renewable.

Geothermal Energy: Steam or hot water from geothermal energy facilities can be used to turn turbines. This word comes from *geo* for earth and *thermal* for heat. The hot molten rock inside the earth isn't going away anytime soon, making geothermal energy renewable. Although it is renewable, geothermal energy has some limitations: people must be careful not to draw steam or hot water out of the earth faster than it can be replenished.

Going Further: Have students find out whether any of the electricity supplied by their local electric utility is generated by natural gas. (This information can usually be found on the utility's website.)

Pages 7-8: Gas Leak Response
Objectives: Recognize the hazards of gas leaks. Explain how to detect and respond to an indoor gas leak and how to do the same for an outdoor gas pipeline leak.

Background/Discussion: Natural gas is a safe fuel when used properly. However, if natural gas leaks from pipelines or appliances and is ignited by a flame or spark, a catastrophic fire or explosion may result.

There are more than three million miles of pipelines in the United States transporting natural gas to our homes, schools, and businesses. To make sure the gas reaches us safely, these pipelines—made of either steel or high-strength plastic—are thoroughly tested and maintained through a variety of methods. It is everyone's responsibility to be safe around natural gas pipelines, and to learn how to recognize and respond to the rare occurrence of a natural gas pipeline leak.

Ask: Have you ever smelled leaking gas? What did it smell like? *(Responses will vary.)* Explain that a chemical called mercaptan is added to natural gas to make it smell like sulfur or rotten eggs. Why do we want natural gas to smell bad? *(So that we will know when it's leaking and can protect ourselves.)*

Ask: Why should you tell an adult when you smell gas? *(There is danger of fire or explosion.)* If you smell gas when no adult is home, what should you do? *(Leave and take everyone with you. Don't use a light switch, TV, remote controller, garage door opener, candle, flashlight, radio, or even a phone, as a spark from any of these could ignite leaking gas. Go to a safe location and ask a trusted adult to report the leak to 911 and the local natural gas utility. Don't go back home until safety officials say it is safe to do so.)*

Page 7 - Message Decoding Puzzle Answer: *A tiny spark from one of these things could ignite leaking gas.*

Page 8 - Discussion/Review:
A leak from a natural gas pipeline, although rare, can be a fire hazard. Pipeline markers can provide important information about whom to contact if you detect an outdoor gas leak. Remind students to be alert for any of the following signs, and explain what to do if they notice any of these:

Gas leak warning signs:
- A smell of sulfur or rotten eggs
- Continuous bubbling in water
- A hissing, whistling, or roaring sound
- Dirt spraying or blowing into the air from a hole in the ground
- Grass or plants dead or dying for no apparent reason

What to do:
- Do not use electricity or fire. Even the tiniest spark from a phone, flashlight, electrical device, or match could ignite leaking gas.
- Go far away from the area immediately. Do NOT go back until safety officials say it is safe.
- Ask a trusted adult to report the leak to 911 and the local natural gas utility.

Page 8 - Word Game Answers: Scrambled words: *whistling, leaks, electrical, hazard, report, dirt*.
Sentences: Gas pipeline *leaks* can pose a *hazard.* Signs of a leak include a *whistling* sound, or *dirt* blowing into the air. If you suspect a gas leak, do not use anything *electrical*. Leave the area and ask an adult to *report* the leak.

Page 9: Gas Pipeline Leak Safety
Objectives: Familiarize students with the 811 service that should be called before any digging project and raise awareness about pipeline markers.

Background/Discussion: If people dig into the underground gas pipeline system, pipes can be damaged and natural gas can leak out. Even a small leak can cause a fire or possibly an explosion. Protecting underground utility lines from damage is everyone's job, so we all need to take care not to damage underground gas pipes with digging equipment.

Remind students that if someone they know is planning a digging project, they must call the 811 utility locator service by dialing 811 several days ahead of time so underground utilities can be marked and people can dig a safe distance away from them.

Explain to students that after the 811 service receives a request to have underground utilities marked, a utility worker comes to the site and uses either colored spray paint or flags to indicate the location of buried utility lines. Natural gas lines are marked in yellow. Remind students that they should never tamper with these utility flags or markings, as they are put there to prevent damage to underground utility lines and to keep people safe.

Ask for examples of types of digging projects that would warrant a call to the 811 service. *(Planting a tree or garden; grading a driveway; installing a sprinkler system; building a home, an addition to a home; installing a fence.)*

Knowing about pipeline markers is also an important aspect of pipeline safety. Emphasize that these yellow markers always have an emergency number on them for reporting any suspicious activity.

Page 10: Indoor Gas Safety
Objective: Recognize important gas safety practices in and around the home.

Background/Discussion: Discuss safe practices for using a gas range, such as keeping the flame no bigger than the pot. Ask*:* Why is it dangerous to store flammable objects near gas appliances? *(Gas appliances use a flame and some, like an oven or heater, can get hot enough to set fire to something flammable that is close by. Also, the fumes of flammable liquids could be ignited by the flame or pilot light inside a gas appliance.)* What does it mean if your gas range has a large, yellow, or flickering flame? *(It is not working properly, and you should call a repairperson.)* Why shouldn't you play with oven knobs or hang things from gas pipes? *(You could turn on the gas by mistake or damage the pipes and cause a gas leak.)*

Stand Up for Safety: Have a full class discussion about the role-play exercise. Ask: What did you learn about yourself or what did it feel like, playing the younger person? What did you learn about yourself or what did it feel like, playing the older person?

Page 11: Carbon Monoxide Safety
Objective: Point out to students the dangers of carbon monoxide (CO) poisoning

Background/Discussion: Explain that CO is produced when any fuel (such as heating oil, propane, kerosene, natural gas, charcoal, wood, gasoline, or diesel) burns without enough oxygen. Breathing a little CO can make people feel headachy, tired, nauseous, and weak. Breathing a lot of CO can cause people to lose consciousness—or even die! Human senses cannot detect CO, so we rely on CO alarms to alert people to CO problems. Your home should have a CO alarm in the hallway near every sleeping area.

CO Math Answers: *903; 391; 50; 13; 44; 442; We can't detect CO with our senses, so we rely on CO* ***alarms*** *to alert us to a problem before the gas reaches dangerous levels.*

Going Further: Have students ask at home if they have a CO detector(s). Encourage students who do not have CO detectors to show their parents or caretakers Page 11 of the booklet.

Pages 12-13: Three States of Matter
Objectives: Describe the characteristics of solids, liquids, and gases. Experiment with the behavior of a gas.

Background/Discussion: Ask: What is matter? *(Anything that takes up space or has a mass of any kind. Everything you can touch is made of matter.)* A solid has a definite shape and volume. A liquid has a definite volume but takes the shape of its container. A gas can change its shape and volume. Even without shape or volume, and even though it is invisible, natural gas is still considered to be matter.

Critical Thinking: Because natural gas expands, if pipelines are damaged, natural gas can leak out. If there is natural gas in the air, it could catch fire or cause an explosion.

Balloon Activity: Setup: Have students wear goggles for the balloon experiment. Reflect*:* When baking soda and vinegar are mixed together, it creates a gas called carbon dioxide. (Carbon dioxide is the same gas that is produced by the human lungs and is a byproduct of our respiratory system. We breathe in oxygen and breathe out carbon dioxide.) The gas begins to expand in the bottle and starts to inflate the balloon. The more gas that is created, the more the balloon will inflate.

Going Further: Ask students if they think blowing a balloon up using their breath is faster or slower than with baking soda and vinegar. Why? If there is more vinegar and baking soda left to redo the activity, test it out!

Pages 14-15: Emergency Preparedness

Objectives: To help students and their families prepare in advance for power outages and to stay safe should a storm, flood, or other natural disaster strike.

Discussion: Ask students if they have ever experienced a serious storm that involved flooding, a long-term power outage, or an evacuation, or if they know someone who has. Have them share their stories with the class. Explain that being prepared ahead of time can make the stress of enduring such an event a lot easier and safer.

Ask students what things their families can do in advance to be prepared for a power outage. *(Purchase a solar or fuel-powered generator; solar or battery-powered lanterns or lights, radios, and chargers; install CO detectors on every floor to alert people if harmful CO gas accumulates when using alternative power sources for lights, heating, and cooking; have on hand a propane camp stove with fuel for cooking outdoors.)* What precautions should be taken involving natural gas during a flood? (*Check gas dryer vents and clear any snow, ice, or debris. Clear snow, ice, and debris from gas meters, avoiding use of sharp objects, shovels, or a blower. Keep clear the path to your gas meters so that first responders can shut off the gas in an emergency and utility workers can have access as well).*

Going Further: Encourage students to assemble an Emergency Kit with their parents/guardians and siblings. Have them report on their progress with the kit, as well as the preparedness tips on p. 14.

Back Cover: Home Safety Inspection
Objective: To encourage students to discuss natural gas safety with their families.

Background/Discussion: Why should you carry out a home safety inspection? *(You might find something hazardous in your home that could be fixed.)*

Explain each of the hazards in this list. Ask students if they can explain why it is a hazard. *(1. Small children playing near the range or other natural gas appliances is dangerous. They could accidentally ignite a fire or turn the gas on by mistake. 2. People digging without first having called 811 could dig into the natural gas*

pipeline, causing the gas to leak out and become a fire hazard. 3. Natural gas ovens are designed to cook food, not to heat rooms. Using your oven to heat the kitchen could damage the oven and produce gases that are dangerous to breathe, such as carbon monoxide. 4. A yellow flame on a gas range should be checked by a qualified repairperson, as it could indicate a gas leak and be a fire hazard. 5. Papers, clothing, curtains, and flammable liquids stored near open flames or heaters could catch fire. 6. If chimney flues and appliance vents get clogged, the results could include a fire hazard, health risks from dangerous fumes, and/or damage to appliances. 7. Laundry hung to dry on gas or water pipes could loosen pipe connections and cause a gas leak.)

Homework: Ask students to take this inspection checklist home and do the inspection with their families. Ask students to report what natural gas hazards, if any, they found in their homes and whether/how their family fixed the hazard.

Follow-up Discussion: Can you think of any other items you could add to this safety inspection checklist?