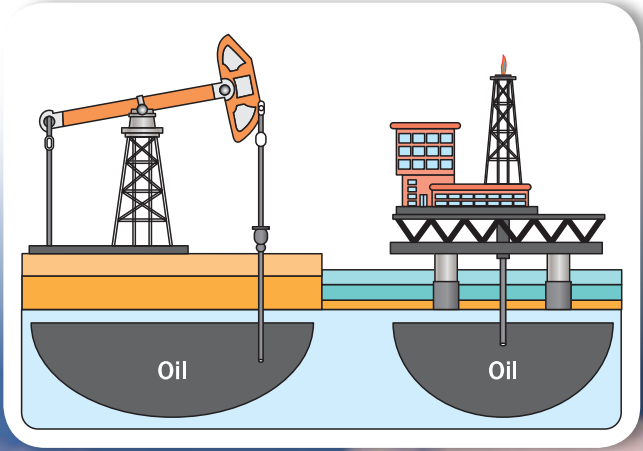
Core Knowledge® Science

Using Natural Resources for Energy

Teacher Guide



Energy from fossil fuels

Hydroelectric energy

Wind energy

Using Natural Resources for Energy

Teacher Guide

Core Knowledge®

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Using Natural Resources for Energy

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Teacher Guide

Core Knowledge Science™ 4

UNIT 5

Introduction

About this Unit

The Big Idea

This unit focuses on human use of nonrenewable and renewable natural resources for energy.

Students will learn about the renewable and nonrenewable resources that people use for energy and the uses of new technologies that protect the environment. We use energy every day of our lives. The sound energy from an alarm clock wakes us up. And if we ride to school in a regular bus, we use the energy from fossil fuels such as gasoline. Much of our electrical energy is generated at coal-burning or nuclear power plants as well.

The energy we use is derived ultimately from Earth's natural resources, which can be classified as either renewable or nonrenewable. Petroleum is extracted from the ground. Coal is mined from beneath the surface of Earth. Wind and solar energy are harnessed to power our energy needs as well. The extraction and use of natural resources must be done with care.

Our history has shown that the unwise use of resources can damage the air, land, and water around us. However, new and improved technology can lessen the environmental impact of extracting and using resources. And on the individual level, people can do many things to protect the environment and ensure that nonrenewable resources continue to be available.

Note to Teachers and Curriculum Planners

This unit introduces Grade 4 students to real-world examples and fundamental concepts that will be explored in greater depth in later grades. Students will learn about how energy and fuels are derived from natural resources. The following are preliminary considerations for planning and instruction relative to this unit:

- Examples of renewable energy found in this unit include wind, solar, and hydroelectric technologies. This unit extends learning from CKSci Grade 4 Unit 1, *Energy Transfer and Transformation*.
- Nonrenewable energy sources learned in this unit include fossil fuels and fissile materials (nuclear energy); however, the exact mechanism of fission is not part of the unit's learning objectives.
- Students investigate cause-and-effect relationships between habitats and human use of resources during this unit. Based on their learning across the unit, the focus extends prior knowledge, such as that from CKSci Grade 3 Unit 3, *Habitats and Change*, in order for students to combine and communicate information about the costs and benefits of different types of energy resources.

Note to Core Knowledge Teachers

Thanks to ongoing research in the field, our understanding of how children learn continues to evolve. In the subject area of science, in particular, students benefit from not just reading about concepts and ideas, but also hands-on experiences. Following the release of the Next Generation Science Standards (NGSS), the Core Knowledge Foundation used this opportunity to update and enhance the science portion of the *2010 Core Knowledge Sequence*. The result of this effort is the revised *2019 Core Knowledge Science Sequence*.

While there have been some shifts in the grade levels at which certain topics are recommended, the fundamental principles of pedagogy inherent to the Core Knowledge approach, such as the importance of building a sequential, coherent, and cumulative knowledge base, have been retained.

Online Resources

To download the *2019 Core Knowledge Science Sequence*, use the links found in the Online Resources Guide.

www.coreknowledge.org/cksci-online-resources

This science unit, aligned to the *2019 Core Knowledge Science Sequence* and informed by NGSS, embodies Core Knowledge's vision of best practices in science instruction and knowledge-based schooling, such as the following:

- building students' knowledge of core ideas in life, physical, and Earth sciences, as well as engineering design
- developing scientific practices that give students firsthand experience in scientific inquiry, engineering, and technology
- connecting scientific learning to concepts across various disciplines, such as mathematics and literacy

To see how you can continue to use your current Core Knowledge materials with the 2019 CKSci™ curriculum, please see below an example of how this unit compares to the *2010 Core Knowledge Sequence*.

Examples of content retained from the *2010 Core Knowledge Sequence*	**Examples of Core Knowledge content in this CKSci unit**
Ecology (Grade 3) • Threats to the environment • Measures to protect the environment **Energy (Grade 6)** • The many forms of energy are interchangeable, for example, gasoline in a car, windmills, and hydroelectric plants. • Sources of energy: for example, heat (coal, natural gas, solar, atomic, geothermal, and thermonuclear), mechanical motion (such as falling water, wind) • Fossil fuels: a finite resource	**Natural Resources** • Humans use natural resources to provide energy for much of modern life. • Examples: using coal, wind, and water to produce electricity; oil and wood for heating; and gasoline to fuel cars **Using Renewable and Nonrenewable Resources** • Fossil fuels: materials burned to produce heat; formed from the remains of once-living organisms • New and improving technologies for using renewable resources for energy • Environmental risks of using any type of resource
For a complete look at how CKSci relates to the 2010 *Sequence*, please refer to the full Correlation Charts available for download using the Online Resources Guide for this unit: **www.coreknowledge.org/cksci-online-resources**	

Problem-Based Learning Projects

This unit is a **CKSci Problem-Based Learning Unit** (PBL, also known as **Project-Based Learning**).

In this pedagogical approach, lessons culminate in a capstone project that occurs at the end of the unit. Each lesson includes guidance for teachers to connect individual objectives to the capstone experience.

One key aspect of the CKSci Problem-Based Learning Units is that students engage with their community—that is, the capstone project is presented to an audience beyond the classroom. The audience is often defined by the students themselves. The audience may include other classes at your school, parents/guardians, school principals, and/or scientists and engineers in your area. The goal is for the community to help determine how well students have applied their knowledge as they communicate possible solutions to real-world problems.

Advance preparation is critical to the success of a **CKSci Problem-Based Learning Unit**. Please refer to the recommendations found throughout the lessons of this Teacher Guide. The goal of this unit is for students to present solutions based on what they learn across multiple lessons and to interact with their community during and after their culminating presentations.

What are the relevant NGSS Performance Expectations for this unit?*

This unit, *Using Natural Resources for Energy*, has been informed by the following Grade 4 Performance Expectations for the NGSS topic *Energy*. Students who demonstrate understanding can

4-ESS3-1 Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Online Resources

For detailed information about the NGSS references, follow the links in the Online Resources Guide for this unit. Use the following link to download any of the CKSci Online Resources Guides:

www.coreknowledge.org/cksci-online-resources

*NEXT GENERATION SCIENCE STANDARDS (NGSS) is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards were involved in the production of this product, and their endorsement is not implied.

Sources:

NGSS Lead States. 2013. *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.

National Research Council. 2012. *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Committee on a Conceptual Framework for New K–12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

What Students Should Already Know

The concept of progressions, articulated in the National Research Council's *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*, is very much aligned to the Core Knowledge principle of building new knowledge on prior knowledge. According to the NRC, students build "progressively more sophisticated explanations of natural phenomena" over the course of many years of schooling. "Because learning progressions extend over multiple years, they can prompt educators to consider how topics are presented at each grade level so that they build on prior understanding and can support increasingly sophisticated learning." In schools following NGSS recommendations, teachers can build on the "prior understandings" captured in the following summaries of NGSS Disciplinary Core Ideas:

PS1.A: Structure and Properties of Matter

Grades K–2

- Different kinds of matter exist (e.g., wood, metal, water), and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties (e.g., visual, aural, textural), by its uses, and by whether it occurs naturally or is manufactured. Different properties are suited to different purposes.

PS1.B: Chemical Reactions

Grades K–2

- Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible (e.g., melting and freezing), and sometimes they are not (e.g., baking a cake, burning fuel).

PS3.A: Definitions of Energy

Grade 4

- Energy can be moved from place to place by moving objects or through sound, light, or electric currents.

PS3.B: Conservation of Energy and Energy Transfer

Grade 4

- Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy.

PS3.D: Energy in Chemical Processes and Everyday Life

Grade 4

- The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use.

LS2.A: Interdependent Relationships in Ecosystems

Grades K–2

- Animals depend on their surroundings to get what they need, including food, water, shelter, and a favorable temperature.

Grade 3

- Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles.

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

Grades K–2

- Organisms obtain the materials they need to grow and survive from the environment. Many of these materials come from organisms and are used again by other organisms.

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

Grades K–2

- The places where plants and animals live often change, sometimes slowly and sometimes rapidly. When animals and plants get too hot or too cold, they may die. If they cannot find enough food, water, or air, they may die.

Grade 3

- When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die.

LS4.C: Adaptation

Grades K–2

- Living things can survive only where their needs are met. If some places are too hot or too cold or have too little water or food, plants and animals may not be able to live there.

LS4.D: Biodiversity and Humans

Grade 3

- Populations live in a variety of habitats, and change in those habitats affects the organisms living there.

ESS1.B: Earth and the Solar System

Grades K–2

- Seasonal patterns of sunrise and sunset can be observed, described, and predicted.

ESS1.C: The History of Planet Earth

Grades K–2

- Some events on Earth occur in cycles, like day and night, and others have a beginning and an end, like a volcanic eruption. Some events, like an earthquake, happen very quickly; others, such as the formation of the Grand Canyon, occur very slowly, over a time period much longer than one can observe.

ESS2.D: Weather and Climate

Grade 3

- Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next.
- Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years.

ESS2.E: Biogeology

Grades K–2

- Plants and animals (including humans) depend on the land, water, and air to live and grow. They in turn can change their environment (e.g., the shape of land, the flow of water).

ESS3.A: Natural Resources

Grades K–2

- Living things need water, air, and resources from the land, and they try to live in places that have the things they need. Humans use natural resources for everything they do: for example, they use soil and water to grow food, wood to burn to provide heat or to build shelters, and materials such as iron or copper extracted from Earth to make cooking pans.

ESS3.C: Human Impacts on Earth Systems

Grades K–2

- Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things—for example, by reducing trash through reuse and recycling.

ETS1.A: Defining and Delimiting Engineering Problems

Grade 3

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

Grade 4

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

ETS1.B: Developing Possible Solutions

Grade 3

- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.

ETS2.A: Interdependence of Science, Engineering, and Technology

Grades K–2

- People encounter questions about the natural world every day. There are many types of tools produced by engineering that can be used in science to help answer these questions through observation or measurement. Observations and measurements are also used in engineering to help test and refine design ideas.

ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World

Grades K–2

- People depend on various technologies in their lives; human life would be very different without technology. Every human-made product is designed by applying some knowledge of the natural world and is built by using materials derived from the natural world, even when the materials are not themselves natural—for example, spoons made from refined metals. Thus, developing and using technology has impacts on the natural world.

What Students Need to Learn

For this unit, the *Core Knowledge Science Sequence* specifies the following content and skills. Specific learning objectives are provided in each lesson throughout the unit. NGSS References, including Performance Expectations, Disciplinary Core Ideas, and Crosscutting Concepts, are included at the start of each lesson as appropriate.

A. Problem-Based Learning Introduction — Lesson 1

- Understand the essential goals of a cost-benefit analysis.

B. Natural Resources: Renewable and Nonrenewable — Lessons 2–3

- Gather information to compare the sources and uses of specific natural resources.
- Identify natural resources as renewable or nonrenewable.
- List examples of renewable resources.
- Identify coal, oil, and natural gas as fossil fuels.

C. Using Nonrenewable Resources for Energy — Lessons 4–8

- Combine information to trace the movement of a fossil fuel (coal, gasoline, oil, or natural gas) from its natural origin to its uses in everyday life.
- Create a diagram to explain how electricity is generated from coal.
- Gather information to communicate the environmental risks of using specific fossil fuels.
- Describe the origins of fossil fuels, such as coal, oil, and natural gas.
- Compare the processes of refining coal and natural gas.
- Identify at least three ways petroleum is used in everyday life.
- Describe the environmental benefits and risks of using nuclear power.

D. Using Renewable Resources for Energy — Lessons 9–17

- Gather information to compare the environmental benefits and risks of using renewable resources for energy to using fossil fuels and nuclear fuels.
- Identify technologies that help reduce the negative effects of resources used for energy.
- Compare the process of obtaining and using a fossil fuel to that of obtaining and using a renewable resource.
- Identify a community/audience, and share findings of a cost-benefit analysis.

E. Sharing the Costs and Benefits of Natural Resource Use — Unit Capstone

- Share findings about costs and benefits of natural resource use with a community.

What Teachers Need to Know

Supportive information on the content standards and the science they address is provided throughout the lessons at points of relevance:

Know the Standards: These sections, found later in this Teacher Guide, explain what to teach and why, with reference to NGSS and Core Knowledge expectations.

Know the Science: These sections provide supporting, adult-level, background information or explanations related to specific examples or Disciplinary Core Ideas.

Using the Student Reader

Student Reader

The *Using Natural Resources for Energy* Student Reader has nine chapters and a student Glossary providing definitions to Core Vocabulary words. Engaging text, photographs, and diagrams encourage students to draw upon their own experiences and the world around them to understand scientific concepts. In addition to Core Vocabulary, the Student Readers include a feature called Word to Know, which provides background information to help students understand key terms, and may sometimes include additional informational boxes, such as Think About.

Explore, then read: In the CKSci program, lessons are sequenced to provide active engagement before reading. First, students explore phenomena through hands-on investigations or teacher demonstrations, accompanied by active questioning and analysis; then, students study the informational text provided in the Student Readers. The icon shown at left will signal Core Lesson segments that focus on Student Reader chapters.

CKSci Student Readers extend, clarify, and confirm what students have learned in their investigations. The text helps students develop a sense of the language of science, while images, diagrams, charts, and graphs deepen conceptual understanding. Use of the CKSci Student Readers supports the Science and Engineering Practice "Obtaining, Evaluating, and Communicating Information" as described in *A Framework for K–12 Science Education*.

Independent reading or group read-aloud: While the text in the Student Readers is written for independent reading, we encourage group read-alouds and engagement with the text. The Teacher Guide provides Guided Reading Supports to prompt discussion, clarify misconceptions, and promote understanding in relation to the Big Questions.

Pacing

The *Using Natural Resources for Energy* unit is one of five units in the Grade 4 CKSci series. To meet NGSS Performance Expectations, we encourage teachers to complete all units during the school year. To be sure all NGSS Performance Expectations are met, each Core Lesson should be completed, and each requires thirty to forty-five minutes of instruction time. The time it takes to complete a lesson depends on class size and individual circumstances.

Within the Teacher Guide, the Core Lessons are divided into numbered segments, generally five or six, with approximate times listed per segment. The final segment is always a Check for Understanding, providing the teacher with an opportunity for formative assessment.

At the end of this Unit Introduction, you will find a Sample Pacing Guide on page 17 and a blank Pacing Guide on pages 18–19, which you may use to plan how you might pace the lessons, as well as when to use the various other resources in this unit. We strongly recommend that you preview this entire unit and create your pacing guide before teaching the first lesson. As a general rule, we recommend that you spend no more than twenty-one days teaching the *Using Natural Resources for Energy* unit so that you have time to teach the other units in the Grade 4 CKSci series.

The Core Lessons

- Lesson time: Each Core Lesson constitutes one classroom session of up to forty-five minutes. Understanding that teachers may have less instructional time, we show a time range of thirty to forty-five minutes per lesson. Teachers may choose to conduct all Core Lesson segments, totaling forty-five minutes; may choose to conduct a subset of the lesson segments; or may choose to spend less time per segment.
- Lesson order: The lessons are coherently sequenced to build from one lesson to the next, linking student engagement across lessons and helping students build new learning on prior knowledge.

PART	LESSON	BIG QUESTION
A. Problem-Based Learning Introduction	**1.** Introduction to Cost-Benefit Analysis	What is a cost-benefit analysis?
B. Natural Resources: Renewable and Nonrenewable (4-ESS3-1)	**2.** Renewable and Nonrenewable Resources	What is the difference between renewable and nonrenewable resources?
	3. Cost-Benefit Analysis Outline	What might a cost-benefit analysis of natural resource use look like?

C. Using Nonrenewable Resources for Energy (4-ESS3-1)	**4.** Types of Fossil Fuels	What are fossil fuels?
	5. Using Fossil Fuels (two class sessions)	What are some costs and benefits of using fossil fuels?
	6. Researching Fossil Fuels	Where can I find reliable information about costs and benefits of using fossil fuels?
	7. Nuclear Energy	What is nuclear power?
	8. Researching Nuclear Power	Where can I find reliable information about costs and benefits of using nuclear power?
D. Using Renewable Resources for Energy (4-ESS3-1)	**9.** Wind Energy	How do people use wind as a source of energy?
	10. Researching Use of Wind Turbines	Where can I find reliable information about costs and benefits of using wind as a source of energy?
	11. Hydroelectric Energy	How do people use moving water as a source of energy?
	12. Researching Use of Hydroelectric Power	Where can I find reliable information about costs and benefits of using moving water as a source of energy?
	13. Solar Energy	How do people use sunlight as a source of energy?
	14. Researching Use of Solar Energy	Where can I find reliable information about costs and benefits of using sunlight as a source of energy?
	15. Geothermal Energy	What is geothermal energy, and how do people use it?
	16. Researching Use of Geothermal Energy	Where can I find reliable information about costs and benefits of using geothermal energy?
	17. Energy Resource Innovations	What other energy resources are being developed?
E. Sharing the Costs and Benefits of Natural Resource Use	Analysis Report (three class sessions)	How can we summarize and share the findings in our research?

Activity Pages

Activity Pages

Black line reproducible masters for Activity Pages and a Unit Capstone, as well as an Answer Key, are included in Teacher Resources on pages 131–161. The icon shown to the left appears throughout the Teacher Guide wherever Activity Pages (AP) are referenced.

Students' achievement of the NGSS Performance Expectations is marked by their completion of tasks throughout the unit.

AP 1.1 Lesson 1—Project Evaluation Guide (AP 1.1)

AP 1.2 Lesson 1—What Is a Cost-Benefit Analysis? (AP 1.2)

AP 1.3 Lesson 1—Energy Research Take-Home Letter (AP 1.3)

AP 2.1 Lesson 2—Lesson 2 Check (AP 2.1)

AP 3.1 Lesson 3—Costs and Benefits Practice Sheet (AP 3.1)

AP 3.2 Lesson 3—Lesson 3 Check (AP 3.2)

AP 4.1 Lesson 4—Formation of Fossil Fuels (AP 4.1)

AP 4.2 Lesson 4—Fossil Fuel Diagram (AP 4.2)

AP 5.1 Lesson 5—Fossil Fuels Costs and Benefits (AP 5.1)

AP 5.2 Lesson 5—Electricity Diagram (AP 5.2)

AP 6.1 Lesson 6—Costs and Benefits of Fossil Fuels (AP 6.1)

AP 7.1 Lesson 7—Lesson 7 Check (AP 7.1)

AP 8.1 Lesson 8—Nuclear Power Costs and Benefits (AP 8.1)

AP 9.1 Lesson 9—Lesson 9 Check (AP 9.1)

AP 10.1 Lesson 10—Wind Power Costs and Benefits (AP 10.1)

AP 11.1 Lesson 11—Lesson 11 Check (AP 11.1)

AP 12.1 Lesson 12—Hydroelectric Power Costs and Benefits (AP 12.1)

AP 13.1 Lesson 13—Lesson 13 Check (AP 13.1)

AP 14.1 Lesson 14—Solar Power Costs and Benefits (AP 14.1)

AP 15.1 Lesson 15—Lesson 15 Check (AP 15.1)

AP 16.1 Lesson 16—Geothermal Energy Costs and Benefits (AP 16.1)

AP 17.1 Lesson 17—Lesson 17 Check (AP 17.1)

AP UC.1 Unit Capstone—How to Publish or Present Your Cost-Benefit Analysis (AP UC.1)

AP UC.2 Unit Capstone—Cost-Benefit Analysis (AP UC.2)

AP UC.3 Unit Capstone—Energy Resources Project Reflection (AP UC.3)

Online Resources for Science

Online Resources

For each CKSci unit, the Teacher Guide includes references to online resources (including external websites and downloadable documents) to enhance classroom instruction. Look for the icon on the left.

Use this link to download the CKSci Online Resources for this unit:

www.coreknowledge.org/cksci-online-resources

Teaching Strategies

Start with the familiar.

Lead with an experience. Begin each lesson with a demonstration, activity, or question about a phenomenon to engage students and focus their attention on the topic. Start with the familiar. Every science topic introduced to students relates in some way to their known world and everyday experiences. The purpose of every lesson is to build a bridge between what is familiar to students and broader knowledge about the way the world works.

Ask the Big Question.

At the beginning of each Teacher Guide lesson, you will find a Big Question and Core Lesson segment devoted to encouraging students to think about this question as they are introduced to new science content. Use this opportunity to engage students in conversation, to think about how their own real-world experiences relate to the topic, or to participate in a demonstration that relates to the Big Question.

Encourage scientific thinking.

Approach the lessons with students not as learning about science but as learning about the world with a scientific mind. Science learning models science practice.

Throughout the lessons, encourage students to ask questions about what they observe, do, and read. Record relevant questions in a prominent place in the classroom. Guide students back to these questions as opportunities to answer them emerge from readings, demonstrations, and activities.

Use continuous Core Vocabulary instruction.

As a continuous vocabulary-building strategy, have students develop a deck of vocabulary cards, adding a card for each Core Vocabulary term as it is introduced. Students can add illustrations and examples to the cards as their comprehension of terms expands. During instruction, emphasize Core Vocabulary terms and their meanings in context rather than relying on isolated drill for memorization of definitions. Students will be given the opportunity to preview Core Vocabulary words early in the lessons and to engage in Word Work activities toward the end of the lessons. Encourage students to come up with definitions in their own words and to use the words in their own sentences.

Core Vocabulary words for each lesson, as well as other key terms teachers are encouraged to use in discussing topics with students, are provided at the start of each lesson. You can find Core Vocabulary definitions in the Word Work lesson segments, as well as in the Glossary on pages 162–163.

Emphasize observation and experience.

Lessons employ various ways for students to learn, including watching, listening, reading, doing, discussing, and writing. To meet the NGSS Performance Expectations, which are multidimensional standards, students must not only gain factual knowledge associated with Disciplinary Core Ideas, but also *use* the content knowledge they acquire.

Use science practices.

Give students opportunities to discover new content knowledge through investigation and to use their new knowledge both in problem-solving exercises and as evidence to support reasoning. Students learn what science and engineering practices are by engaging in those same practices as they learn.

Core Lesson segments are designed to reinforce the idea of science as an active practice, while helping students meet NGSS Performance Expectations. Each lesson segment is introduced by a sentence emphasizing active engagement with an activity.

Make frequent connections.

Use a combination of demonstrations and reading materials, rich with examples, to help students recognize how the science concepts they are learning apply in their everyday lives. Prompt students to relate lesson content to their own experiences, to relate the new and unfamiliar to the familiar, and to connect ideas and examples across disciplines. Refer to the Crosscutting Concepts cited in the lessons, often included in the NGSS References listed at the start of each lesson.

Monitor student progress.

Use verbal questioning, student work, the Check for Understanding assessments at the end of each lesson and the Unit Capstone at the end of the unit (see pages 153–155) to monitor progress during each lesson and to measure understanding at the conclusion of the unit. Many lessons provide tips to help you support students who need further explanations or clarifications.

Effective and Safe Classroom Activities

Conducting safe classroom demonstrations and activities is essential to successful elementary science education. The following resources provide Core Knowledge's recommendations for developing effective science classroom activities.

These resources, included at the back of the Teacher Guide on pages 164–168, consist of the following:

- Classroom Safety for Activities and Demonstrations
- Strategies for Acquiring Materials
- Advance Preparation for Activities and Demonstrations
- What to Do When Activities Don't Give Expected Results

Online Resources

These resources may also be accessed within the CKSci Online Resources Guide for this unit, available at

www.coreknowledge.org/cksci-online-resources

Materials and Equipment

The unit requires a variety of materials to support various ways of learning (including doing, discussing, listening, watching, reading, and writing). Prepare in advance by collecting the materials and equipment needed for all the demonstrations and hands-on investigations.

Part A: Problem-Based Learning Introduction

Lesson 1

- sticky notes (2 per student)
- index cards for student vocabulary deck (2 per student)

Part B: Natural Resources: Renewable and Nonrenewable

Lesson 2

- bag of popcorn (or candy, pennies)
- pencils
- pieces of paper
- index cards for student vocabulary deck (4 per student)
- internet access and the means to project images/video for whole-class viewing

Lesson 3

- access to research materials
- internet access and the means to project images/video for whole-class viewing

Part C: Using Nonrenewable Resources for Energy

Lesson 4

- internet access and the means to project images/video for whole-class viewing

Lesson 5

- box (at least 6 inches deep)
- sand
- mud
- pebbles (or cat litter)

Lesson 5, continued

- black shoe polish (2 cans)
- tape
- sticks or pencils
- clear container or fish tank
- several plastic straws
- pin
- water
- index cards for student vocabulary deck (1 per student)
- internet access and the means to project images/video for whole-class viewing

Lesson 6

- access to the internet or library
- printed source materials about fossil fuels

Lesson 7

- index cards for student vocabulary deck (1 per student)
- internet access and the means to project images/video for whole-class viewing

Lesson 8

- access to the internet or library
- printed source materials about nuclear power

Part D: Using Renewable Resources for Energy

Lesson 9

- index cards for student vocabulary deck (1 per student)
- internet access and the means to project images/video for whole-class viewing

Lesson 10

- access to the internet or library
- printed source materials about wind energy

Lesson 11

- household materials to assemble a water wheel
- index cards for student vocabulary deck (2 per student)
- internet access and the means to project images/video for whole-class viewing

Lesson 12

- access to the internet or library
- printed source materials about hydroelectric power

Lesson 13

- solar oven materials: cardboard boxes, aluminum foil, polystyrene, newspaper, plastic wrap
- index cards for student vocabulary deck (2 per student)
- internet access and the means to project images/video for whole-class viewing

Lesson 14

- access to the internet or library
- printed source materials about solar power

Lesson 15

- index cards for student vocabulary deck (1 per student)
- internet access and the means to project images/video for whole-class viewing

Lesson 16

- access to the internet or library
- printed source materials about geothermal power

Lesson 17

- index cards for student vocabulary deck (3 per student)
- internet access and the means to project images/videos for whole-class viewing

Part E: Sharing the Costs and Benefits of Natural Resource Use

Capstone

- name tags for students and event attendees
- poster board
- old magazines for images
- internet access and the means to project online article for whole-class viewing

Sample Pacing Guide

The sample Pacing Guide suggests use of the unit's resources across a twenty-one-day period. However, there are many ways that you may choose to individualize the unit for your students, based on their interests and needs. You may elect to use the blank Pacing Guide on pages 18–19 to reflect alternate activity choices and alternate pacing for your class. If you plan to create a customized pacing guide for your class, we strongly recommend that you preview this entire unit and create your pacing guide before teaching the first lesson.

Online Resources

For a yearlong pacing guide, please use the link found in the Online Resources Guide for this unit. This yearlong view of pacing also includes information about how this CKSci unit relates to the pacing of other programs, such as CKLA and CKHG in the *Core Knowledge Curriculum Series*™.

www.coreknowledge.org/cksci-online-resources

TG–Teacher Guide; SR–Student Reader; AP–Activity Page

Week 1

Day 1	Day 2	Day 3	Day 4	Day 5
Introduction to Cost-Benefit Analysis TG Lesson 1 AP 1.1, 1.2, 1.3	*Renewable and Nonrenewable Resources* TG Lesson 2 SR Chapter 1 AP 2.1	*Cost-Benefit Analysis Outline* TG Lesson 3 AP 3.1, 3.2	*Types of Fossil Fuels* TG Lesson 4 SR Chapter 2 AP 4.1, 4.2	*Using Fossil Fuels* DAY 1 TG Lesson 5 SR Chapter 3 AP 5.1

Week 2

Day 6	Day 7	Day 8	Day 9	Day 10
Using Fossil Fuels DAY 2 TG Lesson 5 AP 5.1, 5.2	*Researching Fossil Fuels* TG Lesson 6 AP 6.1	*Nuclear Energy* TG Lesson 7 SR Chapter 4 AP 7.1	*Researching Nuclear Power* TG Lesson 8 AP 8.1	*Wind Energy* TG Lesson 9 SR Chapter 5 AP 9.1

Week 3

Day 11	Day 12	Day 13	Day 14	Day 15
Researching Use of Wind Turbines TG Lesson 10 SR Chapter 6 AP 10.1	*Hydroelectric Energy* TG Lesson 11 SR Chapter 6 AP 11.1	*Researching Use of Hydroelectric Power* TG Lesson 12 AP 12.1	*Solar Energy* TG Lesson 13 SR Chapter 7 AP 13.1	*Researching Use of Solar Energy* TG Lesson 14 AP 14.1

Weeks 4 and 5

Day 16	Day 17	Day 18	Days 19–21
Geothermal Energy TG Lesson 15 SR Chapter 8 AP 15.1	*Researching Use of Geothermal Energy* TG Lesson 16 AP 16.1	*Energy Resource Innovations* TG Lesson 17 SR Chapter 9 AP 17.1	*Analysis Report* TG Unit Capstone AP UC.1, UC.2, UC.3

Pacing Guide

Twenty-one days have been allocated to the *Using Natural Resources for Energy* unit to complete all Grade 4 science units in the *Core Knowledge Curriculum Series*™. If you cannot complete the unit in twenty-one consecutive days of science instruction, use the space that follows to plan lesson delivery on an alternate schedule.

Week 1

Day 1	Day 2	Day 3	Day 4	Day 5

Week 2

Day 6	Day 7	Day 8	Day 9	Day 10

Week 3

Day 11	Day 12	Day 13	Day 14	Day 15

Week 4

Day 16	Day 17	Day 18	Day 19	Day 20

Week 5

Day 21	Day 22	Day 23	Day 24	Day 25

Week 6

Day 26	Day 27	Day 28	Day 29	Day 30

Week 7

Day 31	Day 32	Day 33	Day 34	Day 35

Week 8

Day 36	Day 37	Day 38	Day 39	Day 40

PART A

Problem-Based Learning Introduction

Overview

Lesson	Big Question	Advance Preparation
1. Introduction to Cost-Benefit Analysis	What is a cost-benefit analysis?	Gather materials for preview of problem-based learning project. (See Materials and Equipment, page 15.)

Part A: What's the Story?

The role of science is to provide information, often to policy makers. People debate about what to do with the information, and they then make policy decisions. Scientists and engineers are people who study a challenging problem or question, and what they learn is used to determine a course of action to solve the problem. Students learn more about this process by participating in a **problem-based learning project**, where they obtain and combine information to better understand the costs and benefits of different types of energy resources. Every lesson is designed to help students complete a unit culminating project in which they publish or present their findings to the community.

In Lesson 1, we start by setting the foundation for the remainder of the unit. Students begin by learning about the basics of a cost-benefit analysis, including making one of their own. They consider a problem and then look at and consider the costs and benefits associated with the problem. Finally, they compare these costs and benefits to determine the best solution to the problem. This will prepare them to address the NGSS Performance Expectations associated with this unit, including obtaining, evaluating, combining, and communicating information in preparation for the problem-based learning project.

So, to repeat, **the role of science is to provide information**. Help your students obtain and combine information to describe that energy and fuels are derived from natural resources and that their uses affect the environment, and you will lay the groundwork for meeting NGSS Performance Expectation 4-ESS3-1 addressed in the rest of this unit as well as beginning students on their problem-based learning project.

LESSON 1

Introduction to Cost-Benefit Analysis

Big Question: What is a cost-benefit analysis?

Problem-Based Learning Project: Investigate the costs and benefits of different types of energy resources, including renewable and nonrenewable, and propose the types best suited to implement locally.

At a Glance

Learning Objectives

- ✓ Define cost-benefit analysis.
- ✓ Identify and compare examples of pros and cons.
- ✓ Differentiate between verifiable facts and values-based opinions.

Lesson Activities

- problem-based learning introduction
- vocabulary instruction
- cost-benefit analysis exercise

NGSS References

Performance Expectation 4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Disciplinary Core Idea ESS3.A: Natural Resources

Crosscutting Concepts: Cause and Effect

Science and Engineering Practices: Obtaining, Evaluating, and Communicating Information

Obtaining, Evaluating, and Communicating Information will be important in this lesson as students are introduced to the problem that will serve as the main focus of this unit. Students will work toward obtaining, evaluating, and communicating quality information taken from multiple sources that will enable them to complete the problem-based inquiry culminating project. This lesson gives students an opportunity to practice doing a cost-benefit analysis of a concept that is familiar to them, with which they will need to evaluate and communicate the information they use in their analyses.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 162–163 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

analysis	fact	**pros and cons**
benefit	opinion	values
cost-benefit analysis		

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue above.

Instructional Resources

Activity Pages

AP 1.1
AP 1.2
AP 1.3

Activity Pages
Project Evaluation Guide (AP 1.1)

What Is a Cost-Benefit Analysis? (AP 1.2)

Energy Research Take-Home Letter (AP 1.3)

Decide how you will group students for this problem-based learning unit.

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- sticky notes (2 per student)
- index cards for student vocabulary deck (2 per student)

At the end of this lesson, students will perform a mock cost-benefit analysis based on a familiar scenario that you give to them. Prepare in advance for this activity by drawing a T-chart on the board or chart paper. The T-chart should contain one side with the heading "Costs" and one side with the heading "Benefits."

Advance Planning: Problem-Based Learning Project

Advance planning will be needed to carry out the unit culminating presentation event. Students may choose to prepare a presentation for their community. If so, they will need to identify invitees from your community, including other students, parents, and school administrators. You will also need to decide on a date and time that work for your class and school. Send out invitations as far in advance as possible. Be sure to allow students enough time to practice their presentations, especially using audiovisual tools. This will be revisited in the Unit Capstone lesson.

The Core Lesson 45 min

1. Focus student attention on the Big Question. 5 min

What is a cost-benefit analysis? Introduce students to this unit's **Problem-Based Learning Project**. Explain that this unit is different from all others. In this unit they will learn about the costs and benefits of using different types of energy resources. Every lesson in the unit develops student understanding of the issues surrounding different types of energy resources and culminates in a problem-based project. As students progress through the unit, they will research different energy resources and then determine which would be best for their community. At the end of the unit, they will publish or present their findings.

Present students with the following scenario that will engage them in the opening of this lesson: *Imagine that the school has the option of making your lunch period ten minutes longer each day.* Use the following questions to lead a whole-class discussion about the effects of extending the lunch period:

- » Why would a longer lunch period be good? (*gives students more time to eat and burn off their energy*)
- » Why would a longer lunch period be bad? (*cuts into learning time*)

Explain that most decisions that need to be made can have good effects as well as bad effects. For every decision, there is something that can be both good and bad about it. Tell students that they may have already heard of some of the common expressions used to think about decisions, such as the following:

- advantages and disadvantages
- benefits and drawbacks
- pros and cons

Tell students that they will learn more about these ways of weighing decisions in the lesson.

2. Teach Core Vocabulary. 10 min

Prepare Core Vocabulary Cards

Write these terms on the board. Have students write each term in the upper left corner of an index card and underline it (one term per card).

cost-benefit analysis **pros and cons**

Word Work

- **cost-benefit analysis:** (n. a study of the costs and benefits associated with an action) Explain to students that in this lesson, they will begin learning how to conduct a cost-benefit analysis. Ask students to write an example of a cost-

benefit analysis on their cards (example: a study to determine the costs and benefits of a new roadway). Then have volunteers share their examples, and discuss them as a class.

- **pros and cons:** (n. the benefits and costs of any factor being evaluated) Ask students if they have ever made a pros and cons list. Explain that pros and cons are often used to help people make decisions. Tell students to write down the following definition for *pro*: "something that is good; a positive." Then have them write down the following definition for *con*: "something that is bad; a drawback." Explain the parallels between pros and cons and benefits and costs.

3. Preview the unit capstone project. 10 MIN

Activity Pages

AP 1.1
AP 1.2

Introduce the problem-based inquiry project that will serve as the basis for this entire unit: **Develop a cost-benefit analysis examining human uses of several types of natural resources for energy.**

Explain that in this unit, students will learn about the many ways that humans use natural resources for energy. They will collect information from multiple sources that they can use to help them with their final project. At the end of the unit, they will complete a project where they make a cost-benefit analysis to examine the ways that natural resources are used. (See **Know the Science**.)

Distribute Project Evaluation Guide (AP 1.1). Explain that throughout this unit, students will be developing the knowledge they will need to perform a cost-benefit analysis and make a final product that details the costs and benefits of using natural resources. Review the "expert" level for each skill/row. Allow students to ask questions. (See **Know the Standards**.)

Know the Science

How do scientists use cost-benefit analyses? *To help society make good decisions.* The role of science is to inform. A cost-benefit analysis of scientific information gives insight into the risks and benefits associated with a particular decision, which can then be used to influence policies or laws that affect nature and society.

Know the Standards

Influence of Science, Engineering, and Technology on Society and the Natural World is an NGSS Connection to Engineering, Technology, and Applications of Science. This problem-based learning science unit supports understanding that "Engineers improve existing technologies or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands." Throughout this unit, students will analyze the benefits and risks associated with various natural resources based on the impact they have on humans and environmental systems. In the capstone lesson, students will conduct a cost-benefit analysis and publish it to a community audience to describe the various effects of using natural resources.

Distribute What Is a Cost-Benefit Analysis? (AP 1.2). It is a study of the costs and benefits associated with an action. Tell students that you will go over the Activity Page questions together and students will take notes to learn about a cost-benefit analysis. Let students know that they can hold onto these Activity Pages and use them to refer back to throughout the unit (you will not be collecting them).

Go through the questions on the top half of the Activity Page one at a time, giving students a chance to write their notes onto the blank lines. Make sure to cover the following:

- A cost-benefit analysis is used when trying to better understand a solution to a problem.
- A cost-benefit analysis looks closely at the strengths and weaknesses of a solution.
- A cost-benefit analysis looks at any possible alternatives to a solution.

    SUPPORT—Ask: Why is it important to look at the alternatives to a solution? (*so you can see if there are better solutions that weren't thought of yet*)

Tell students that there are different ways that they can present their final cost-benefit analysis projects. They will have the freedom to decide what they want to make. Some ideas include a brochure or a poster. Let students know that they will receive more information on how to make their final cost-benefit analyses as they work through this unit.

CHALLENGE—If time permits, challenge students to work with a neighbor to discuss what an analysis is. Prompt students to define *analysis* with an emphasis on the difference between verifiable facts and values-based judgments.

4. Practice doing a cost-benefit analysis. 10 MIN

Activity Page

AP 1.2

Direct student attention to the bottom half of Activity Page 1.2. Tell them that they will now do a cost-benefit analysis based on a scenario that you give them.

Pass out two sticky notes to each student. Give students the following scenario: *Your school has decided to eliminate homework because some research has shown that it is more valuable for students to spend their time outside of the classroom on things such as social and family activities rather than studies. As a result, students will have slightly shorter recess breaks during the school day to allow for more in-class learning time.*

Tell students to use the guide on Activity Page 1.2 to conduct a cost-benefit analysis of the scenario. For their activity, students should do the following:

- Write down one cost of this decision on one sticky note.

    SUPPORT—If needed, prompt students to think about why this might be a bad idea.

- Write down one benefit of this decision on the other sticky note.

SUPPORT—If needed, prompt students to think about why this might be a good idea.

For this particular activity, students do not need to come up with a sticky note that lists the alternatives to the decision, even though this is a normal part of conducting a cost-benefit analysis.

Show students where to paste their sticky notes on the T-chart when they are finished.

Circulate around the room as students work on their cost-benefit analyses. You may need to repeat the scenario a couple of times in order for students to remember the information they need to do their analyses.

5. Summarize and discuss. 5 MIN

Activity Page

AP 1.3

Bring the class back together once all students have had a chance to post their sticky notes onto the T-chart. Quickly read through the answers that students posted in each column, pointing out similarities and patterns.

Address any misunderstandings of costs and benefits, such as if students placed their sticky notes in the wrong column of the T-chart or if students did not seem to understand the meaning of *cost* and *benefit*.

Distribute one copy of Energy Research Take-Home Letter (AP 1.3) to each student. Read the letter with the class, and answer any questions students may have. Have students take the letters home to share with their parents or guardians.

6. Check for understanding. 5 MIN

Activity Pages

AP 1.1
AP 1.2
AP 1.3

Formative Assessment Opportunity

Allow students to keep Activity Pages 1.1, 1.2, and 1.3, as they may need to refer back to these in future lessons.

Problem-Based Learning Progress

Review progress students have made in learning about costs and benefits. They have

- learned how to conduct a cost-benefit analysis.
- conducted a test cost-benefit analysis.
- previewed the unit capstone project.

Explain that in Lessons 2–17, students will learn more about renewable and nonrenewable resources so that they can develop an informed cost-benefit analysis of energy resources in their area.

PART B

Natural Resources: Renewable and Nonrenewable

Overview

Lesson	Big Question	Advance Preparation
2. Renewable and Nonrenewable Resources	What is the difference between renewable and nonrenewable resources?	Read Student Reader, Chapter 1.
3. Cost-Benefit Analysis Outline	What might a cost-benefit analysis of natural resource use look like?	Gather materials for problem-based learning project. (See Materials and Equipment, page 15.)

Part B: What's the Story?

As part of their **problem-based learning project**, students learned in Part A (Lesson 1) about the costs and benefits associated with every decision a person or group makes. Students also compared the costs and benefits of extending the lunch hour, considering which was better: making the lunch hour longer or leaving it as is.

In Part B (Lessons 2–3), students take a closer look at costs and benefits and how they apply to renewable and nonrenewable resources. More importantly, students learn more about how to make a cost-benefit analysis and research to find information that will influence the outcome of their analysis.

In Lesson 2, we start by reading about and discussing examples of renewable and nonrenewable resources that are used for energy. Students come to an understanding that some resources cannot be replenished quickly enough before being exhausted while others can be. As a result, students begin their problem-based learning project by asking the question or trying to solve the challenging problem of what can be done to meet our future energy needs.

In Lesson 3, students learn more about cost-benefit analyses, including how to conduct research and make comparisons. As part of their problem-based learning project, they also come to an understanding of how to obtain and evaluate information and what *scientific consensus* means.

So, to repeat, **humans must obtain and evaluate the costs and benefits associated with each type of natural resource used to meet our energy needs**. Help your students obtain and combine information to describe that energy and fuels are derived from natural resources and that their uses affect the environment, and you will lay the groundwork for meeting the NGSS Performance Expectation 4-ESS3-1 addressed in the rest of this unit as well as continuing the problem-based learning project.

LESSON 2

Renewable and Nonrenewable Resources

Big Question: What is the difference between renewable and nonrenewable resources?

Problem-Based Learning Project: Learn more about renewable and nonrenewable resources, as well as their costs and benefits to society and the environment, in anticipation of the unit capstone project.

At a Glance

Learning Objectives

- ✓ Gather information to compare the sources and uses of specific natural resources.
- ✓ Identify natural resources as renewable or nonrenewable.
- ✓ List examples of renewable resources.

Lesson Activities

- optional videos
- optional game
- reading and discussion
- vocabulary instruction

NGSS References

Performance Expectation 4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Disciplinary Core Idea ESS3.A: Natural Resources

Crosscutting Concepts: Cause and Effect

Science and Engineering Practices: Obtaining, Evaluating, and Communicating Information

Cause and Effect is important for this lesson because different types of resources, including renewable resources and nonrenewable resources, have different effects on the environment.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 162–163 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

biosphere	**nonrenewable resource**	**renewable resource**
electricity	radioactivity	sustainable
fossil fuel		

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue above.

Instructional Resources

Student Reader

Ch. 1

Activity Page

AP 2.1

Student Reader, Chapter 1
"Renewable and Nonrenewable Resources"

Activity Page
Lesson 2 Check (AP 2.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- bag of popcorn (or candy, pennies)
- pencils
- pieces of paper
- index cards for student vocabulary deck (4 per student)
- internet access and the means to project images/video for whole-class viewing

The Core Lesson 45 min

1. Focus student attention on the Big Question. 5 min

What is the difference between renewable and nonrenewable resources?
Explain to students that this lesson is part of a **Problem-Based Learning Project**. As a result, this unit is different from all others. In it, they will learn about the costs and benefits of using different types of energy resources. Every lesson in the unit develops student understanding of the issues surrounding different types of energy resources and culminates in a problem-based learning project. As students progress through the unit, they will research different energy resources and then determine which would be best for their community. At the end of the unit, they will publish or present their findings.

Explain to students that in this lesson, they will compare renewable and nonrenewable resources as they prepare a cost-benefit analysis for their unit capstone project.

Write the Big Question on the board or chart paper.

- Circle the word *resources*, and ask students to describe what it means in their own words. (*something that can be used or is helpful*)
- Call on volunteers to give examples of resources. (*water, electricity, wind, coal*)
- Circle the words *renewable* and *nonrenewable*. Tell students that all resources can be lumped into either of these two categories.
- Have students work with a neighbor and discuss what they each believe renewable and nonrenewable resources are based on what they understand the words *renewable* and *nonrenewable* to mean.

  SUPPORT—If needed, conduct this activity with the whole class instead of pairing students up, and focus on the meaning of one term at a time. Ask: What does it mean when something is renewable? (*It can be used again.*) What does it mean when something is not renewable? (*It can only be used once; it has a limit as to how many times it can be used.*)

Explain that students will learn about the difference between renewable and nonrenewable resources in their reading today.

2. Read and discuss: "Renewable and Nonrenewable Resources." 15 MIN

Student Reader

Ch. 1

Prepare to read together or have students read independently "Renewable and Nonrenewable Resources," Chapter 1 in the Student Reader. This chapter describes the difference between renewable resources and nonrenewable resources, including examples of each.

Preview Core Vocabulary Terms

Before students read, write these terms on the board or chart paper. Encourage students to pay special attention to these terms as they read:

electricity
fossil fuel
nonrenewable resource
renewable resource

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Include suggested questions and prompts:

Page 1

After reading, ask: Why are wood and solar energy renewable resources? (*They cannot be used up completely.*) Why is natural gas a nonrenewable resource? (*It cannot replenish itself quickly; it takes a long time to form more of it.*)

Page 2

After reading page 2, focus on the term *abundant*. Call on a volunteer to explain what this term means (*plenty of; available*). Ask: How can resources such as fossil fuels be abundant but not renewable? (*There can be plenty of a resource available to use, but it is not renewable because it takes a long time for it to replenish itself.*) How can a resource such as wind be renewable but not abundant? (*A resource can be renewable, but if it is not abundant, then that means there is not a lot of that resource to be used.*)

SUPPORT—If needed, explain to students what *abundant* means.

CHALLENGE—If time permits, have students work with a neighbor to come up with scenarios in which resources are

- abundant and renewable
- abundant and nonrenewable
- not abundant and renewable
- not abundant and nonrenewable

Students may need access to the internet to collect their answers.

Page 3

Prompt students to discuss different types of renewable resources. Ask: Without looking at your page, what are some renewable resources that are used for energy? (*wood, wind, water, sunlight, heat*)

SUPPORT—Draw student attention to the term *transformed* on the page. Make sure students are clear about the difference between the transformation of energy and the transfer of energy. Explain that the transformation of energy means that one type of energy becomes another form of energy. When energy is transferred, on the other hand, it goes from one thing or place to another while keeping its original form.

Draw student attention to the pictures on the page. Ask: What do old windmills and new turbines have in common? (*They both convert wind energy to mechanical energy.*) What do the old water-powered mills and the hydroelectric dams have in common? (*They both convert water energy to energy that can be used.*)

SUPPORT—If time permits, write the term *sustainable* on the board or chart paper. Help break down the meaning of this word by asking students to explain what *sustain* means. Then ask them how the meaning of the word changes by adding the suffix *-able*.

Page 4

Prompt students to discuss that renewable resources have drawbacks, even if the resources are beneficial to the environment and better for humans to use. Ask: What are some downsides to using renewable resources?

SUPPORT—You can provide more examples beyond the ones in the reading, such as disrupting where people are allowed to live.

Pages 5–8

Review these pages together since they focus on nonrenewable sources of energy. Ask students to explain the similarities and differences among petroleum, natural gas, coal, and nuclear power, including their benefits and drawbacks. Be sure to discuss the costs and benefits of these resources as well. Emphasize the costs and benefits of each resource as a way to point out their differences and similarities. You may choose to explain to students that nuclear energy is the result of a chain reaction, which occurs when the splitting of one atom causes other atoms to split and so on and so on.

SUPPORT—Draw a chart on the board or chart paper that allows students to graphically visualize the similarities and differences among petroleum, natural gas, and coal. Include the following information:

- where these types of resources are found and extracted
- how the resources are used
- why the resources are beneficial
- why the resources are harmful

CHALLENGE—Draw student attention to the illustrations on pages 5 and 7. Ask: What kind of negative effects do you think oil spills from extracting petroleum and pollution from burning coal can have? (*They can harm animals that live in the sea; they can pollute seawater.*) Do these effects impact humans? (*yes, because we rely on sea animals for food*)

Online Resources

SUPPORT—If time permits, show students a video of the inside of the Chernobyl Exclusion Zone, the site of the nuclear explosion that is referred to on page 8. (See the Online Resources for a link to a suggested video.) Ask: Although nuclear explosions such as the one in Chernobyl are not everyday occurrences, do you think using nuclear power is a good idea or a bad idea and why?

Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found.

www.coreknowledge.org/cksci-online-resources

3. Demonstrate examples and guide discussion. 10 MIN

Choose one or more of the following examples to stimulate further discussion. Analyze with students 1) the use of renewable and nonrenewable resources, 2) what makes a resource renewable or nonrenewable, and 3) whether or not the resources are abundant.

Option 1: Show a video of renewable energy. (See the Online Resources on the next page for a link to a suggested video.) Ask what students can observe in the video:

» What are examples of renewable energy sources? (*wind, solar, geothermal*)

» What is the percentage of renewable energy that people use? (*ten percent*)

» What is the most widely used type of energy by humans? (*fossil fuels*)

» What are the benefits of using renewable energy? (*no emissions, better for climate, can decrease pollution, better for health and environment, reliable and will not run out*)

» What are some downsides of using renewable energy sources? (*more difficult to generate as much power; disruption of ecosystems and habitats; intermittent availability of energy*)

Option 2: Show a video of fossil fuels. (See the Online Resources for a link to a suggested video.) Ask what students can observe in the video:

» Where do fossil fuels come from? (*inside Earth's crust*)

» Are fossil fuels renewable or nonrenewable? (*nonrenewable*)

» How do humans use fossil fuels? (*powering their homes, heating, transportation*)

» What happens if we run out of fossil fuels? (*It will take a long time for fossil fuels to replenish themselves since they are not renewable.*)

» How are fossil fuels bad for the environment? (*They cause pollution and emit greenhouse gases.*)

» What are some examples of fossil fuels that you read about? (*coal, petroleum, natural gas*)

Online Resources

Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to these resources may be found.

www.coreknowledge.org/cksci-online-resources

Option 3: Demonstrate the use of renewable resources by playing a game:

- Divide the class into small groups, and have each group meet around a table.
- Distribute the following materials to each group:
  - sixteen pieces of popcorn (or candy/pennies)
  - one pencil
  - one piece of paper
- Designate one person from the team to be the recorder.
- Tell students that the pieces of popcorn represent renewable energy.
- To play the game, have each student in the group take turns taking at least one piece of popcorn from the group's reserves to "use" as energy. Students can take as many pieces as they want. Explain that the energy (popcorn) in the reserves will be replenished based on how many pieces of popcorn are left over after each round.
- The recorder writes down how many pieces of popcorn are left over in the reserves at the end of each round.
- As students complete each round, circulate around the room, and replenish their renewable resources with more popcorn by half. For instance, if students have ten pieces of popcorn left over after a round, give them another five pieces of popcorn to use for the next round.
- Play the game for a total of six rounds.
- If students run out of reserves, they do not get their energy replenished and are out of the game.

- At the end of the game, the group with the most popcorn left over in their reserves wins.
- Discuss as a class the purpose of the game. Ask:
  - » What does this game show you about how renewable energy is used? (*It can be replenished; we keep getting more energy to use.*)
  - » What did you learn about using your energy? (*The more energy we had left over, the more energy was replenished; the more energy we used, the less energy was replenished.*)
  - » What happened if you used up all of your energy during one of the rounds? (*We didn't get any more energy.*)

4. Identify renewable and nonrenewable resources. 5 MIN

Give students a few minutes to work with a neighbor to make a list of where renewable and nonrenewable resources can be found in daily life and the local community. Invite teams to share their ideas as a whole class, and make a master list on the board or chart paper. Ask the following:

- » Why is it important to know where to find renewable and nonrenewable resources in daily life? (*so we know how much of them we are using*)
- » Do you think there are ways that the local community can use more renewable resources and fewer nonrenewable resources? (*yes*) What are some of those ways? (*finding ways to get more energy from sunlight; using more wind turbines*)

5. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary words. Have students write the words in the upper left corner of four index cards and underline them.

electricity **fossil fuel** **renewable resource** **nonrenewable resource**

Word Work

electricity: (n. a form of energy resulting from the flow of charged particles) Have volunteers discuss how they or their families have used electricity in real life. Then have them write examples of machines that use electricity on their cards (fans, televisions, radios, etc.). Ask volunteers to share their examples, and discuss whether any of the examples given can be fueled by other means (gas stoves vs. electric stoves; electric clocks vs. solar clocks; etc.).

fossil fuel: (n. a fuel formed from the fossilized remains of organisms) Have students look at each word in the term *fossil fuel* separately. Ask them to write down what the word *fossil* means (the petrified remains of a once-living organism). Then have

them write down what the word *fuel* means (a source of energy that helps meet our needs). Next, ask students to use the term *fossil fuel* in a sentence. (*Oil is one kind of fossil fuel*.) Have volunteers share their sentences with the class.

nonrenewable resource: (n. a resource that cannot be restored as quickly as it is used) Discuss the prefix *non-* with students. Explain that the prefix means "not" and is used to form adjectives, or words that help describe nouns. Remove the prefix from the word *nonrenewable*, and have students discuss how the meaning changes. But when the prefix *non-* is added to the beginning of the word *renewable*, it changes the meaning to the opposite of what it was before. Have students write a sentence using the term *nonrenewable resource*. (*Some resources are nonrenewable resources*.)

renewable resource: (n. a resource that can be restored more quickly than it is used up) Discuss the suffix *-able* with students. Explain that the suffix means "capable of" and is used to form adjectives, or words that help describe nouns. Remove the suffix from the word *renewable*, and have students focus on the term *renew*. *Renew* is a verb. But when the suffix *-able* is added to the end of the word *renew*, it changes its meaning. Have students write a sentence using the word *renewable resource*. (*Some resources are renewable resources*.)

As a whole class, brainstorm three to five words that have the suffix *-able*. (*teachable, capable, enjoyable, comfortable, reasonable*)

6. Check for understanding. 5 MIN

Activity Page

AP 2.1 and Answer Key

Formative Assessment Opportunity

Have students complete Lesson 2 Check (AP 2.1). Collect the assessment, and check students' answers to identify concepts with which they are still struggling. See the Activity Page Answer Key for correct answers and sample student responses. Incorporate adjustments as you open the next lesson. Provide additional guidance for students who need more support.

Problem-Based Learning Progress

Review progress students have made in learning how to compare the costs and benefits of renewable and nonrenewable sources of energy. They have learned about

- renewable resources of energy.
- nonrenewable resources of energy.

Explain that in Lesson 3, students will learn more about how to conduct a cost-benefit analysis and apply it to their unit capstone project.

LESSON 3

Cost-Benefit Analysis Outline

Big Question: What might a cost-benefit analysis of natural resource use look like?

Problem-Based Learning Project: As part of learning how to perform a cost-benefit analysis, students explore how to arrive at a consensus and what it means for sources of research to be reliable.

At a Glance

Learning Objectives

- ✓ Develop a plan to organize cost-benefit information.
- ✓ Learn what *consensus* means.
- ✓ Learn to identify reliable sources of information and recognize authorities.

Lesson Activities

- optional videos/photos
- role-playing
- discussion
- vocabulary instruction

NGSS References

Performance Expectation 4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Disciplinary Core Idea ESS3.A: Natural Resources

Crosscutting Concepts: Cause and Effect

Science and Engineering Practices: Obtaining, Evaluating, and Communicating Information

Obtaining, Evaluating, and Communicating Information is essential when conducting a cost-benefit analysis, which is the goal of this unit. Students must learn how to differentiate reliable sources of information from unreliable sources.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. No new Core Vocabulary terms are introduced in this lesson.

authority consensus cost-benefit analysis reliable

Instructional Resources

Activity Pages

AP 3.1

AP 3.2

Activity Pages
Costs and Benefits Practice Sheet (AP 3.1)

Lesson 3 Check (AP 3.2)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- access to research materials
- internet access and the means to project images/video for whole-class viewing

The Core Lesson 45 min

1. Focus student attention on the Big Question. 5 min

What might a cost-benefit analysis of natural resource use look like? Remind students that this lesson is part of the **Problem-Based Learning Project**. In this lesson, students continue to learn how to perform a cost-benefit analysis in support of the unit capstone project, which is to publish or present a cost-benefit analysis of energy resources in their area and to decide which one would best meet the community's needs.

Write the Big Question on the board or chart paper. Compare the hyphenated *cost-benefit* to other binary pairs of opposing terms, such as *up/down* and *good/bad*. Set up a T-chart on the board or chart paper with "Costs" and "Benefits" as the column heads. Ask a volunteer to name a natural resource that is used as a building material in construction. (*iron/steel, rock, wood*)

Select two resources that students name. Create rows in the T-chart, and place the resource names at their heads. (*e.g., wood, iron*)

As a whole class, discuss the costs and benefits of using wood and iron to build a house. Steer the discussion toward properties of these materials as well as how they are produced for use (from raw materials to building products). As costs and benefits are mentioned, categorize them, and plug them into the chart. (*Example costs of wood: flammable, not as strong as iron, renewable but can be harvested too quickly, trees provide habitat and other services; example benefits of wood: lightweight, fairly renewable, easier to cut and connect*)

> **SUPPORT**—Students may not be familiar with the properties of wood and iron. If possible, pass around small samples of equal size of the two materials. Even a toothpick and a steel nail would suffice.

Discuss what kinds of categories of costs and benefits you may have already identified, such as environmental, economic, or practical. Encourage students to think about how they can identify and apply these categories in this lesson and throughout the unit.

2. Reinforce with visual modeling. 5 MIN

Activity Page

AP 3.1

Distribute Costs and Benefits Practice Sheet (AP 3.1). Explain that there are two aspects, or dimensions, to consensus, which is when there is agreement on a subject. There can be a broad consensus, meaning there are a lot of people who agree about a given thing. There can also be deep consensus, meaning there are a lot of specific details that people agree on. Explain to students that they will research a real-world example of scientific consensus on a subject. When they do this at the end of the lesson, they will list at least two ways that scientists agree on the costs of the subject and two ways that scientists agree on the benefits of the subject.

3. Demonstrate examples and guide discussion. 10 MIN

Begin by showing students how internet search engines tend to work when default settings are applied. You can use virtually any search term here, but "climate change" and "vaccines" are likely to generate some politicized or otherwise countering results. Show students that some "hits" are advertisements and that these can sometimes be spotted. Tell them that ads should not be relied on for information, because the main goal of the ad is to sell something, not provide facts. Encourage students to rely on U.S. government sources of information, such as NASA, NOAA, and other agencies. Major news media can also be reliable, or trustworthy, but students should look for "opinion" or "editorial" or "op-ed" to determine if something they are about to read is from one person's point of view and potentially biased. It is also important for students to understand that some resources can be authorities on a subject. An authority is an expert. For example, a group of scientists who study climate change are a reliable authority on the subject.

Here are some other specific activities that will help students hone their senses so they can avoid nonreputable or fake sources of information:

- Provide some examples of both real and fabricated news stories that have scientific content. Discuss what distinguishes one from the other.
- Discuss social media and the prevalence of fake information in those media, including "memes" that may be amusing but are based on misleading context or manipulated images. Show some example of infamous fake photographs, such as the image of a naval helicopter with a rescue ladder deployed and a huge great white shark appearing to leap at the rescue diver dangling from the ladder.

Online Resources

Use this link to download the CKSci Online Resources Guide for this unit, where specific links to these resources may be found.

www.coreknowledge.org/cksci-online-resources

4. Role-play about resources. 15 MIN

Provide brief scripts for several students to read to the class. They should read the scripts as though they are trying to convince the class that what they are reading is factual, as a salesperson might do. The point here is to introduce students to the value of skepticism regardless of who is doing the talking or whether anything is really being sold. The following are examples of scripts and questions that should be asked of the audience after they have heard them:

- "Hello! I'm here to tell you about an exciting opportunity to switch from dirty, nonrenewable energy resources such as coal and oil to clean, renewable solar power! For no cost up front, my company, Heliocentric Technologies, can put a dozen solar panels on your house. These panels will meet up to seventy-five percent of your home's energy demands. An easy payment plan will allow you to slowly pay for these panels over ten years. You will basically make that money back in energy savings!"

  Ask: What are some reasons to be skeptical of what [student's name] said? (*They're selling something. There are no details about how much money it will cost. The claim about meeting seventy-five percent of the home's energy demands seems far-fetched or just a guess, not based on an energy assessment of an actual home.*)
- "I'm running for the town's select board, and I'd like your vote. The other candidate wants to put solar panels and wind turbines on all town-owned buildings within five years. That's a nice idea, but let's face it: the weather is too hard to predict in this area for solar and wind power to meet all of your home's energy needs. Coal is a reliable, time-tested source of energy. My grandfather and great-grandfather both worked in the coal mines, and I believe if we can restart the coal mining in this town, it will bring in money for our schools. Then, down the line, we can talk about switching to wind and solar."

  Ask: Does anything bother you about [student's name]'s claims? (*They seem to be biased by their family's history in the coal-mining business. They make claims without offering data or specifics.*)

Activity Page

AP 3.1

Now have students pick the subject they will research for Costs and Benefits Practice Sheet (AP 3.1). Have them fill out the sheet as they complete their research. Note that some students will not be able to determine which resources are reliable even after this activity. Circulate around the room as students conduct their research, answering questions and offering pointers to help them find reliable sources of information.

5. Outline cost-benefit analysis categories. 5 MIN

Circle back to the activity you did at the beginning of the lesson, in which you roughly outlined a cost-benefit analysis and identified categories of information about building materials. Discuss the different types of information that students should gather about energy resources in this unit as they build their cost-benefit analysis. Incorporate what they have learned about reliable, authoritative sources

of information so they will apply some skepticism and filter search results as they conduct research for the project. Give them some hypothetical scenarios in which they can apply what they have learned in this lesson:

- Which of the following would be reliable sources of information about the environmental costs of burning petroleum-based fuels?
  - a group that advocates for the oil industry (*no*)
  - a major U.S. government agency (*yes*)
  - a group on social media that opposes fossil fuels (*no*)
  - a major news organization (*possibly*)
- Which of the following would be reliable sources of information about the benefits of nuclear power?
  - a large mining company (*no*)
  - a major news organization (*possibly*)
  - an opinion piece in a newspaper (*no*)

6. Check for understanding. 5 MIN

Activity Page

AP 3.2 and Answer Key

Formative Assessment Opportunity

Have students complete Lesson 3 Check (AP 3.2). Collect the assessment, and check students' answers to identify concepts with which they are still struggling. See the Activity Page Answer Key for correct answers and sample student responses. Incorporate adjustments as you open the next lesson. Provide additional guidance for students who need more support.

Problem-Based Learning Progress

Review progress that students have made in developing their cost-benefit analysis. They have

- continued learning about cost-benefit analysis.
- learned what constitutes reliable and trustworthy sources.

Explain that in Lessons 4–17, students will apply what they have learned about cost-benefit analysis to researching different types of renewable and nonrenewable resources that might meet their community's energy resource needs.

PART C

Using Nonrenewable Resources for Energy

Overview

Lesson	Big Question	Advance Preparation
4. Types of Fossil Fuels	What are fossil fuels?	Read Student Reader, Chapter 2.
5. Using Fossil Fuels (2 days)	What are some costs and benefits of using fossil fuels?	Read Student Reader, Chapter 3.
6. Researching Fossil Fuels	Where can I find reliable information about costs and benefits of using fossil fuels?	Gather materials for problem-based learning project. (See Materials and Equipment, page 15.)
7. Nuclear Energy	What is nuclear power?	Read Student Reader, Chapter 4.
8. Researching Nuclear Power	Where can I find reliable information about costs and benefits of using nuclear power?	Gather materials for problem-based learning project. (See Materials and Equipment, page 15.)

Part C: What's the Story?

In Part B (Lessons 2–3), students learned the basics about natural resources used for energy, as well as about their costs and benefits. Students also learned how to make a cost-benefit analysis and obtain information by conducting research, determining which sources are factual and which are not.

In Part C (Lessons 4–8) and as part of their **problem-based learning project**, students will continue to ask questions about nonrenewable natural resources used for energy, as well as obtain and evaluate that information for a cost-benefit analysis.

In Lesson 4, we start by having students read and learn about different kinds of fossil fuels—which are nonrenewable—how they provide energy, and their effects on the environment. Students also choose one fossil fuel and draw how it forms, as well as complete a Venn diagram to show how fossil fuels are similar to and different from each other.

In Lesson 5, students read and learn about the specifics of harvesting fossil fuels for energy use. These include the ways that fossil fuels such as petroleum, coal, and natural gas are taken from the ground, transported over long distances, and used. It also covers many of the costs and benefits of those fuels. Students are then expected to model how energy from coal is turned into electricity and explain some of the pros (benefits) and cons (costs) of using fossil fuels to meet our energy needs.

In Lesson 6, students are tasked with researching additional information about fossil fuels, how they're used, and their costs and benefits. More importantly, as part of their problem-based learning project, students must evaluate their sources to determine whether the sources are authentic, or factual, and appropriate for use. Students then evaluate the information found in each source and make a record of the information they consider trustworthy.

In Lesson 7, students read and learn more about nuclear energy, how it is developed, how it is used, and some of the costs and benefits. At the end of the lesson, students complete a Lesson Check to reinforce main ideas through repetition and sustained inquiry.

In Lesson 8, which concludes Part C, students continue their sustained inquiry by researching additional information about nuclear energy. As with Lesson 6, students are expected to evaluate their sources to determine whether the sources are authentic, or factual, and appropriate for use. Students then evaluate the information found in each source and make a record of the information they consider trustworthy.

So, to repeat, **nonrenewable resources for energy have costs and benefits, and understanding those costs and benefits means obtaining and evaluating authentic sources of information**. Help your students obtain and combine information to describe that some energy and fuels are derived from nonrenewable natural resources and that their uses affect the environment, and you will lay the groundwork for meeting the NGSS Performance Expectation 4-ESS3-1 as well as help students on their problem-based learning project.

LESSON 4

Types of Fossil Fuels

Big Question: What are fossil fuels?

Problem-Based Learning Project: Investigate different types of fossil fuels to learn more about their costs and benefits.

At a Glance

Learning Objectives

- ✓ Identify types of fossil fuels.
- ✓ Describe the formation of petroleum, coal, and natural gas.

Lesson Activities

- reading and discussion
- vocabulary instruction
- optional video
- optional diagramming and drawing activities

NGSS References

Performance Expectation 4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Disciplinary Core Idea ESS3.A: Natural Resources

Crosscutting Concepts: Cause and Effect

Science and Engineering Practices: Obtaining, Evaluating, and Communicating Information

Obtaining, Evaluating, and Communicating Information is important for this lesson because fossil fuels are derived from natural sources, even though they are not renewable resources. Students must be able to evaluate a resource and determine whether it is renewable or nonrenewable.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 162–163 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

crude oil	**fossil fuel**	**nonrenewable resource**
decompose	natural gas	petroleum

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue above.

Instructional Resources

Student Reader

Ch. 2

Activity Pages

AP 4.1

AP 4.2

Student Reader, Chapter 2
"Types of Fossil Fuels"

Activity Pages
Formation of Fossil Fuels (AP 4.1)

Fossil Fuel Diagram (AP 4.2)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- internet access and the means to project images/video for whole-class viewing

The Core Lesson 45 min

1. Focus student attention on the Big Question. 5 min

What are fossil fuels? Continue working on this unit's **Problem-Based Learning Project**. Remind students that this unit is different from all the others because it contains a single project that is designed to help them understand how to deal with a problem through a capstone project. In this lesson, students will learn more about specific types of fossil fuels, their costs, and their benefits. Explain that this will help them complete the project in the capstone lesson.

Review what students have learned about renewable and nonrenewable resources. Ask the following:

- What are renewable resources? (*resources that can be replenished and that do not run out*)
- What are nonrenewable resources? (*resources that cannot always be replenished because they run out*)
- What are examples of renewable resources? (*sunlight, wind, water, geothermal heat*)
- What are examples of nonrenewable resources? (*natural gas, coal, nuclear power*)
- What does it mean if a resource is in abundance? (*There is a lot of it.*)

SUPPORT—If needed, allow students to review "Renewable and Nonrenewable Resources," Chapter 1 in the Student Reader, as they answer the questions.

Explain that today students will focus on fossil fuels, which are nonrenewable resources.

2. Encourage student questions. 5 MIN

Lead a discussion about how people use energy. Ask: What are some ways that people use energy in their daily lives? (*cooking, cleaning, transportation, building things, computers and technology*) Prompt students to think about whether the types of things that people use energy for use mostly renewable or nonrenewable forms of energy. (*nonrenewable*) (See **Know the Science**.)

3. Read and discuss: "Types of Fossil Fuels." 15 MIN

Student Reader

Ch. 2

Prepare to read together or have students read independently "Types of Fossil Fuels," Chapter 2 in the Student Reader. This chapter describes the different types of fossil fuels, how they are formed, and their variations.

Know the Science

How much energy used by humans is nonrenewable? *About ninety percent of energy that humans use is nonrenewable!* According to the U.S. Energy Information Administration, approximately ninety percent of all energy that is used in the United States is nonrenewable, including petroleum, natural gas, coal, and nuclear power. Only about ten percent of the energy used in the United States is renewable, in the form of geothermal, solar, wind, biomass waste, biofuels, wood, and hydroelectric power. The largest industry for energy consumption is electric power, followed by transportation, industrial, residential, and commercial. The three major fossil fuels (petroleum, natural gas, and coal) accounted for a combined total of nearly seventy-eight percent of the primary energy production in the United States in 2017.

Preview Core Vocabulary Term

Before students read, write the term **fossil fuel** on the board or chart paper. Encourage students to use the term frequently as they discuss what they read. Inform students that they already encountered the term *fossil fuel* in "Renewable and Nonrenewable Resources," Chapter 1 in the Student Reader, but that today they will focus more closely on what fossil fuels really are.

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Include suggested questions and prompts:

Page 9

After reading, ask students to describe a fossil fuel in their own words. (*fuel that comes from within Earth*) Ask: If fossil fuels are found in Earth's crust, why are they considered nonrenewable resources? (*because they cannot be replenished quickly and their availability is limited*)

Page 10

After reading, ask: Why is it important for oil companies to constantly be looking for new places to dig up petroleum? (*Petroleum is a fossil fuel, which is a nonrenewable resource, so having an abundance of petroleum is important for being able to use it while it's still available*.)

SUPPORT—If needed, prompt students to reread the first paragraph about how fossil fuels, such as petroleum, are used.

Page 11

Discuss the term *decompose* in the first paragraph of the page. Remind students that they have already heard this term when learning about the cycling of energy and matter in ecosystems. Call on a volunteer to explain its meaning. (*To decompose is to break down, as in organic matter that becomes decayed over time and cycles back into the earth*.)

Prompt students to discuss the difference between the formation of coal and the formation of natural gas.

SUPPORT—If needed, draw a T-chart on the board or chart paper with one column for coal and another column for natural gas. Allow students to describe how these differ in the ways in which they are formed.

Page 12

After reading, ask: How do you think the varieties of fossil fuels affect the way they are used? (*Certain varieties may be more powerful than others and used for different things*.)

4. Demonstrate examples and guide discussion. 10 MIN

Online Resources

Activity Pages

AP 4.1
AP 4.2

Choose one or more of the following examples to stimulate further discussion. (If time permits, use all three, showing the video first.) Analyze with students 1) the different types of fossil fuels and 2) how fossil fuels are used.

Option 1: Show a video of fossil fuels. (See the Online Resources for a link to a suggested video.) Ask what students can observe in the video:

- What are the three main types of fossil fuels? (*petroleum, coal, and natural gas*)
- What do these types of fossil fuels have in common? (*They are found in Earth; they are nonrenewable resources; they are all used for energy.*)
- How do these types of fossil fuels differ? (*They are formed in different ways.*)
- How are fossil fuels used in everyday life? (*transportation, industry, plastic products, makeup, medicine*)

Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found.

www.coreknowledge.org/cksci-online-resources

Option 2: Have students work in pairs or independently to draw an illustration of how petroleum, coal, or natural gas is formed. Distribute Formation of Fossil Fuels (AP 4.1). Tell students they will use the drawing boxes on the page for their illustrations and will answer the questions after they complete their drawings. Invite students to share their illustrations with the rest of the class when they are finished. Ask the following:

- Which kind of fossil fuel formation did you portray in your picture?
- Can you describe how that fossil fuel is formed?
- What does your drawing show about how that fossil fuel is formed?

Option 3: Have students work in pairs or independently to complete a three-circle Venn diagram that compares the three fossil fuels: petroleum/oil, natural gas, and coal. Distribute Fossil Fuel Diagram (AP 4.2). Review with students the Venn diagram on the page.

SUPPORT—If needed, review with students how to complete a Venn diagram. Explain that the differentiating features of each fossil fuel should be written in the large space of the circle (model this for students). Then explain that the similarities between fossil fuels should be written in the smaller spaces of the circles, where the circles intersect with one another (model this for students). If continued support is needed, conduct this activity as a whole class, and use question prompts such as the following:

- What do petroleum, coal, and natural gas have in common? What is similar about them?
- How do these substances differ from one another?

Revisit Core Vocabulary Terms

Inform students that *fuel* can be used as both a noun and a verb. As a noun, fuel is a type of energy source. Ask volunteers to use *fuel* in a sentence, first as a noun and then as a verb. Write two sentences on the board or chart paper (one using *fuel* as a noun, the other as a verb). (*He added more fuel to his car so it would drive. Don't fuel the fire!*)

Have students withdraw their Core Vocabulary cards for **fossil fuel** and **nonrenewable resource**. On each, have students write or draw three examples. Discuss the examples with the class. Point out that in most cases, the examples were the same.

Have students safely store their deck of Core Vocabulary cards in alphabetical order. They will add to the deck in later lessons.

5. Summarize and discuss. 5 MIN

Discuss with students where they find and use fossil fuels in daily life and in their local community. Ask the following:

- What are some activities that you participate in that use fossil fuels? (*driving to school or riding the bus; using electricity; playing with toys that were made using fossil fuels*)
- Do you see fossil fuels being used in the local community? (*yes*) Where? (*homes, schools, businesses, stores, gas stations*)

6. Check for understanding. 5 MIN

Activity Pages

AP 4.1
AP 4.2
Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key for correct answers and sample student responses.

- Collect the completed Formation of Fossil Fuels (AP 4.1) and Fossil Fuel Diagram (AP 4.2). Scan the illustrations that students drew, the answers they wrote, and the Venn diagrams they completed.
- Invite student questions for a brief closing discussion. Use the discussion as an opportunity to reinforce main ideas about fossil fuels, such as that they are nonrenewable sources of energy, they can be abundant or not abundant, and they are found in Earth.

Problem-Based Learning Progress

Review progress students have made in analyzing the costs and benefits of fossil fuels, which are nonrenewable. They have

- learned about different types of fossil fuels.
- started research.
- begun the cost-benefit analysis for the unit capstone project.

Remind students that in Lessons 5–17, they will continue to combine what they learn about costs and benefits of different types of renewable and nonrenewable energy resources.

LESSON 5

Using Fossil Fuels

Big Question: What are some costs and benefits of using fossil fuels?

Problem-Based Learning Project: Investigate how fossil fuels are used to learn more about their costs and benefits.

At a Glance

Learning Objectives

- ✓ Combine information to trace the movement of a fossil fuel (coal, gasoline, oil, or natural gas) from its natural origin to its uses in everyday life.
- ✓ Gather information to compare and communicate the environmental benefits and risks of using renewable resources for energy or using fossil fuels and nuclear fuels.
- ✓ Identify technologies that help reduce the negative effects of resources used for energy.

Lesson Activities (2 days)

- reading and discussion
- vocabulary instruction
- optional video
- student diagraming

NGSS References

Performance Expectation 4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Disciplinary Core Idea ESS3.A: Natural Resources

Crosscutting Concepts: Cause and Effect

Science and Engineering Practices: Obtaining, Evaluating, and Communicating Information

Obtaining, Evaluating, and Communicating Information is important for this two-day lesson as students read about and gather information related to the extraction, transportation, and use of fossil fuels. The information students obtain will be evaluated to study the costs and benefits of using nonrenewable resources. Students will gain practice in communicating this information in preparation for their unit capstone product.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to this term, which is intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 162–163 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

greenhouse gas industrial petrochemical petroleum

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary term designated in blue above.

Instructional Resources

Student Reader

Ch. 3

Activity Pages

AP 5.1

AP 5.2

Student Reader, Chapter 3
"Using Fossil Fuels"

Activity Pages
Fossil Fuels Costs and Benefits (AP 5.1)

Electricity Diagram (AP 5.2)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- box (at least 6 inches deep)
- sand
- mud
- pebbles (or cat litter)
- black shoe polish (2 cans)
- tape
- sticks or pencils
- clear container or fish tank
- several plastic straws
- pin
- water
- index cards for student vocabulary deck (1 per student)
- internet access and the means to project images/video for whole-class viewing

Advance Preparation

Assemble the oil drilling model prior to class:

- Open the cans of black shoe polish.
- Tape the open cans to the bottom of the box. Spread the cans out randomly.

- Fill the box with sand, followed by mud and pebbles. Make sure the can of polish is completely covered.

Assemble the natural gas model prior to class:

- Connect a series of plastic straws together to make a pipeline.
- Bury the straws in the clear container/fish tank underneath sand. Make sure to leave two ends of the straw exposed above the sand. This is where the water will enter.

The Core Lesson Two days, 45 min each

1. Day 1: Focus student attention on the Big Question. 5 min

What are some costs and benefits of using fossil fuels? Continue working on this unit's **Problem-Based Learning Project**. Remind students that this unit is different from all the others because it contains a single project that is designed to help them understand how to deal with a problem through a capstone project. In this lesson, students will learn more about how fossil fuels are used and what kinds of costs and benefits they result in. Explain that this will help them complete the project in the capstone lesson.

Review what students have learned about fossil fuels so far. Ask the following:

» What are the three main types of fossil fuels? (*petroleum/oil, natural gas, coal*)

» Where are fossil fuels found? (*inside Earth*)

» Are fossil fuels renewable or nonrenewable sources of energy? (*nonrenewable*) Why? (*because they take a very long time to replenish*)

» What are some examples of ways that people use fossil fuels? (*transportation, electricity, heating/cooling, making things*)

Explain that today students will focus on how fossil fuels are extracted from the earth, transported to where they need to go, burned, and used by humans.

2. Read and discuss: "Using Fossil Fuels." 35 min

Student Reader

Ch. 3

Prepare to read together or have students read independently "Using Fossil Fuels," Chapter 3 in the Student Reader. This chapter describes the ways in which fossil fuels are extracted from the earth, transported to where they need to go, burned, and used by humans.

Preview Core Vocabulary Term

Prepare students to approach the reading by drawing their attention to terms they will use as they explore ways that fossil fuels are extracted, transported, and burned. Before students read, write **greenhouse gas** on the board or chart paper. Verify

that students know what a greenhouse is and understand fundamentally how it works—the sun warms the air in the greenhouse, and the warm air is trapped by the plastic/glass walls.

Write *gas* on the board or chart paper apart from the term in bold. Ask students to explain what a gas is. (*a state of matter*) Remind students that they already encountered this term when used to describe the fossil fuel called natural gas. Prompt students to pay attention to the use of this word throughout their reading.

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Include suggested questions and prompts:

Page 13

After reading, draw student attention to the part of the page that mentions the transformation of energy. Ask students to recall the meaning of *energy transformation*. Ask: Why do you think it is important for people to transform the energy of fossil fuels? (*so the fuels can be used to power different things*)

> **SUPPORT**—If needed, remind students of the difference between energy transformation and energy transfer.

Point out that the energy industry in the United States on the whole relies on fossil fuels to meet its energy needs. *Industrial* means "relating to industry." There are many industries, including those that have arisen to meet our energy needs. One of these is the gas and oil industry.

Page 14

After reading, bring out the oil drilling model you prepared for class. You will need the following additional materials:

- sticks or pencils

Place the box on a table in the front of the classroom. Invite one student at a time to come up to the table. Give the student a clean stick or pencil, and tell him or her to insert it all the way into Earth's crust until he or she reaches the bottom. Then, have the student pull out the stick or pencil and see whether it is clean. If the tip is black, then the student struck oil! If the tip is clean, then the student did not find any oil. Continue until all students have had a chance to find oil.

Once all students have participated in the demonstration, ask: What would happen if the drilling were not done carefully? What could happen to the oil if it were under pressure? [Note that students will have to recall some of what they learned in the previous chapters in this unit.] (*It could spill onto the ground or into the ocean.*)

Page 15

After reading, ask students to summarize the different ways to transport oil. (*pipelines, trains, tankers*)

Make sure students understand that the oil must be transported from its source to a refinery. Ask the following:

- Is transporting oil a cost or a benefit or both? Why? (*It is both. Transporting oil is very expensive, and it can result in dangerous spills. Those are costs. However, it also gets it to where people can use it to meet their energy needs. That is a benefit.*)

Pages 16–17

Call on a volunteer to explain why petroleum needs to be refined. (*so that it can be burned and used for various forms of energy*) Have students describe the steps in the refinement of oil. (*Students should identify that oil is extracted, transported, placed in tanks, heated, and transformed into usable forms*.)

Draw student attention to the term *petrochemical* on page 17. Ask students to identify examples of petrochemical uses with which they might be familiar and may see in their communities. Two common examples might be the asphalt used for paving roads and plastic toys or other plastic products.

> **CHALLENGE**—For students willing to go a little further, have them use the internet and a classroom computer to research the word *petrochemical* and other types of petrochemicals not mentioned on the page. Have them report their findings, such as making chemicals, plastics, and other synthetic materials; waxes; motor oil; and jet fuel.

Page 18

After reading the page, have students consider the costs and benefits of mining coal. Emphasize that there are benefits and risks to extracting all types of fossil fuels. Encourage a healthy classroom debate for students to voice their opinions on whether they think coal should be mined if it puts people in danger. Keep a costs and benefits chart on the board or chart paper. Ask: Do the benefits of using coal outweigh the risks of mining the coal? (*Accept all thoughtful answers*.)

Ask a volunteer to explain the benefits of transporting coal. (*It is less likely than oil to result in an environmental disaster because it does not spread if it spills*.) Ask another volunteer to summarize the costs associated with transporting and processing coal. (*Coal dust can escape and pollute the air or water; washing the coal leads to toxic waters*.)

Page 19

After reading, ask: What is similar about the way that petroleum and natural gas are extracted and transported? (*They both come from Earth's crust and have to be drilled out; they are both transported by pipelines or ships*.)

Show students a demonstration of underground gas pipes. Bring out the model that you made in advance, and set it on a table in the front of the classroom. You will also need water that you can pour into the straw, as well as a sharp pin.

- Model for students how the water (which represents gas) flows through the straws underground. Pour some water into one exposed side of the straw. Students should not see anything happen.
- Then, model for students what happens during a gas leak. Pierce a part of the buried straw with the pin. Now add more water, and watch as the sand in the container becomes saturated.
- Ask students to describe what is happening. (*Gas is spilling underground*.) Ask: What kind of effect can this have on the environment? (*The gas can harm plants; it can soak up to the surface and pollute the ground*.)

Page 20

Ask students if they have heard of the term *climate change*. Ask volunteers to explain what they have heard. Note that some students will have heard different things based on the perspectives of the people around them. Then explain that scientists believe one cause of climate change to be greenhouse gases. Discuss with students the fact that when greenhouse gases become trapped in Earth's atmosphere, climates around the globe change.

3. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Card

Direct student attention to the Core Vocabulary term **greenhouse gas**. Have students write the term in the upper left corner of an index card and underline it.

Word Work

- **greenhouse gas:** (n. a gas that traps heat in Earth's atmosphere) Ask students to write in their own words one sentence that uses the term *greenhouse gas*. (*A greenhouse gas traps heat in Earth's atmosphere.*) Then ask students to share what they understand about greenhouse gases in relation to fossil fuels.

Have students store their deck of Core Vocabulary cards in alphabetical order.

1. Day 2: Refocus student attention on the Big Question. 5 MIN

What are some costs and benefits of using fossil fuels? Remind students of what they learned in the previous class session.

- Ask students if they have any questions about what they read about fossil fuels.
- Go over the Big Question again. Prompt students to ask themselves, "Is using fossil fuels good or bad?" Let students know that they will get to work on answering this question today in class.
- Tell students that today they will make a list of the costs and benefits of using fossil fuels based on what they learned about the extraction, transportation, and burning of petroleum, coal, and natural gas.

2. Analyze costs and benefits. 10 MIN

Activity Page

AP 5.1

Establish a Scientific Mindset

Students now get to evaluate the information they obtained about fossil fuels through their Student Readers. Make a connection to science and engineering. (See **Know the Standards** on the next page.) Ask: Why is it important for scientists and engineers to consider the costs and benefits of using fossil fuels? (*Scientists perform investigations and tests to learn more about the natural world and its resources. Engineers perform investigations and tests to see how designs work to come up with solutions to problems based on the natural world and its resources.*)

Ask students to discuss any personal experience with making lists of costs and benefits:

» Have you ever had to make a decision and you didn't know whether an answer was right or wrong? (*Most students will likely answer yes.*)

» What were you trying to decide? (*Encourage volunteers to give details.*)

» Did you make a list of the things that were good about the decision and the things that were bad about the decision? (*Most students will likely reply that they did not; encourage them to think about doing this in the future.*)

Discuss good analysis skills, such as the following:

- keeping an open mind
- considering options from both sides
- using facts, evidence, and data

Distribute Fossil Fuels Costs and Benefits (AP 5.1). Tell students that they will work on making a list of the costs and benefits (risks and advantages) of using fossil fuels. Review the Activity Page together as a class, making sure students understand their task.

Give students time to complete their lists independently, or pair students together and have them work on their lists with their partner while discussing their answers. Circulate around the room, and provide prompts and cues for students to consider:

» What are the costs and benefits associated with how the fossil fuels are extracted? (*Example benefit: They create jobs. Example risk: Some of them can leak out and pollute the ground.*)

» What are the costs and benefits associated with how the fossil fuels are transported? (*Example benefit: They create jobs. Example risk: Some of them can leak out and pollute the area around them.*)

» What are the costs and benefits associated with burning the fossil fuels? (*Example benefit: They create energy that can fuel things. Example risk: They can pollute the air, water, and ground.*)

After students have completed the Activity Page, draw a T-chart on the board or chart paper that you will use to make a master list of the costs and benefits of using fossil fuels. Invite volunteers to share the things they listed on their Activity Pages, and add those to the master list. Draw attention to similarities.

Know the Standards

Obtaining, Evaluating, and Communicating Information: Paired with Performance Expectation 4-ESS3-1, this Science and Engineering Practice focuses on obtaining and evaluating information from sources to explain phenomena. With this activity, students begin to learn that scientific information can be retrieved through reading materials, such as Student Readers. Over Grades 3–5, this practice is developed in several ways, including by reading grade-appropriate informational texts; using data from tables, diagrams, and charts; and communicating scientific information by speaking and writing. Many of these skills are closely aligned to English language arts standards for reading informational texts, speaking, and writing.

Encourage a healthy discussion about whether or not people should continue to use fossil fuels. If students disagree with each other, invite them to politely state their position and share why they think fossil fuels should or should not be used. (This activity will be livelier if students have differing opinions.)

3. Support student diagramming. 15 MIN

Activity Page

AP 5.2

Distribute Electricity Diagram (AP 5.2). Tell students that they will work on making a diagram that shows how coal is turned into electricity based on the steps listed on the Activity Page. Allow students to work independently or in pairs.

> **SUPPORT**—Remind students that good diagrams include labels, numbers, arrows, and other markers or indicators that help people understand the process that is being shown. Encourage students to use these on their diagrams to help make the process clearer.

Circulate around the room as students work on their diagrams, providing support as necessary. Use question prompts if needed:

- Where does coal come from? (*Earth; mines*)
- In what form is coal found? (*solid*)
- What do people do with coal in its original form? (*burn it for heat*)

Once students complete their diagrams, invite volunteers to share and discuss their drawings with the class. Address any misunderstandings, such as the idea that coal can "leak" into the ground and pollute it in the same way that oil or natural gas can.

4. Demonstrate examples and guide discussion. 10 MIN

Online Resources

Show students a video of live footage of the *Deepwater Horizon* oil rig explosion. (See the Online Resources for a link to a suggested video.) Ask the following:

- What kind of impact do you think this event had on the environment? (*It had a negative impact on the environment because so much oil was spilled; it harmed ocean organisms; it polluted the ocean.*)
- Do you think disasters like these should stop people from drilling for oil? Why or why not? (*Accept all thoughtful answers.*)

Show students a video of the oil refinement process. (See the Online Resources for a link to a suggested video.) Ask:

- Which liquids need more processing for them to be useful? (*heavier liquids*)
- What does cracking do? (*It turns heavy oil into lighter fluids.*)
- What is reforming? (*a process that increases the amount of gasoline produced from crude oil*)
- What role do molecules play in oil refinement? (*The molecules are being changed so the oil can be used for different things.*)

Use this link to download the CKSci Online Resources Guide for this unit, where specific links to these resources may be found.

www.coreknowledge.org/cksci-online-resources

5. Check for understanding. 5 MIN

Activity Pages

AP 5.1
AP 5.2
Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key for correct answers and sample student responses.

- Collect the completed Fossil Fuels Costs and Benefits (AP 5.1) and Electricity Diagram (AP 5.2). Scan the lists and drawings that students made.
- Invite student questions for a brief closing discussion. Use the discussion as an opportunity to reinforce main ideas about how fossil fuels are extracted, transported, and burned.

Problem-Based Learning Progress

Review progress students have made in analyzing the costs and benefits of using fossil fuels, which are nonrenewable. They have

- learned about the uses of different types of fossil fuels.
- continued researching the subject.
- recorded information to include in the cost-benefit analysis for the unit capstone project.

Remind students that in Lessons 6–17, they will continue to combine what they are learning about cost-benefit analysis and different types of resources that might meet their community's energy resource needs.

LESSON 6

Researching Fossil Fuels

Big Question: Where can I find reliable information about costs and benefits of using fossil fuels?

Problem-Based Learning Project: Investigate different types of fossil fuels to learn more about their costs and benefits.

At a Glance

Learning Objectives

- ✓ Identify reliable sources of information about fossil fuel costs and benefits.
- ✓ Conduct research on fossil fuel costs and benefits and incorporate the research results into the unit project.

Lesson Activities

- discussion
- vocabulary instruction
- research
- cost-benefit analysis

NGSS References

Performance Expectation 4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Disciplinary Core Idea ESS3.A: Natural Resources

Crosscutting Concepts: Cause and Effect

Science and Engineering Practices: Obtaining, Evaluating, and Communicating Information

Obtaining, Evaluating, and Communicating Information is important throughout this unit. Students will work toward obtaining, evaluating, and communicating quality information taken from multiple sources, which will enable them to complete the problem-based inquiry capstone project. This lesson focuses on the first energy resource whose costs and benefits they are to analyze—fossil fuels.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 162–163 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

cost-benefit analysis
emission
flare

fossil fuel
fracking

greenhouse gas
strip mining

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue above.

Instructional Resources

Activity Page

AP 6.1

Activity Page
Costs and Benefits of Fossil Fuels (AP 6.1)

(AP 1.1 and AP 1.2 for review)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- access to the internet or library
- printed source materials about fossil fuels

By this point students should be working with a master cost-benefit analysis chart to organize or summarize their research, or they should have some other system for gathering and organizing their research. If some summary information is being gathered or recorded as a class, make the chart or class file visible and available to all students during this lesson.

The Core Lesson 45 min

1. Focus student attention on the Big Question. 10 min

Where can I find reliable information about costs and benefits of using fossil fuels? Continue working on this unit's **Problem-Based Learning Project**. Remind students that this unit is different from all the others because it contains a single project that is designed to help them understand how to deal with a problem through a capstone project. In this lesson, students will learn more about finding

reliable information concerning the use of fossil fuels, their costs, and their benefits. Explain that this will help them complete the project in the capstone lesson.

Explain to students that this is the first of several lessons in which they will focus their cost-benefit analysis on a specific energy resource. Review what your class has already learned about fossil fuels. Ask the following:

- What are the three main fossil fuels? (*natural gas, petroleum, coal*)
- How are fossil fuels, which contain chemical energy, converted to forms of energy that humans want? (*They are burned.*)
- What are other uses for fossil fuels? (*Plastics and other products can be made from petroleum.*)

Discuss the varieties of costs and benefits and the different classification schemes that can be applied to them. For example, focus on short-term and long-term costs and benefits. Ask the following:

- What are some short-term benefits of burning coal? (*provides heat, which can be used directly or be used to power a generator to provide electricity*)
- What are some long-term benefits of using coal? (*abundant resource, inexpensive, found in many locations around the world, easy to transport*)
- What are some short- and long-term costs of using coal? (*short term: poor air quality; long term: too much carbon in the atmosphere/global warming, mercury in water and wildlife, other coal-related pollution and environmental problems*)

Tell students that they will learn more about the costs and benefits of fossil fuels as they conduct their research.

Revisit Core Vocabulary Terms

Write these terms on the board or chart paper. Direct students to locate the index cards they made in previous lessons.

cost-benefit analysis **fossil fuel** **greenhouse gas**

As students work through the lesson, have them look for places where they encounter the Core Vocabulary terms. Each time they encounter one, have them write how it was used on that word's card.

2. Review the unit capstone project. 5 MIN

Activity Pages

AP 1.1
AP 1.2

Review the problem-based inquiry project that is the basis for this unit: **Develop a cost-benefit analysis examining human uses of several types of natural resources for energy.**

Refer students back to Project Evaluation Guide (AP 1.1). Remind them that they will perform a cost-benefit analysis and make a final product that details the costs and benefits of using natural resources. Contrast "expert" level with other levels for each skill/row. (See **Know the Standards**.)

If necessary, refer students back to What Is a Cost-Benefit Analysis? (AP 1.2). They should be clear on the distinction between costs and benefits by this point so they can correctly assign information about fossil fuels to the appropriate categories and eventually produce a valid cost-benefit analysis.

3. Support student research. 25 MIN

In Lesson 3, you discussed how to identify reliable sources of information that come from authorities. Remind students that governmental and educational websites are much more likely to be reliable than social media sites or even some news media, though there are exceptions to this. Sites that end with ".edu" or ".gov" indicate an educational or governmental organization. The ".org" ending may be used by nonprofit organizations. These can also be reliable sources of information, but they may be biased or their use of information may be for a specific purpose, such as advocating for or against the use of fossil fuels.

> **NOTE**—The design, content, and tone of government-run websites such as the EPA's can change with each new administration, particularly on topics involving science, industry, and the environment. This is a topic that might itself be worth discussing as a class, or it might motivate you to vet the .gov sites before steering your students to them. Government sites can also be deleted, archived, or temporarily closed due to different events, so it is wise to check on them before directing students to them. Also note that .edu sites can sometimes contain student essays or papers rather than peer-reviewed articles. Help students understand how to identify when an article on a .edu site is valid and can be used as a source of information.

Online Resources

Use this link to download the CKSci Online Resources Guide for this unit, where specific links to recommended resources may be found.

www.coreknowledge.org/cksci-online-resources

Know the Standards

Influence of Science, Engineering, and Technology on Society and the Natural World is an NGSS Connection to Engineering, Technology, and Applications of Science. This problem-based learning science unit supports understanding that "Engineers improve existing technologies or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands." As students research the costs and benefits of using fossil fuels, they should consider the role of engineering. For example, how are the extraction and burning of coal different from what they were a hundred years ago? What are the new costs and benefits?

Your school library may also have valuable and reliable resources. It may save your class time to select and make copies of specific articles or reference materials instead of using class time on self-directed research.

Give students adequate time to conduct research on fossil fuel costs and benefits. Make sure they find out how fossil fuels are used to generate electricity in your local area or state.

4. Check for understanding. 5 MIN

Activity Page

AP 6.1 and Answer Key

Formative Assessment Opportunity

Direct students to Costs and Benefits of Fossil Fuels (AP 6.1), where they will summarize their research findings. Discuss students' findings as a class. Make sure that students have read about and recorded the major costs and benefits of fossil fuel use. Those are summarized in the sample table in the Answer Key.

Problem-Based Learning Progress

Review progress students have made in analyzing the costs and benefits of using fossil fuels, which are nonrenewable. They have

- researched the use of different types of fossil fuels.
- continued the cost-benefit analysis for the unit capstone project.

Remind students that in Lessons 7–17, they will continue to combine what they learn about cost-benefit analysis and different types of renewable and nonrenewable resources that might meet their community's energy resource needs.

LESSON 7

Nuclear Energy

Big Question: What is nuclear power?

Problem-Based Learning Project: Investigate nuclear power to learn more about its costs and benefits in anticipation of the unit capstone project.

At a Glance

Learning Objectives

- ✓ Describe the costs and benefits of using nuclear power.
- ✓ Gather information to compare the sources and uses of specific natural resources.
- ✓ Gather information to compare the costs and benefits of using renewable resources for energy to using fossil fuels and nuclear fuels.

Lesson Activities

- optional videos
- reading and discussion
- vocabulary instruction

NGSS References

Performance Expectation 4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Disciplinary Core Idea ESS3.A: Natural Resources

Crosscutting Concepts: Cause and Effect

Science and Engineering Practices: Obtaining, Evaluating, and Communicating Information

Cause and Effect is an important theme throughout this unit. Nuclear energy in power plants is unleashed through a chain reaction called fission. When controlled, this reaction can produce much-needed energy for humans to use. If uncontrolled, the reaction can have devastating effects on humans and other organisms, and these effects can linger for hundreds or thousands of years.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to this term, which is not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 162–163 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

atom enriched **nuclear energy**

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary term designated in blue above.

Instructional Resources

Student Reader

Ch. 4

Activity Page

AP 7.1

Student Reader, Chapter 4
"Nuclear Energy"

Activity Page
Lesson 7 Check (AP 7.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- index cards for student vocabulary deck (1 per student)
- internet access and the means to project images/video for whole-class viewing

The Core Lesson 45 min

1. Focus student attention on the Big Question. 10 min

What is nuclear power? Continue working on this unit's **Problem-Based Learning Project**. Remind students that this unit is different from all the others because it contains a capstone project that is designed to help them understand how to deal with a problem. In this lesson, students will learn more about nuclear power, its costs, and its benefits. Explain that this will help them complete the project in the capstone lesson.

Write the Big Question on the board or chart paper. Write the words *power* and *energy* on the board or chart paper. Ask students to explain the difference, if they think there is one, between the terms. Explain that *nuclear power* usually refers to the type of energy that is used in a nuclear power plant to generate electricity. Nuclear energy is the type of energy that is released from atoms that are split. The resulting heat of a nuclear reaction is used to create steam. The steam causes turbines to turn and produce electricity.

Access prior knowledge (and misconceptions) that students might have about nuclear energy. Ask students to say terms that they think of when they hear the word *nuclear*. Write these terms on the board or chart paper. Revisit them as you proceed through this lesson and the next, and discuss whether the terms remain at the forefronts of students' minds or if some of them seem less relevant or perhaps more or less scary. For example, students might say "bomb" or "mutant" before the lesson but focus more on power station design and storage issues by the end of it.

Explain to students that the focus of this lesson is on nuclear power for generating electricity, not nuclear power for warfare.

2. Read and discuss: "Nuclear Energy." 20 MIN

Student Reader

Ch. 4

Prepare to read together or have students read independently "Nuclear Energy," Chapter 4 in the Student Reader. This chapter describes how energy locked up in atoms of certain elements is released and converted to thermal energy (heat) and electrical energy (electricity). It also outlines some of the costs and benefits associated with nuclear power, including radiation and explosions.

Preview Core Vocabulary Term

Before reading, write the term **nuclear energy** on the board or chart paper. Have students identify the term as they read. Stop to discuss the meaning of the term in context.

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Include suggested questions and prompts:

Page 21

Reinforce for students that, like coal, uranium is a naturally occurring earth material, but unlike coal, it requires a sophisticated process of enrichment to be useful as an energy resource. (See **Know the Science**.)

Know the Science

How does refined uranium release energy? *Through a chain reaction!* Uranium-235, is unstable. This means the atoms of uranium-235 readily change into other kinds of atoms. When a single neutron, an essential part of an atom, hits an atom of uranium-235, a large amount of energy is released and the atom splits into two different atoms and three loose neutrons. In refined uranium-235, these three neutrons can readily hit three uranium-235 atoms, releasing nine neutrons. As this continues, more and more neutrons are released until the reaction becomes self-sustaining. It is considered a chain reaction because it is like a chain; one neutron can lead to the release of three neutrons, which can lead to the release of nine atoms, which can lead to the release of 27 neutrons, and so forth.

Pages 22–23

As you read through the first two paragraphs, have students use a finger to trace the movement of energy and matter in the power plant. Their fingers should start in the reactor, move into the boiler, and then move through the steam line to the turbine. Explain that much of the energy leaves the power plant at that point as electricity but that some remains as heat that is transferred from the condenser to cooling towers. The steam (matter) condenses and circulates back to the reaction. Ask the following:

- In what forms does energy leave the power plant? (*heat and electricity*)
- Does any matter leave the power plant as a result of the chain reaction? (*No, it shouldn't. If an accident occurs, then it might. Otherwise, matter should be recycled within the plant until the control rods are spent.*)

Page 24

Ask the following:

- If Earth has a lot of uranium that has not yet been mined or enriched, why isn't nuclear power considered renewable? (*The amounts of those materials are limited, and it's very expensive to mine and enrich them.*)
- How does the radioactivity of nuclear waste factor into nuclear power being called nonrenewable? (*The waste needs to be handled very carefully, stored in secure locations, and then left alone for a very long time.*)

Consider projecting a website or sharing another resource to show how important or unimportant nuclear power is to different countries. This information might be useful in the next lesson as students consider the costs and benefits of nuclear power. Economic costs, geography, access to other resources, conflicts with other countries, and other factors can determine whether a country relies heavily on nuclear power, uses it somewhat, or cannot rely on it at all.

One resource that will likely be useful throughout the unit as students conduct their cost-benefit analysis is a table that summarizes how each state generates its electricity. There are several sites that provide such a table.

Online Resources

Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found.

www.coreknowledge.org/cksci-online-resources

3. Demonstrate examples and guide discussion. 5 MIN

Use a video to review the content of Chapter 4. (See the Online Resources for a link to a suggested video.) After watching the video, review the main costs and benefits of nuclear power. Ask the following:

- What are two of the main benefits of using nuclear power to generate electricity? (*get lots of energy from a small amount of matter, no greenhouse gas emissions*)
- What are two of the main costs of nuclear power? (*dangerous materials both during and after their use, limited amount of expensive material*)

Online Resources

Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found.

www.coreknowledge.org/cksci-online-resources

4. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Card

Direct student attention to the Core Vocabulary term **nuclear energy**. Have students write the term on the upper left corner of an index card and underline it.

Word Work

nuclear energy: (n. energy produced by the splitting of atoms, tiny particles of matter) Discuss with students the two parts of the term *nuclear energy*. Students should be familiar with the definition of *energy* by this time, but they may not fully understand what *nuclear* means. Explain that it refers to the nucleus, or center part, of an atom, the smallest unit of matter. Tell them that they will learn more about this term in Grade 5. Ask students to use the term *nuclear energy* in a sentence based on what they have learned so far in this unit. (*One cost of nuclear energy is that it could release radiation into the atmosphere.*)

5. Check for understanding. 5 MIN

Activity Page

AP 7.1 and Answer Key

Formative Assessment Opportunity

Have students complete Lesson 7 Check (AP 7.1). Collect the assessment, and check students' answers to identify concepts with which they are still struggling. See the Activity Page Answer Key for correct answers and sample student responses. Incorporate adjustments as you open the next lesson. Provide additional guidance for students who need more support.

Problem-Based Learning Progress

Review progress students have made in analyzing the costs and benefits of nuclear power, which is nonrenewable. They have learned about

- how nuclear energy is generated.
- how nuclear energy moves from a power plant to homes and businesses.

Remind students that in Lessons 8–17, they will continue to combine what they have learned about cost-benefit analysis and different types of renewable and nonrenewable resources that might meet their community's energy resource needs.

LESSON 8

Researching Nuclear Power

Big Question: Where can I find reliable information about costs and benefits of using nuclear power?

Problem-Based Learning Project: Investigate nuclear power to learn more about its costs and benefits.

At a Glance

Learning Objectives

- ✓ Identify reliable sources of information about nuclear power costs and benefits.
- ✓ Conduct research on nuclear power costs and benefits and incorporate the research results into the unit project.

Lesson Activities

- discussion
- research
- cost-benefit analysis

NGSS References

Performance Expectation 4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Disciplinary Core Idea ESS3.A: Natural Resources

Crosscutting Concepts: Cause and Effect

Science and Engineering Practices: Obtaining, Evaluating, and Communicating Information

Obtaining, Evaluating, and Communicating Information is important throughout this unit. Students will work toward obtaining, evaluating, and communicating quality information taken from multiple sources that will enable them to complete the problem-based inquiry capstone project. This lesson's focus is a cost-benefit analysis of nuclear power.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. No new Core Vocabulary terms are introduced in this lesson.

cost-benefit analysis
fission
nuclear power
nuclear waste

Instructional Resources

Activity Page

AP 8.1

Activity Page
Nuclear Power Costs and Benefits (AP 8.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- access to the internet or library
- printed source materials about nuclear power

By this point students should be working with a master cost-benefit analysis chart to organize or summarize their research, or they should have some other system for gathering and organizing their research. If some summary information is being gathered or recorded as a class, make the chart or class file visible and available to all students during this lesson.

The Core Lesson 45 min

1. Focus student attention on the Big Question. 5 min

Where can I find reliable information about costs and benefits of using nuclear power? Continue working on this unit's **Problem-Based Learning Project**. Remind students that this unit is different from all the others because it contains a single capstone project that is designed to help them understand how to deal with a problem. In this lesson, students will research nuclear energy, its costs, and its benefits. Explain that this will help students complete the project in the capstone lesson.

Students should have a feel for how this lesson should go from having completed Lesson 6 on fossil fuel costs and benefits. Review what your class has already learned about nuclear power. Ask the following:

» What is the actual fuel for nuclear power? (*an enriched unstable material such as uranium-235*)

» How is the energy released by a nuclear reaction converted into electricity? (*Heat produced by the reaction boils water, which becomes steam, which passes through a turbine, which is connected to a generator.*)

Discuss the costs and benefits of nuclear power to help students figure out some different categories that they can research. Ask the following:

» How is nuclear power good for the environment? (*It doesn't produce carbon emissions.*)

» What are the environmental costs of nuclear power? (*Accidents can release harmful radiation; explosions can destroy large areas of Earth's surface.*)

» How does nuclear power compare to fossil fuels in terms of usefulness in transportation and everyday activities? (*It is much less practical because nuclear reactors are large, expensive, heavily regulated, and dangerous. You cannot have a nuclear reactor in a car or in a backyard power generator.*)

Tell students that they will conduct research to learn more about the costs and benefits of nuclear power.

2. Review the unit capstone project. 5 MIN

Activity Pages

AP 1.1
AP 1.2

Place this lesson in the context of the problem-based inquiry project that is the basis for the unit: **Develop a cost-benefit analysis examining human uses of several types of natural resources for energy.** Review Project Evaluation Guide (AP 1.1). (See **Know the Standards**.)

If necessary, refer students back to What Is a Cost-Benefit Analysis? (AP 1.2). Discuss and evaluate how students' cost-benefit analyses went in Lesson 6. If anything was left out of those analyses, or if you or the students otherwise felt that something was missing, encourage students to revise their approach to their research in this lesson.

3. Identify resources and conduct research. 25 MIN

As in Lesson 6, students should look for information on websites that end with ".edu" or ".gov" and then, with your guidance, look at sites that end with ".com" or ".org." Explain that nuclear power has its advocates and its detractors and that there is a lot of misinformation out there about nuclear power and related issues. Nuclear power has been politicized for decades because it is such a powerful technology but also because it can be weaponized.

Know the Standards

Interdependence of Science, Engineering, and Technology is an NGSS Connection to Engineering, Technology, and Applications of Science. This problem-based learning science unit supports understanding that "knowledge of relevant scientific concepts and research findings is important in engineering."

Students who search for "nuclear power" in an internet search engine may end up with results in which *nuclear power* means countries that use nuclear power or, more specifically, have nuclear weapons. Prepare to explain this meaning of the term if students are puzzled by search results.

Online Resources

Use this link to download the CKSci Online Resources Guide for this unit, where specific links to recommended resources may be found.

www.coreknowledge.org/cksci-online-resources

As in Lesson 6, you might prefer to identify and set aside some vetted materials. This might be especially helpful or necessary for students to learn about how nuclear power is used, if at all, in their community or state.

Give students adequate time to conduct research on nuclear power costs and benefits. Tell students to consider the amounts of nonnuclear energy that go into the processes of mining, transporting, enriching, and storing fissile materials for use in nuclear power plants. If there is a nuclear power plant in their town or state, students should try to find out how expensive the plant was to construct and where waste from the plant is stored.

4. Summarize and discuss. 5 MIN

Activity Page

AP 8.1

Briefly discuss how the costs and benefits of nuclear power compare to those of fossil fuels. Ask the following:

- How do the environmental benefits of nuclear power relate to the environmental costs of fossil fuels? (*Nuclear power does not have the carbon emissions that fossil fuel power has.*)
- What is one way in which the waste produced by nuclear power is more of a problem than the waste or by-products of fossil fuel use? (*Nuclear waste remains radioactive and dangerous for a very long time, requiring secure storage. Fossil fuel by-products are less hazardous, and some can even be useful for other purposes.*)

Direct students to Nuclear Power Costs and Benefits (AP 8.1), where they will summarize their research findings. Discuss their findings as a class. Make sure that students have read about and recorded the major costs and benefits of nuclear power. Those are summarized in the sample table in the Answer Key.

5. Check for understanding. 5 MIN

Activity Page

AP 8.1 and Answer Key

Formative Assessment Opportunity

Have students complete Nuclear Power Costs and Benefits (AP 8.1). Collect the Activity Page, and check students' answers to identify concepts with which they are still struggling. See the Activity Page Answer Key for correct answers and sample student responses. Incorporate adjustments as you open the next lesson. Provide additional guidance for students who need more support.

Problem-Based Learning Progress

Review progress students have made in analyzing the costs and benefits of nuclear energy, which is nonrenewable. They have

- started research.
- continued the cost-benefit analysis for the unit capstone project.

Remind students that in Lessons 9–17, they will continue to combine what they have learned about cost-benefit analysis and different types of renewable and nonrenewable resources that might meet their community's energy resource needs.

PART D

Using Renewable Resources for Energy

Overview

Lesson	Big Question	Advance Preparation
9. Wind Energy	How do people use wind as a source of energy?	Read Student Reader, Chapter 5.
10. Researching Use of Wind Turbines	Where can I find reliable information about costs and benefits of using wind as a source of energy?	Gather materials for problem-based learning project. (See Materials and Equipment, page 16.)
11. Hydroelectric Energy	How do people use moving water as a source of energy?	Read Student Reader, Chapter 6.
12. Researching Use of Hydroelectric Power	Where can I find reliable information about costs and benefits of using moving water as a source of energy?	Gather materials for problem-based learning project. (See Materials and Equipment, page 16.)
13. Solar Energy	How do people use sunlight as a source of energy?	Read Student Reader, Chapter 7.
14. Researching Use of Solar Energy	Where can I find reliable information about costs and benefits of using sunlight as a source of energy?	Gather materials for problem-based learning project. (See Materials and Equipment, page 16.)
15. Geothermal Energy	What is geothermal energy, and how do people use it?	Read Student Reader, Chapter 8.
16. Researching Use of Geothermal Energy	Where can I find reliable information about costs and benefits of using geothermal energy?	Gather materials for problem-based learning project. (See Materials and Equipment, page 16.)
17. Energy Resource Innovations	What other energy resources are being developed?	Read Student Reader, Chapter 9.

Part D: What's the Story?

Students learned in Parts B and C (Lessons 2–8) that humans use natural resources to meet their energy needs and that many of these natural resources are nonrenewable, which means that they are not being replenished as they are being used. Through readings and research, students learned about the costs and benefits of using different kinds of natural resources for energy, including petroleum, coal, natural gas, and nuclear energy.

In Part D (Lessons 9–17), students study renewable resources, or resources that can be replenished more easily, and how they can be used to meet our energy needs. Students also learn about the costs and benefits of each kind in anticipation of completing their **problem-based learning project**.

In Lesson 9, we start by having students read and learn about wind energy being used to generate electrical power to keep homes, businesses, and other buildings warm or cool, well lit, and comfortable for human usage. At the end of the lesson, students complete a Lesson Check to reinforce main ideas through repetition and sustained inquiry.

In Lesson 10, students are tasked with researching additional information about wind energy, how it is used, and its costs and benefits. More importantly, as part of their problem-based learning project, students must evaluate their sources to determine whether the sources are authentic, or factual, and appropriate for use. Students then evaluate the information found in each source and make a record of the information they consider trustworthy.

In Lesson 11, students read and learn about hydroelectric energy. This is electricity generated by the pull of gravity on large bodies of water. At the end of the lesson, students complete a Lesson Check to reinforce main ideas through repetition and sustained inquiry.

In Lesson 12, students are tasked with researching additional information about hydroelectric energy, how it is used, and costs and benefits. As with Lesson 10 and as part of their problem-based learning project, students must evaluate their sources to determine whether the sources are authentic, or factual, and appropriate for use. Students then evaluate the information found in each source and make a record of the information they consider trustworthy.

In Lesson 13, students read and learn about solar energy. This is energy that comes from the sun and can be harnessed to generate heat or electricity. At the end of the lesson, students complete a Lesson Check to reinforce main ideas through repetition and sustained inquiry.

In Lesson 14, students are tasked with researching additional information about solar energy, how it is used, and costs and benefits. As with Lessons 10 and 12 and as part of their problem-based learning project, students must evaluate their sources to determine whether the sources are authentic, or factual, and appropriate for use. Students then evaluate the information found in each source and make a record of the information they consider trustworthy.

In Lesson 15, students read and learn about geothermal energy. This is energy that comes from inside Earth and can be harnessed to generate heat. In many places where there is much volcanic activity, such as Iceland, geothermal energy is used to heat water, houses, and businesses. At the end of the lesson, students complete a Lesson Check to reinforce main ideas through repetition and sustained inquiry.

In Lesson 16, students are tasked with researching additional information about geothermal energy, how it is used, and costs and benefits. As with Lessons 10, 12, and 14, and as part of their problem-based learning project, students must evaluate their sources to determine whether the sources are authentic, or factual, and appropriate for use. Students then evaluate the information found in each source and make a record of the information they consider trustworthy.

In Lesson 17, students read and learn about inventive ways that scientists are trying to generate energy at low cost from a number of sources. At the end of the lesson, students complete a Lesson Check to reinforce main ideas through repetition and sustained inquiry.

So, to repeat, **renewable resources for energy have costs and benefits, and understanding those costs and benefits means obtaining and evaluating authentic sources of information**. Help your students obtain and combine information to describe that some energy and fuels are derived from renewable natural resources and that their uses affect the environment, and you will lay the groundwork for meeting the NGSS Performance Expectation 4-ESS3-1 as well as help students on their problem-based learning project.

LESSON 9

Wind Energy

Big Question: How do people use wind as a source of energy?

Problem-Based Learning Project: Investigate wind energy to learn more about its costs and benefits.

At a Glance

Learning Objectives

- ✓ Describe wind energy and how it is converted to electricity
- ✓ Trace the steps required to harness wind energy and transform it to electricity.

Lesson Activities

- optional videos
- reading and discussion
- vocabulary instruction

NGSS References

Performance Expectation 4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Disciplinary Core Idea ESS3.A: Natural Resources

Crosscutting Concepts: Cause and Effect

Science and Engineering Practices: Obtaining, Evaluating, and Communicating Information

Obtaining, Evaluating, and Communicating Information is the focus of this unit as students obtain information through their Student Readers, evaluate said information, and then communicate their understanding of it back to their teacher through the Lesson 9 Check.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 162–163 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

power grid viable **wind farm**
renewable resource

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue above.

Instructional Resources

Student Reader

Ch. 5

Activity Page

AP 9.1

Student Reader, Chapter 5
"Wind Energy"

Activity Page
Lesson 9 Check (AP 9.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- index cards for student vocabulary deck (1 per student)
- internet access and the means to project images/video for whole-class viewing

The Core Lesson 45 min

1. Focus student attention on the Big Question. 5 min

How do people use wind as a source of energy? Continue working on this unit's **Problem-Based Learning Project**. Remind students that this unit is different from all the others because it contains a single capstone project that is designed to help them understand how to deal with a problem. In this lesson, students will learn about wind energy, its costs, and its benefits. Explain that this will help students complete the project in the capstone lesson.

Write the Big Question on the board or chart paper. As you might have done in Lesson 7, write the words *power* and *energy* on the board or chart paper. Discuss

the distinction between wind energy (a form of mechanical energy consisting of moving air particles) and wind power, which is often used to describe the conversion of wind energy into electricity.

Access prior knowledge (and misconceptions) that students might have about wind energy. It can be helpful to explain that a wind turbine is basically the opposite of an electric fan. Instead of having electricity powering a small motor that turns a shaft connected to three or four blades, the system runs in the opposite direction: wind pushes against the blades, which causes a shaft to turn, which makes a generator send electricity to a power station. Turbines tend to be much larger than electric fans, but small-scale turbines can be mounted on boats or homes to provide some electricity.

2. Read and discuss: "Wind Energy." 25 MIN

Student Reader

Ch. 5

Prepare to read together or have students read independently "Wind Energy," Chapter 5 in the Student Reader. This chapter describes how the energy in moving air masses can be harnessed to generate electricity.

Preview Core Vocabulary Terms

Before reading, write these terms on the board or chart paper. Encourage students to pay special attention to these terms throughout the lesson:

renewable resource **wind farm**

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Include suggested questions and prompts:

Page 25

Discuss why a breezy island or similar location could benefit from wind power. Ask the following:

- Why do you think a small island would be a good place for using wind energy? (*plenty of wind off the water*)
- Why might renewable energy resources such as wind and solar be especially useful in this kind of place? (*limited and expensive access to fossil fuels, environmental risks of relying on fossil fuels*)
- Why does the story on the page specify that wind power is good for the afternoon? Why not all the time? (*Wind isn't always available or strong enough to turn the turbines.*)

Pages 26–27

Explain that electric generators are heavy and expensive. Ask: Why would it be more efficient in terms of cost to have ten large wind turbines instead of one hundred small turbines if the overall electrical output of both systems is the same? (*Because the generators are expensive and difficult to set up, it is more efficient to have a small number of them and instead have the turbines be very large.*)

Pages 28–29

Review what the words *criteria* and *constraints* mean with the class. Define them if necessary. Say: Criteria are the things a project needs to accomplish. For example, a wind farm may need to supply or replace a certain amount of electricity per unit of time. That's one criterion. A constraint is some kind of limitation, such as not being able to build a wind farm in a given area or not being allowed to have turbines taller than a certain height. Ask the following:

- What kinds of constraints might be placed on a turbine's design by the environment? *(how much wind it needs to handle, waves or other forces that may strike the tower, temperature changes, storms)*
- What kinds of constraints or criteria might people place on a wind farm that's being planned? *(They might not want to see it or hear the turbines or worry about crashing boats into them. They might also want a plan in place to repair a turbine in the event that one breaks down or falls.)*

Page 30

Ask: What are several different constraints that weather places on the viability of wind power? (*There needs to be enough wind to push against the turbine blades and make it spin, but there also needs to be enough wind to make the turbine spin fast enough to power the generator. If the wind is blowing too hard, the turbine may be overwhelmed, or the tower itself might be harmed.*)

Consider projecting a website or sharing another resource to show how important wind power is to different countries. This information might be useful in the next lesson as students dig deeper into the costs and benefits of wind power. As noted in Lesson 7, one resource that will likely be useful throughout the unit as students conduct their cost-benefit analysis is a table that summarizes how each state generates its electricity. There are several sites that provide such a table.

Online Resources

Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found.

www.coreknowledge.org/cksci-online-resources

3. Demonstrate examples and guide discussion. 5 MIN

Use a video to review the content of Chapter 5. (See the Online Resources for a link to a suggested video.) After watching the video, review the main costs and benefits of wind power. Ask the following:

- What are the benefits of using wind power? *(renewable energy source, no pollution)*
- What are the costs of using wind power? *(Wind farms can take up a lot of space and make it off-limits for other activities, and wind isn't always abundant or strong enough to generate much power.)*

Online Resources

Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found.

www.coreknowledge.org/cksci-online-resources

4. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Have students locate their card prepared in Lesson 2 for **renewable resource**. Then have students prepare a new card for **wind farm** by writing the term in the upper left corner of a new card and underlining it.

Word Work

- **wind farm:** (n. many wind turbines installed together in an area to generate electricity for a community) The term *farm* is usually used for places or businesses that produce food. For example, in agriculture, a potato farm produces potatoes, while in aquaculture, an oyster farm produces oysters. In renewable energy, a farm produces electricity generated by a renewable energy resource. A coal-fired power plant would not be called a farm, nor would a nuclear power plant or diesel-powered generator. Have students write an explanation for how wind farms can also resemble plant farms. (*because the turbines themselves look like trees, as though the turbines sprouted from the soil*)
- **renewable resource:** Instruct students to add an answer to the following question to their existing card: Why is wind energy considered a renewable resource?

  Have students safely store their deck of Core Vocabulary cards in alphabetical order. Students will add to the deck in later lessons.

5. Check for understanding. 5 MIN

Activity Page

AP 9.1 and Answer Key

Formative Assessment Opportunity

Have students complete Lesson 9 Check (AP 9.1). Collect the assessment, and check students' answers to identify concepts with which they are still struggling. See the Activity Page Answer Key for correct answers and sample student responses. Incorporate adjustments as you open the next lesson. Provide additional guidance for students who need more support.

Problem-Based Learning Progress

Review progress students have made in analyzing the costs and benefits of wind energy, which is renewable. They have

- learned about how wind energy is generated and used.
- continued the cost-benefit analysis for the unit capstone project.

Remind students that in Lessons 10–17, they will continue to apply what they have learned about cost-benefit analysis to researching different types of renewable and nonrenewable resources that might meet their community's energy resource needs.

LESSON 10

Researching Use of Wind Turbines

Big Question: Where can I find reliable information about costs and benefits of wind as a source of energy?

Problem-Based Learning Project: Investigate wind turbines to learn more about wind energy's costs and benefits.

At a Glance

Learning Objectives

- ✓ Identify reliable sources of information about wind energy costs and benefits.
- ✓ Conduct research on wind energy costs and benefits and incorporate the research results into the unit project.

Lesson Activities

- discussion
- vocabulary instruction
- research
- cost-benefit analysis

NGSS References

Performance Expectation 4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Disciplinary Core Idea ESS3.A: Natural Resources

Crosscutting Concepts: Cause and Effect

Science and Engineering Practices: Obtaining, Evaluating, and Communicating Information

Obtaining, Evaluating, and Communicating Information is the key practice of this unit. Students will work toward obtaining, evaluating, and communicating quality information taken from multiple sources that will enable them to complete the problem-based inquiry capstone project. This lesson's focus is a cost-benefit analysis of using wind energy to generate electricity.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 162–163 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

renewable resource **wind farm**

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue above.

Instructional Resources

Activity Page

AP 10.1

Activity Page
Wind Power Costs and Benefits (AP 10.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- access to the internet or library
- printed source materials about wind energy

By this point students should be working with a master cost-benefit analysis chart to organize or summarize their research, or they should have some other system for gathering and organizing their research, as part of their unit capstone project. If some summary information is being gathered or recorded as a class, make the chart or class file visible and available to all students during this lesson.

The Core Lesson 45 min

1. Focus student attention on the Big Question. 10 min

Where can I find reliable information about costs and benefits of wind as a source of energy? Continue working on this unit's **Problem-Based Learning Project**. Remind students that this unit is different from all the others because it contains a single capstone project that is designed to help them understand how to deal with a problem. In this lesson, students will learn about wind turbines, their costs, and their benefits. Explain that this will help students complete the project in the capstone lesson.

By this point, students have already conducted cost-benefit analyses of two other energy resources, so they should be ready to take what they have already learned about wind energy and conduct additional research on its costs and benefits, including looking at local or state angles on the issue. Review what your class has already learned about wind power. Ask the following:

- What kinds of environments are good for harnessing wind energy? (*relatively open areas with steady breezes, such as coastal areas or plains*)
- What is the name of the machine that converts wind energy into electricity? (*a turbine with a generator*)
- What is the difference between a windmill and a wind turbine? (*A windmill does not convert mechanical energy into electricity. A turbine does.*)

Discuss the costs and benefits of wind power to help students figure out some different categories that they can research. Ask the following:

- How is wind power good for the environment? (*It doesn't produce carbon emissions. It doesn't use fossil fuels.*)
- What are the environmental costs of wind power? (*It can harm wildlife, especially birds; construction of towers can damage and alter natural habitats.*)
- Can wind power be used in the transportation industry? (*only if it is used to charge batteries or provide electricity to vehicles powered by electrified tracks or wires*)

Tell students that they will conduct research to learn more about the costs and benefits of wind power.

Preview Core Vocabulary Terms

Before students begin their research, write these terms on the board or chart paper. Encourage students to pay special attention to these terms as they research:

renewable resource **wind farm**

Know the Standards

Interdependence of Science, Engineering, and Technology is an NGSS Connection to Engineering, Technology, and Applications of Science. This problem-based learning science unit supports understanding that "knowledge of relevant scientific concepts and research findings is important in engineering." Students might encounter articles or other sources of information that describe how costs of turbine materials have declined and/or advances in materials science have allowed turbines to become larger and more efficient. There are also connections to biology, such as developing experimental turbine blades that have knob-like shapes that mimic those of the pectoral fins of humpback whales.

Use this link to download the CKSci Online Resources Guide for this unit, where specific links to recommended resources may be found: **www.coreknowledge.org/cksci-online-resources**

2. Review the unit capstone project. 5 MIN

Activity Page

AP 1.1

Review the problem-based inquiry project that is the basis for the unit: **Develop a cost-benefit analysis examining human uses of several types of natural resources for energy**. Review Project Evaluation Guide (AP 1.1). (See **Know the Standards** on the previous page.)

3. Support student research. 15 MIN

As in Lessons 6 and 8, students should look for information on websites that end with ".edu" or ".gov" and then, with your guidance, look at sites that end with ".com" or ".org." Wind power has had its share of detractors and skeptics. That means that some search results that appear on internet search sites are likely to be skewed because people or companies are paying for certain results or advertisements. Students should avoid sites tagged with "ad" and focus on reputable organizations and media.

Online Resources

Use this link to download the CKSci Online Resources Guide for this unit, where specific links to recommended resources may be found.

www.coreknowledge.org/cksci-online-resources

Give students adequate time to research wind power costs and benefits. Tell students to consider the amounts of materials and transportation costs that are involved in setting up utility-scale wind power or offshore wind farms. Some such projects require many years of planning and construction and the use of nonrenewable energy resources such as diesel fuel and gasoline.

4. Teach Core Vocabulary. 5 MIN

Revisit Core Vocabulary Cards

Direct student attention back to the Core Vocabulary words (displayed on the board or chart paper earlier in the lesson). Have students access the cards they made for these terms:

renewable resource **wind farm**

If they have not done so already, have students add wind as an example of a renewable resource on that term's card. Have them draw how a wind farm works on that term's card.

5. Check for understanding. 10 MIN

Activity Page

AP 10.1 and Answer Key

Formative Assessment Opportunity

Briefly discuss how the costs and benefits of wind power compare to those of nonrenewables such as fossil fuels and nuclear power. Ask the following:

» How do the environmental benefits of wind power compare to the environmental costs of fossil fuels? (*Wind power does not have the carbon emissions that fossil fuel power has.*)

» How is wind power used in this area? If it isn't used, why not? (*Answers will vary but should reflect whether and how wind power is being used in the area.*)

Distribute Wind Power Costs and Benefits (AP 10.1) to students, where they will summarize their research findings. Have students share and compare their findings as a class. Make sure that students have read about and recorded the major costs and benefits of wind power. Some of them are summarized in the sample table in the Answer Key.

Problem-Based Learning Progress

Review progress students have made in analyzing the costs and benefits of wind turbines, which generate electricity from wind. They have

- researched how wind energy is generated and used.
- continued the cost-benefit analysis for the unit capstone project.

Remind students that in Lessons 11–17, they will continue to apply what they have learned about cost-benefit analysis to researching different types of renewable and nonrenewable resources that might meet their community's energy resource needs.

LESSON 11

Hydroelectric Energy

Big Question: How do people use moving water as a source of energy?

Problem-Based Learning Project: Investigate how and why people use moving water as a source of energy.

At a Glance

Learning Objectives

- ✓ Describe hydroelectric energy and how it is produced.
- ✓ Trace the steps required to harness the energy of moving water and convert into electricity.

Lesson Activities

- optional videos
- reading and discussion
- vocabulary instruction

NGSS References

Performance Expectation 4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Disciplinary Core Idea ESS3.A: Natural Resources

Crosscutting Concepts: Cause and Effect

Science and Engineering Practices: Obtaining, Evaluating, and Communicating Information

Cause and Effect is important to this unit because students learn about how the movement of water (cause) can make a form of electric power (effect). Hydroelectric power, or hydropower, is another renewable energy resource. Some forms of hydropower (effect) are dependent on solar energy (cause). Other forms are powered by tidal movement (cause).

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 162–163 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

cost-effective **hydroelectric power**

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue above.

Instructional Resources

Student Reader

Ch. 6

Activity Page

AP 11.1

Student Reader, Chapter 6
"Hydroelectric Energy"

Activity Page
Lesson 11 Check (AP 11.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- household materials to assemble a water wheel
- index cards for student vocabulary deck (2 per student)
- internet access and the means to project images/video for whole-class viewing

The Core Lesson 45 min

1. Focus student attention on the Big Question. 10 min

How do people use moving water as a source of energy? Continue working on this unit's **Problem-Based Learning Project**. Remind students that this unit is different from all the others because it contains a single capstone project that is designed to help them understand how to deal with a problem. In this lesson, students will learn about energy from moving water, its costs, and its benefits. Explain that this will help students complete the project in the capstone lesson.

Write the Big Question on the board or chart paper. Explain that moving water is the form of energy that is first required to generate hydroelectric energy. As with the other forms of energy that students are learning about in this unit, the term *power* is usually used to mean electricity generated from a given source of energy.

If you used the example of a fan to explain how a turbine works in Lesson 9, you can do the same thing here but explain that the moving fluid in hydropower is water instead of air. The general principles are the same: the moving fluid particles move against the turbine blades, causing them to rotate the shaft they are attached to, and the rotation of the shaft either directly drives a generator or some gears are involved to convert the shaft rotation to the right speed for the generator. Usually, the force that moves the water is gravity, but in some cases the movement of the tides or the up-and-down motion caused by ocean waves is the force that provides the initial energy.

Preview Core Vocabulary Terms

Write these terms on the board or chart paper. Encourage students to pay special attention to these terms as they watch and discuss the video:

cost-effective **hydroelectric power**

Remind students that the whole point of this unit is for them to figure out the cost-effectiveness of different energy resources. Discuss in general terms why hydroelectric power might be cost effective in the long run but not in the short run. Ask the following:

- What takes more time and money to set up—a small gas-powered generator or a hydroelectric turbine? (*hydroelectric turbine*)
- Why might a renewable energy solution such as a hydroelectric dam be cost effective in the long run compared to the gas-powered generator? (*Hydropower is renewable. It doesn't require a fuel. As long as there is flowing water and the components of the system work, the energy basically has an ongoing and renewable source.*)

Point out that students will complete Core Vocabulary cards for these terms by the end of today's lesson.

2. Read and discuss: "Hydroelectric Energy." 25 MIN

Student Reader

Ch. 6

Prepare to read together or have students read independently "Hydroelectric Energy," Chapter 6 in the Student Reader. This chapter describes how the energy in moving water can be harnessed to generate electricity.

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Include suggested questions and prompts:

Pages 31–33

These pages explain hydroelectric energy, describe the steps and components of a hydroelectric dam, and explain the engineering choices that help make a hydroelectric dam more cost effective in the long run.

SUPPORT—Show the slide of a hydroelectric dam from Unit 1 *Energy Transfer and Transformation*. (See the Online Resources Guide for a link to this specific resource.)

Provide materials with which students can make their own water wheels. Explain to students that they need to build some kind of rotating wheel with water-catching paddles or blades and that the wheel needs to turn a shaft whose end is not in the stream. There are different toy systems that can be used to build water wheels, and there are also science kits that take things a step further and allow for electricity to be generated. Those kits allow students to find the speed that needs to be reached by the turbine or wheel in order for electricity to be generated.

Pages 34–35

Ask volunteers to describe how blocking fish such as salmon and trout from returning to their native streams to reproduce affects more than just the predators that eat them. (*After salmon reproduce, they die. The carcasses of the fish decompose on riverbeds or on the banks of rivers. The nutrients in those remains are released into the environment and taken up by trees, shrubs, mosses, and other plants. In this way, the migration of fish up rivers is a way of fertilizing forests. If that process is blocked, the forests can suffer.*)

SUPPORT—Show a video of a fish ladder or similar system at work at a real-world dam. (See the Online Resources Guide for a link to this specific resource.)

Page 36

After students have read the page, ask: What are some of the costs and benefits of the hydroelectric power of tides? Note that the costs are not described on the page. Students will need to brainstorm these. (*Benefits include the fact that there is so much water in the seas, and so much of it is moved by wind and gravity, that there is a lot of power to be harnessed. Costs include the literal costs of making machines to harness that power and powerful storms that may pose a threat to that machinery.*)

SUPPORT—Show a time-lapse video of tidal movement at the head of the Bay of Fundy. The movement of all that seawater represents a tremendous amount of energy of motion. Show a video of a tidal power turbine in the Bay of Fundy. (See the Online Resources Guide for a link to these specific resources.)

Online Resources

Use this link to download the CKSci Online Resources Guide for this unit, where specific links to these resources may be found.

www.coreknowledge.org/cksci-online-resources

3. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary words. Have students write each term in the upper left part of an index card and underline it. Students should record definitions and helpful explanations, examples, or illustrations. Students can flesh out their cards with details from below.

cost-effective **hydroelectric power**

Word Work

- **cost effective:** (adj. describing the balance of factors when benefits outweigh costs) Explain to students that in the term *cost-effective*, the word *effective* is describing the word *cost*. Have students write the definition of the term on their cards and then describe something they believe is cost effective. (*Building dams to generate electricity is cost effective because they generate a lot of electricity over time*.)
- **hydroelectric power:** (n. electricity generated by the energy in moving water, usually through a dam) Have students break the word *hydroelectric* into its two parts: *hydro* and *electric*. Have students write on their cards what each word means (*hydro* means water; *electric* refers to a form of energy).

Try to get students to use the *energy* versions when the physical energy itself is the subject and to use *power* versions when the subject is the type of energy that produces electricity. Organize information in a chart that can be revised as you work through the remaining lessons in the unit. The beginnings of a sample chart are shown here:

***Energy* term(s)**	***Power* term(s)**
nuclear energy—the energy contained in atoms	**nuclear power**—converting nuclear energy into heat to generate electricity
wind energy—the energy of motion in moving particles of air	**wind power**—converting the energy of moving air into mechanical and electrical energy
hydroelectric energy—the production of electricity from the energy of moving water	**hydroelectric power or hydropower**—*same meaning as the* energy *version*
solar energy—	**solar power**—
geothermal energy—	**geothermal power**—

Students can revise their Core Vocabulary cards to indicate how terms of *energy* and *power* are used as synonyms or how they differ in meaning. Have students safely store their deck of Core Vocabulary cards in alphabetical order. Students will add to the deck in later lessons.

4. Check for understanding. 5 MIN

Activity Page

AP 11.1 and Answer Key

Formative Assessment Opportunity

Have students complete Lesson 11 Check (AP 11.1). Collect the assessment, and check students' answers to identify concepts with which they are still struggling. See the Activity Page Answer Key for correct answers and sample student responses. Incorporate adjustments as you open the next lesson. Provide additional guidance for students who need more support.

Problem-Based Learning Progress

Review progress students have made in analyzing the costs and benefits of hydroelectric energy, which is a renewable resource. They have

- learned about how hydroelectric energy is generated and used.
- continued the cost-benefit analysis for the unit capstone project.

Remind students that in Lessons 12–17, they will continue to apply what they have learned about cost-benefit analysis to researching different types of renewable and nonrenewable resources that might meet their community's energy resource needs.

LESSON 12

Researching Use of Hydroelectric Power

Big Question: Where can I find reliable information about the costs and benefits of using moving water as a source of energy?

Problem-Based Learning Project: Continue investigating how and why people use moving water as a source of energy.

At a Glance

Learning Objectives

- ✓ Identify reliable sources of information about hydroelectric power costs and benefits.
- ✓ Conduct research on hydroelectric power costs and benefits and incorporate the research results into the unit project.

Lesson Activities

- discussion
- vocabulary instruction
- research
- cost-benefit analysis

NGSS References

Performance Expectation 4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Disciplinary Core Idea ESS3.A: Natural Resources

Crosscutting Concepts: Cause and Effect

Science and Engineering Practices: Obtaining, Evaluating, and Communicating Information

Obtaining, Evaluating, and Communicating Information is the key practice of this unit. Students will work toward obtaining, evaluating, and communicating quality information taken from multiple sources that will enable them to complete the problem-based inquiry capstone project. This lesson's focus is a cost-benefit analysis of hydroelectric power.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 162–163 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

hydroelectric power **renewable resource**

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue above.

Instructional Resources

Activity Page

AP 12.1

Activity Page
Hydroelectric Power Costs and Benefits (AP 12.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- access to the internet or library
- printed source materials about hydroelectric power

This is the fourth of six discrete lessons in which students are to conduct a cost-benefit analysis of an energy resource as part of their unit capstone project. By this point, they should have a streamlined process that includes ways of researching the local or state tie-ins to the topic. However, if other lessons allowed for ample local research and this one does not, you may need to provide more guidance about sources.

The Core Lesson 45 min

1. Focus student attention on the Big Question. 5 min

Where can I find reliable information about costs and benefits of using moving water as a source of energy? Continue working on this unit's **Problem-Based Learning Project**. Remind students that this unit is different from all the others because it contains a single capstone project that is designed to help them understand how to deal with a problem. In this lesson, students will research energy

from moving water, its costs, and its benefits. Explain that this will help students complete the project in the capstone lesson.

By this point there should be a rhythm to how students consider the Big Question and approach the cost-benefit analysis of the lesson as well as the unit project. Review what your class has already learned about hydroelectric power. Ask the following:

- What do you need for hydroelectric energy to be a large-scale provider of electricity? (*large volume of moving water or a reservoir that can be drained*)
- What is the name of the machine that converts the energy of motion in moving water into electricity? (*a turbine with a generator*)
- What is the difference between a water mill and a hydroelectric turbine? (*A water mill does not convert mechanical energy into electricity; it just uses the mechanical energy to move machinery. A turbine does convert mechanical energy into electricity.*)

Discuss the costs and benefits of hydroelectric power to help students figure out some different categories that they can research, to see if there are types of hydroelectric power that are more or less cost effective than others. Ask the following:

- How do you think the scale of a hydroelectric power project affects how cost effective it is? (*Larger projects are less likely to pay off in the short term but more likely to pay off in the long run.*)
- What are the environmental costs of hydroelectric power facilities that use dams? (*The dams block fish migrations, flood upriver areas, and reduce flow and volume downriver.*)
- What are the environmental costs of hydroelectric power facilities that do not use dams but instead have turbines or wheels installed in naturally flowing bodies of water? (*Their costs are much lower. They do not alter the flow of the water as much, nor do they interfere with wildlife as much as dams.*)

Tell students that they will conduct research to learn more about the costs and benefits of hydroelectric power.

Preview Core Vocabulary Terms

Write these terms on the board or chart paper. Encourage students to pay special attention to these terms as they conduct their research:

hydroelectric power **renewable resource**

2. Review the unit capstone project. 5 MIN

Activity Page

AP 1.1

Review the problem-based inquiry project that is the basis for the unit: **Develop a cost-benefit analysis examining human uses of several types of natural resources for energy**. Review Project Evaluation Guide (AP 1.1). (See **Know the Standards**.)

3. Support student research. 25 MIN

As in Lessons 6, 8, and 10, students should look for information on websites that end with ".edu" or ".gov" and then, with your guidance, look at sites that end with ".com" or ".org."

Online Resources

Use this link to download the CKSci Online Resources Guide for this unit, where specific links to recommended resources may be found.

www.coreknowledge.org/cksci-online-resources

Give students adequate time to research hydroelectric power costs and benefits. Encourage them to focus on the effect of scale on the costs and benefits of hydroelectric power.

4. Teach Core Vocabulary. 5 MIN

Revisit Core Vocabulary Cards

Have students withdraw the Core Vocabulary cards they made for the previous lesson. For **hydroelectric power**, have them write on the card examples of ways that hydroelectric power can be generated. For **renewable resource**, have them write on the card why hydroelectric power is considered a renewable resource.

Know the Standards

Influence of Engineering, Technology, and Science on Society and the Natural World is an NGSS Connection to Engineering, Technology, and Applications of Science. This problem-based learning science unit supports understanding that "over time, people's needs and wants change, as do their demands for new and improved technologies." Hydroelectric power has been both embraced as a clean energy technology and attacked as environmentally destructive. While the energy harnessed and produced is "clean," the overall impact on the environment can be seen as harmful, depending on one's point of view or main concerns. There might be ways to refine or reengineer hydroelectric power so that environmental impacts are lessened. On the other hand, a society might decide that the environmental costs of hydroelectric power are worth bearing because the costs of fossil fuel use are worse. Changes among the needs, demands, and wants of our society have already resulted in some dams being dismantled.

5. Check for understanding. 5 MIN

Activity Page

AP 12.1 and Answer Key

Formative Assessment Opportunity

Discuss how the costs and benefits of hydroelectric power compare to those of nonrenewables such as fossil fuels. Ask the following:

» How do the environmental benefits of hydroelectric power compare to the environmental costs of fossil fuels? (*Hydroelectric power does not have the carbon emissions that fossil fuel power releases, but it does affect natural habitats, including the rivers that are often dammed to generate hydroelectric power.*)

» How is hydroelectric power used in this area? If it isn't used, why not? (*Answers will vary.*)

Direct students to Hydroelectric Power Costs and Benefits (AP 12.1), where they will summarize their research findings. Have students share and compare their findings as a class. Make sure that students have read about and recorded the major costs and benefits of wind power. Some of them are summarized in the sample table in the Answer Key.

Problem-Based Learning Progress

Review progress students have made in analyzing the costs and benefits of hydroelectric energy, which is a renewable resource. They have

- researched how hydroelectric energy is generated and used.
- continued the cost-benefit analysis for the unit capstone project.

Remind students that in Lessons 13–17, they will continue to apply what they have learned about cost-benefit analysis to researching different types of renewable and nonrenewable resources that might meet their community's energy resource needs.

LESSON 13

Solar Energy

Big Question: How do people use sunlight as a source of energy?

Problem-Based Learning Project: Investigate how and why people use sunlight as a source of energy.

At a Glance

Learning Objectives

- ✓ Describe solar energy.
- ✓ Trace the steps required to harness solar energy and convert it into electricity or other useful forms of energy.

Lesson Activities

- optional videos
- reading and discussion
- vocabulary instruction

NGSS References

Performance Expectation 4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Disciplinary Core Idea ESS3.A: Natural Resources

Crosscutting Concepts: Cause and Effect

Science and Engineering Practices: Obtaining, Evaluating, and Communicating Information

Cause and Effect is important to this unit. Like hydroelectric power and wind energy, solar energy is another renewable energy resource that can have many effects. Solar energy is the original source (cause) of much of the energy (effect) that is available on Earth, whether it's nonrenewables such as coal and petroleum or renewables such as wind energy and hydroelectric power. The sun provides more than enough energy to power all of humanity's activities, so the challenge is how to efficiently harness that energy.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 162–163 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

efficiency	photon	**solar power**
electron	**solar cell**	

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue above.

Instructional Resources

Student Reader

Ch. 7

Activity Page

AP 13.1

Student Reader, Chapter 7
"Solar Energy"

Activity Page
Lesson 13 Check (AP 13.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- solar oven materials: cardboard boxes, aluminum foil, polystyrene, newspaper, plastic wrap
- index cards for student vocabulary deck (2 per student)
- internet access and the means to project images/video for whole-class viewing

The Core Lesson 45 min

1. Focus student attention on the Big Question. 10 min

How do people use sunlight as a source of energy? Continue working on this unit's **Problem-Based Learning Project**. Remind students that this unit is different from all the others because it contains a single capstone project that is designed to help them understand how to deal with a problem. In this lesson, students will learn about energy from sunlight, its costs, and its benefits. Explain that this will help students complete the project in the capstone lesson.

Write the Big Question on the board or chart paper. Remind students that *energy* is used interchangeably with *power* but that the latter term is more often used to

describe the conversion of a nonelectrical type of energy into electricity. In this case, *solar power* is used interchangeably with *solar energy*, but it's more precise to use the *energy* phrase when talking specifically about sunlight. This is analogous to how *hydroelectric power* and *wind power* are used. (See **Know the Science** below.)

Discuss basic solar-powered devices that students may use in their everyday lives, such as calculators, outdoor lighting, battery chargers, and other devices that convert sunlight into electricity. Discuss passive solar as well—using sunlight to produce thermal energy, or heat. A greenhouse is passive solar in action. The light and heat allow plants to grow even if the outside temperature is low. Likewise, a car left in a parking lot will get very hot inside if the windows are not blocked. Ask the following:

- What are some other things that can be heated or powered by passive solar power? (*water heaters, some homes and businesses, etc.*)
- What are some other solar-powered devices? (*cell phone chargers, flashlights, reading lamps, walkway lights, stop signs, wireless speakers, etc.*)

2. Read and discuss: "Solar Energy." 25 MIN

Student Reader

Ch. 7

Prepare to read together or have students read independently "Solar Energy," Chapter 7 in the Student Reader. This chapter describes how the energy in sunlight can be converted to electricity.

Preview Core Vocabulary Terms

Before reading, write these terms on the board or chart paper. Encourage students to pay special attention to these terms as they read:

solar cell **solar power**

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Include suggested questions and prompts:

Know the Science

What is the difference between energy and power? ***Energy is the ability to cause change, and energy is required to perform work. Power is a measure of the rate of work that results from an amount of energy.*** The terms *energy* and *power* are often used interchangeably in everyday life, and this is suitable in Grade 4 discussions. But in science, they are not interchangeable. Each represents something different but closely related. Energy is what makes things happen. Power is the rate, or speed, at which they happen. For example, a person expends energy to move a heavy object across the floor. The amount of energy used—how it is measured—is the power that was used. Electric power, for another example, is measured in watts (as on a light bulb) and in joules per second (the joule is a unit of energy, and the second is a unit of time).

Page 37

Discuss how much of the energy that is present on or above Earth's surface is a result of solar energy striking the planet. Ask the following:

- How is wind related to solar energy? (*Wind is a result of solar energy causing uneven heating of different areas of Earth's surface.*)
- How is thermal energy related to solar energy? (*Thermal energy, which is heat present in the atmosphere, geosphere, and hydrosphere, is largely a product of solar energy that has been absorbed and then moved through different substances, including air and water.*)
- How are fossil fuels related to solar energy? (*The fossil fuels we rely so much on are forms of chemical energy that organisms made from sunlight long ago.*)

Pages 38–39

Discuss the different factors that can limit the amount of sunlight that strikes a given area of Earth's surface. Ask the following:

- What is the most basic problem with relying on solar energy to provide all your energy needs? (*The sun goes down at night. For about half the time, there is no sunlight available at all.*)
- What other geographical factors affect how much sunlight strikes a given area? (*Latitude. Areas near the equator get more direct sunlight, and it is more consistent throughout the year. Areas near the poles can go months with little sunlight and months almost without night. Sunlight is very variable/extreme near the poles.*)
- What other factors limit the exposure of Earth's surface to sunlight? (*cloud cover, trees, mountains, buildings*)
- What kinds of terrain do you think are good for placing a large number of solar panels? (*relatively flat areas of land that aren't covered with trees*)

Pages 40–42

Show a video of a concentrated solar power plant.

Online Resources

Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found.

www.coreknowledge.org/cksci-online-resources

When reading the passage about rooftop solar hot water heaters, clarify that it is rare for the water that is actually used by the household to be heated directly on the roof. Instead, water or some other fluid that is heated on the roof is directed into a tank or a heat exchanger, where the heat from the warm fluid is passed through pipes to heat the water that can then be used for a shower, a washing machine, a sink, or a dishwasher.

Introduce students to solar ovens whose designs can be found online. Provide materials that students can use to design their own solar ovens. This can be done as a whole-class project to see if something such as an egg can be cooked all the way through by heat in a solar oven, or you might opt to turn it into a multiday activity with pairs developing and testing their own designs. An alternative of this activity is to instead evaluate how passive solar energy is part of your school's design. Are there rooms where available sunlight is used to provide heat? In contrast, are there spaces that receive too much sunlight and the school must use energy to cool those spaces?

3. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary words. Have students write each term in the upper left part of an index card and underline it. Students should record definitions and helpful explanations, examples, or illustrations. Students can flesh out their cards with details from below.

solar cell **solar power**

Word Work

- **solar cell:** (n. a device that converts sunlight to electricity) Explain that the solar cell is the basic unit of photovoltaic solar equipment. Cells are organized into modules, and modules are connected in panels. Multiple panels form an array. A typical rooftop solar array consists of anywhere from several to several dozen panels. Ask students whether they have ever seen any solar cells/panels, where they saw them, and what they think they were being used for. Then have students write what they are used for on their cards.
- **solar power:** (n. the use of sunlight to meet energy needs) Point out that the terms *solar power* and *solar cell* both have the word *solar* in them. On their card, have students write what the word *solar* means. (*having to do with the sun*) Then have them write the term *solar power* in a sentence. (*Some people use solar power to heat their homes.*) Ask volunteers to share their sentences with the class, and discuss them.

Have students safely store their deck of Core Vocabulary cards in alphabetical order. Students will add to the deck in later lessons.

4. Check for understanding. 5 MIN

Activity Page

AP 13.1 and Answer Key

Formative Assessment Opportunity

Have students complete Lesson 13 Check (AP 13.1). Collect the assessment, and check students' answers to identify concepts with which they are still struggling. See the Activity Page Answer Key for correct answers and sample student responses. Incorporate adjustments as you open the next lesson. Provide additional guidance for students who need more support.

Problem-Based Learning Progress

Review progress students have made in analyzing the costs and benefits of solar energy, which is a renewable resource. They have

- learned how solar energy is generated and used.
- continued the cost-benefit analysis for the unit capstone project.

Remind students that in Lessons 14–17, they will continue to apply what they have learned about cost-benefit analysis to researching different types of renewable and nonrenewable resources that might meet their community's energy resource needs.

LESSON 14

Researching Use of Solar Energy

Big Question: Where can I find reliable information about costs and benefits of using sunlight as a source of energy?

Problem-Based Learning Project: Continue investigating how and why people use sunlight as a source of energy.

At a Glance

Learning Objectives

- ✓ Identify reliable sources of information about solar power costs and benefits.
- ✓ Conduct research on solar power costs and benefits and incorporate the research results into the unit project.

Lesson Activities

- discussion
- vocabulary instruction
- research
- cost-benefit analysis

NGSS References

Performance Expectation 4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Disciplinary Core Idea ESS3.A: Natural Resources

Crosscutting Concepts: Cause and Effect

Science and Engineering Practices: Obtaining, Evaluating, and Communicating Information

Obtaining, Evaluating, and Communicating Information is the key practice of this unit. Students will work toward obtaining, evaluating, and communicating quality information taken from multiple sources that will enable them to complete the problem-based inquiry capstone project. This lesson's focus is a cost-benefit analysis of solar power.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

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renewable resource **solar cell**

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue above.

Instructional Resources

Activity Page

AP 14.1

Activity Page
Solar Power Costs and Benefits (AP 14.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- access to the internet or library
- printed source materials about solar power

The Core Lesson 45 min

1. Focus student attention on the Big Question. 5 min

Where can I find reliable information about costs and benefits of using sunlight as a source of energy? Continue working on this unit's **Problem-Based Learning Project**. Remind students that this unit is different from all the others because it contains a single capstone project that is designed to help them understand how to deal with a problem. In this lesson, students will research energy from sunlight, its costs, and its benefits. Explain that this will help students complete the project in the capstone lesson.

By this point, there should be a rhythm to how students conduct the cost-benefit analysis of this lesson and the unit project. Review what your class has already learned about solar power. Ask the following:

» What are three different ways of using solar energy? (*passive solar to heat a home, photovoltaic panels to make electricity, and concentrated solar thermal to power a turbine and generator*)

- What is the major drawback of solar power in some locations? (*not many hours of sunlight, cloudy weather*)
- What is one problem with photovoltaic technology that has prevented solar power from being a bigger producer of electricity? (*It's not very efficient.*)

Discuss the costs and benefits of solar power to guide students toward different branches or categories of inquiry. Ask the following:

- What are the costs and benefits of a large-scale solar power facility such as a concentrated solar thermal plant or a huge solar array farm in the desert? (*Big projects cost a lot of money up front but are more likely to pay off in the long run, and they can service more people/homes, too.*)
- What can be done to make more use of solar energy in areas that have short days in the winter? (*Batteries could store power generated during the daylight hours. Solar thermal can run into the night using residual heat.*)

Tell students that they will conduct research to learn more about the costs and benefits of solar power.

Preview Core Vocabulary Terms

Write these terms on the board or chart paper. Encourage students to pay special attention to these terms as they conduct their research:

renewable resource **solar cell**

2. Review the unit capstone project. 5 MIN

Activity Page

AP 1.1

Review the problem-based inquiry project that is the basis for the unit: **Develop a cost-benefit analysis examining human uses of several types of natural resources for energy**. Reference the Project Evaluation Guide (AP 1.1). (See **Know the Standards**.)

Know the Standards

Influence of Engineering, Technology, and Science on Society and the Natural World is an NGSS Connection to Engineering, Technology, and Applications of Science. This problem-based learning science unit supports understanding that "over time, people's needs and wants change, as do their demands for new and improved technologies." Solar power has become more efficient and less expensive, which has made it much more attractive to homeowners who want to rely less on nonrenewable energy or even make money by selling electricity to the grid. There is also off-the-grid appeal to "going solar," and improvements in battery technology are now allowing some homes to be powered entirely by solar energy.

3. Support student research. 20 MIN

Online Resources

As in Lessons 6, 8, 10, and 12, students should look for information on websites that end with ".edu" or ".gov" and then, with your guidance, look at sites that end with ".com" or ".org" as appropriate. Use this link to download the CKSci Online Resources Guide for this unit, where specific links to recommended resources may be found: **www.coreknowledge.org/cksci-online-resources**

Give students adequate time to research solar power costs and benefits. Encourage them to focus on the effect of scale on the costs and benefits of solar power.

4. Teach Core Vocabulary. 5 MIN

Have students sort through their vocabulary decks and find the cards for **renewable resource** and **solar cell**.

Revisit Core Vocabulary Cards

- On the *renewable resource* card, ask students to explain why solar energy is a renewable resource.
- On the *solar cell* card, have students write "energy from the sun" next to *solar* and "battery" next to *cell*. Then have them write on their cards what they think this means. (*battery that stores energy from the sun; a device that converts sunlight into electricity*)

5. Check for understanding. 10 MIN

Activity Page

AP 14.1 and Answer Key

Formative Assessment Opportunity

Discuss how the costs and benefits of solar power compare to those of nonrenewables such as fossil fuels and nuclear power. Ask the following:

» How do the environmental benefits of solar power compare to the environmental costs of fossil fuels? (*Both nuclear and nonrenewables have some environmental costs related to the mining and manufacture of materials, but solar has very few negative environmental impacts.*)

» How is solar power used in this area? If it isn't used, why not? (*Answers will vary.*)

» What are some secondary benefits of using solar arrays? (*They can shade parking lots and rooftops, making them cooler.*)

Direct students to Solar Power Costs and Benefits (AP 14.1), where they will summarize their research findings. Have students share and compare their findings as a class. Make sure that students have read about and recorded the major costs and benefits of solar power. Some of them are summarized in the sample table in the Answer Key.

Problem-Based Learning Progress

Review progress students have made in analyzing the costs and benefits of solar energy, which is a renewable resource. They have

- researched how solar energy is generated and used.
- continued the cost-benefit analysis for the unit culminating project.

Remind students that in Lessons 15–17, they will continue to apply what they have learned about cost-benefit analysis to researching different types of renewable and nonrenewable resources that might meet their community's energy resource needs.

LESSON 15

Geothermal Energy

Big Question: What is geothermal energy, and how do people use it?

Problem-Based Learning Project: Investigate how and why people use geothermal energy.

At a Glance

Learning Objectives

- ✓ Describe geothermal energy and its sources.
- ✓ Trace the steps required to harness geothermal energy and convert it to electricity.

Lesson Activities

- optional videos
- reading and discussion
- vocabulary instruction

NGSS References

Performance Expectation 4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Disciplinary Core Idea ESS3.A: Natural Resources

Crosscutting Concepts: Cause and Effect

Science and Engineering Practices: Obtaining, Evaluating, and Communicating Information

Cause and Effect is the focus of this unit. Like hydropower, wind energy, and solar energy, geothermal energy is a renewable energy resource. It is the other source of heat on Earth. Sunlight provides heat from above, while Earth's interior (cause) provides heat (effect) from within. Throughout this lesson, students learn more about how geothermal energy (cause) heats buildings and is used as a power source (effect).

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to this term, which is not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 162–163 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

geothermal energy renewable resource

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary term designated in blue above.

Instructional Resources

Student Reader

Ch. 8

Activity Page

AP 15.1

Student Reader, Chapter 8
"Geothermal Energy"

Activity Page
Lesson 15 Check (AP 15.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- index cards for student vocabulary deck (1 per student)
- internet access and the means to project images/video for whole-class viewing

The Core Lesson 45 min

1. Focus student attention on the Big Question. 10 min

What is geothermal energy, and how do people use it? Continue working on this unit's **Problem-Based Learning Project**. Remind students that this unit is different from all the others because it contains a single culminating project that is designed to help them understand how to deal with a problem. In this lesson, students will research energy from inside Earth, its costs, and its benefits. Explain that this will help students complete the project in the capstone lesson.

Geothermal energy is thermal energy of some kind or another located under Earth's surface. As you might have done in previous lessons, explain to students that *energy* is used interchangeably with *power* but that the latter term is more often used to

describe the conversion of a nonelectrical type of energy to electricity. In this case, *geothermal power* is used interchangeably with *geothermal energy*, but it's more precise to use the *energy* phrase when talking specifically about heat in Earth's interior, from the core to the crust. Geothermal energy is used by the geothermal power industry.

Discuss students' prior knowledge of or experience with geothermal energy. Some students might have enjoyed hot springs or visited a park where geysers release hot water. These are both examples of hot water that rises to Earth's surface. Heat can be used directly, or it can be converted into electricity through a steam-turbine-generator process.

Preview Core Vocabulary Term

Before students read, write **geothermal energy** on the board or chart paper. Encourage students to pay special attention to the term as they read. Point out that students will complete a Core Vocabulary card for this term by the end of today's lesson.

2. Read and discuss: "Geothermal Energy." 25 MIN

Student Reader

Ch. 8

Prepare to read together or have students read independently "Geothermal Energy," Chapter 8 in the Student Reader. This chapter describes how heat from Earth's interior can be converted to electricity and used more directly to transfer heat.

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Include suggested questions and prompts:

Page 43

Have students consider how heat pumps warm homes. Ask: How can heat pumps also be used to cool homes? (*In summer, when the daytime temperature at Earth's surface can be uncomfortably hot, the soil and rock underground are relatively cool. The same pump system that brings warmth to a home in winter can be used to transfer heat out of the home and send it underground.*)

Discuss what Iceland is like. Explain that this is a relatively unusual environment. Volcanic activity provides heat very close to Earth's surface, including these hot pools. Most of Earth's surface does not have this kind of easy access to geothermal energy. Ask: Does this suggest that geothermal heat is common or uncommon in the world? (*Uncommon. The fact that there are so few spots in the world for geothermal heat is why using it to meet large-scale energy needs is not easy.*)

Page 44

Discuss how thermal energy moves. Ask: Why does thermal energy move from the hot liquid pumped from a production well into the cooler liquid that runs through the boiler? (*Thermal energy, or heat, moves from warmer material to cooler material.*)

Page 45

This page describes low-temperature geothermal plants that can tap or recycle lower-temperature fluids through warm rock of Earth's crust. Ask: What is the key to using this technology? (*The key to this technology is using fluids in the boiler that have a lower boiling point. This allows the same steam-turbine-generator conversion to occur but at a lower temperature, meaning less geothermal energy is required. This is similar to the heat pump described on the first page, but it is done at a larger scale.*)

Page 46

This page summarizes the costs and benefits of using geothermal energy. The main disadvantage is the lack of sites where geothermal energy is abundant, reliable, and cost effective to tap. The figure shows the share of electricity generation that renewables and nonrenewables had in 2017 in the United States. Students might need help deciphering this figure. Ask:

- What is the overall share of the United States' electricity generation by nonrenewable energy resources? (*eighty-three percent*)
- Where does geothermal energy rank among the renewables in terms of its share of electricity generation? (*last*)
- How much more is natural gas used to make electricity than geothermal energy in the U.S.? (*eighty times more*)

Online Resources

SUPPORT—Show a video that summarizes the geothermal energy picture in the United States and describes some of the different types of geothermal plants. Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found.

www.coreknowledge.org/cksci-online-resources

3. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Card

Direct student attention to **geothermal energy** written on the board or chart paper earlier in the lesson. Have students write the term in the upper left part of an index card and underline it. Students should record a definition and a helpful explanation, examples, or illustrations. Students can flesh out their cards with details from below.

Word Work

geothermal energy: (n. energy produced by heat that is transferred from Earth's interior) Thermal energy is one of the primary types of energy. Have students write down some of the others that they can remember. (*mechanical energy, atomic energy, radiant energy, electrical energy, and chemical energy*) Then have students describe what geothermal energy is. (*Geothermal energy is specifically the thermal energy, or heat, that is generated by processes in Earth's interior. It is heat that is transferred from Earth's interior to Earth's surface.*)

Have students safely store their deck of Core Vocabulary cards in alphabetical order. Students will add to the deck in later lessons.

4. Check for understanding. 5 MIN

Activity Page

AP 15.1 and Answer Key

Assessment Opportunity

Have students complete Lesson 15 Check (AP 15.1). Collect the assessment, and check students' answers to identify concepts with which they are still struggling. See the Activity Page Answer Key for correct answers and sample student responses. Incorporate adjustments as you open the next lesson. Provide additional guidance for students who need more support.

Problem-Based Learning Progress

Review progress students have made in analyzing the costs and benefits of geothermal energy, which is a renewable resource. They have

- learned how geothermal energy is generated and used.
- continued the cost-benefit analysis for the unit culminating project.

Remind students that in Lessons 16–17, they will continue to apply what they have learned about cost-benefit analysis to researching different types of renewable and nonrenewable resources that might meet their community's energy resource needs.

LESSON 16

Researching Use of Geothermal Energy

Big Question: Where can I find reliable information about costs and benefits of using geothermal energy?

Problem-Based Learning Project: Research the costs and benefits of geothermal energy.

At a Glance

Learning Objectives

- ✓ Identify reliable sources of information about geothermal energy costs and benefits.
- ✓ Conduct research on geothermal energy costs and benefits and incorporate the research results into the unit project.

Lesson Activities

- discussion
- vocabulary instruction
- research
- cost-benefit analysis

NGSS References

Performance Expectation 4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Disciplinary Core Idea ESS3.A: Natural Resources

Crosscutting Concepts: Cause and Effect

Science and Engineering Practices: Obtaining, Evaluating, and Communicating Information

Obtaining, Evaluating, and Communicating Information is the key practice of this unit. By the time they arrive at this lesson, students should be nearly finished with obtaining, evaluating, and communicating quality information taken from multiple sources that will enable them to complete the problem-based inquiry culminating project. This lesson's focus is a cost-benefit analysis of geothermal energy.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 162–163 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

geothermal energy geyser **renewable resource**

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue above.

Instructional Resources

Activity Page

AP 16.1

Activity Page
Geothermal Energy Costs and Benefits (AP 16.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- access to the internet or library
- printed source materials about geothermal power

This is the sixth and final lesson in which students conduct a cost-benefit analysis of a specific energy resource.

The Core Lesson 45 min

1. Focus student attention on the Big Question. 10 min

Where can I find reliable information about costs and benefits of using geothermal energy? Continue working on this unit's **Problem-Based Learning Project**. Remind students that this unit is different from all the others because it contains a single culminating project that is designed to help them understand how to deal with a problem. In this lesson, students will research energy from inside Earth, its costs, and its benefits. Explain that this will help students complete the project in the capstone lesson.

By this point in the unit, students should have absorbed the information in the Student Reader chapter on geothermal energy in anticipation of this lesson. Review what your class has already learned about geothermal energy. Ask the following:

» What do engineers need to look for and tap into to generate electricity from geothermal energy? (*a source of heat in rock and soil not too far below Earth's surface*) Where are reservoirs of hot geothermal fluids often found? (*volcanic areas, near plate boundaries*)

» How is geothermal energy used in a similar way to other energy resources? (*Heat is used to make steam that spins a turbine that powers a generator.*)

Discuss different types of geothermal energy use. Ask the following:

» What is the advantage of using a geothermal reservoir that consists of steam that can be used directly in a turbine? (*It's the most direct way to use the energy to make electricity. There's no need for heat-exchanging pipes or fluids.*)

» What is the advantage of recycling wastewater in an abandoned oil field to generate electricity? (*It makes use of something that is already there, including the wastewater.*)

Tell students that they will conduct research to learn more about the costs and benefits of geothermal energy.

Preview Core Vocabulary Terms

Before students research, write these terms on the board or chart paper. Encourage students to pay special attention to these terms as they read:

geothermal energy **renewable resource**

2. Review the unit capstone project. 5 MIN

Activity Page

AP 1.1

Review the problem-based inquiry project that is the basis for the unit: **Develop a cost-benefit analysis examining human uses of several types of natural resources for energy**. Review Project Evaluation Guide (AP 1.1). You might also want to review the cost-benefit charts or analyses that students have completed thus far and make sure they are on the right track with the project before they proceed with this final cost-benefit analysis lesson.

3. Support student research. 15 MIN

Continue to direct students to appropriate ".edu" or ".org" websites and avoid overtly biased media or anything that is tagged as an "ad." Videos should be screened by you before sharing them with students. Some videos that seem to be apolitical or appear to be documentaries can in fact be advertisements, "advertorials," or other products that are intended to sell something, push a particular narrative, or potentially mislead people. Use this link to download the CKSci Online Resources Guide for this unit, where specific links to recommended resources may be found.

Online Resources

www.coreknowledge.org/cksci-online-resources

Give students adequate time to research geothermal energy costs and benefits. As in the other lessons of this unit, a chart that summarizes the electricity generation fuel shares for each state may be useful and worth providing to the whole class.

4. Teach Core Vocabulary. 5 MIN

Have students sort through their vocabulary decks and find the cards for **renewable resource** and **geothermal energy**.

Revisit Core Vocabulary Cards

- On the *renewable resource* card, ask students to explain why geothermal energy is a renewable resource.
- On the *geothermal energy* card, have students write "from Earth" next to *geothermal* and "power" next to *energy*. Then have them write on their cards what they think this means. (*energy that comes from inside Earth; energy that is transferred from Earth's interior to Earth's surface*)

5. Check for understanding. 10 MIN

Activity Page

AP 16.1 and Answer Key

Formative Assessment Opportunity

Compare the costs and benefits of geothermal energy to those of nonrenewables. Ask the following:

» How do the environmental benefits of geothermal energy compare to the environmental costs of fossil fuels? (*Carbon emissions are a major environmental cost of fossil fuel use. Lack of carbon emissions is a major benefit of geothermal energy use.*)

» Is geothermal energy used very widely in your area? If not, why? (*Answers will vary. States with volcanic activity or plate boundaries are more likely to have large-scale geothermal energy use.*)

Direct students to Geothermal Energy Costs and Benefits (AP 16.1), where they will summarize their research findings. Have students share and compare their findings as a class. Make sure that students have read about and recorded the major costs and benefits of geothermal power. Some of them are summarized in the sample table in the Answer Key.

Problem-Based Learning Progress

Review progress students have made in analyzing the costs and benefits of geothermal energy, which is a renewable resource. They have

- researched the costs and benefits of geothermal energy.
- continued the cost-benefit analysis for the unit culminating project.

Remind students that in Lesson 17, they will apply what they have learned about cost-benefit analysis to researching different types of renewable and nonrenewable resources that might meet their community's energy resource needs.

LESSON 17

Energy Resource Innovations

Big Question: What other energy resources are being developed?

Problem-Based Learning Project: Research the costs and benefits of new developments in energy resources.

At a Glance

Learning Objective

✓ Identify technologies that help reduce the negative effects of resources used for energy.

Lesson Activities

- optional animation
- reading and discussion
- vocabulary instruction

NGSS References

Performance Expectation 4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Disciplinary Core Idea ESS3.A: Natural Resources

Crosscutting Concepts: Cause and Effect

Science and Engineering Practices: Obtaining, Evaluating, and Communicating Information

Cause and Effect is important to this unit as students learn more about ways that energy can be harnessed (cause) to generate power (effect). The previous lessons focused on existing technologies and techniques for harnessing energy resources, both renewables and nonrenewables. This lesson looks at underutilized resources as well as new technologies to tap into energy that is available all around us (cause)—or even in our own footsteps—to power the things around us (effect).

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 162–163 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

biofuel	**fuel cell**	permafrost
ferment	**hybrid**	regenerative braking

Core Vocabulary Deck As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit. The deck will include the Core Vocabulary terms designated in blue above.

Instructional Resources

Student Reader

Ch. 9

Activity Page

AP 17.1

Student Reader, Chapter 9
"Energy Resource Innovations"

Activity Page
Lesson 17 Check (AP 17.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- index cards for student vocabulary deck (3 per student)
- internet access and the means to project images/videos for whole-class viewing

The Core Lesson 45 min

1. Focus student attention on the Big Question. 10 min

What other energy resources are being developed? Continue working on this unit's **Problem-Based Learning Project**. Remind students that this unit is different from all the others because it contains a single culminating project that is designed to help them understand how to deal with a problem. In this lesson, students will research new energy developments, their costs, and their benefits. Explain that this will help students complete the project in the capstone lesson.

Write the Big Question on the board or chart paper. Assess prior knowledge of alternative energy resources that have not already been covered in this unit. Ask the following:

» Are there any fossil fuels that have not yet been utilized as major sources of energy for human activities? (*Answers will vary. Some students may have heard about methane hydrates, though this is unlikely. Others may discuss biofuels, but these are not fossil fuels.*)

» What are some examples of humans using their bodies to generate electricity? (*Students may mention exercise bikes whose electronics are powered by the moving pedals or wind-up toys and rechargeable devices that can be wound by hand.*)

2. Read and discuss: "Energy Resource Innovations." 25 MIN

Student Reader

Ch. 9

Prepare to read together or have students read independently "Energy Resource Innovations," Chapter 9 in the Student Reader. This chapter describes innovations that are being made in developing new sources of energy and improving technology to harness more energy from resources that are already known.

Preview Core Vocabulary Terms

Before students read, write these terms on the board or chart paper. Encourage students to pay special attention to these terms as they read:

biofuel **fuel cell** **hybrid**

Point out that students will complete Core Vocabulary cards by the end of today's lesson.

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Include suggested questions and prompts:

Page 47

Emphasize that methane hydrate is another fossil fuel. It just happens to be underutilized so far. Explain that not only would burning methane hydrate put carbon dioxide into the atmosphere just as burning other fossils does, but allowing methane hydrate to melt would release methane into the atmosphere. Ask the following:

» Why is methane a problem when it enters the atmosphere? (*It is a powerful greenhouse gas, meaning it traps heat against Earth's surface.*)

Page 48

This page defines biofuels, which some regard as "greener" than fossil fuels. In reality, the overall impact of their use may not be much better for the environment. Explain that to some extent, it depends on how the biofuels are produced, including land use and energy consumption. Ask the following:

» Gasoline is burned in a car engine. Biofuel is burned in another car engine. Which one is "cleaner" in terms of the effects on the atmosphere? (*They are the same—the fuels are burned, emitting carbon.*)

» Corn plants (not corn) and sugarcane can be processed into biofuels, but what is the potential problem with turning this into a large-scale industry? (*It requires a lot of farmland. If a natural habitat such as a rain forest is cut down to make farmland for the biofuel industry, then the overall effect on the environment is negative.*)

Page 49

Draw a three-column chart on the board or chart paper with "Hybrid," "Plug-In Hybrid," and "Plug-In Electric" headings. As you read the page, add notes to the columns to differentiate the different types. Ask the following:

» How does a non-plug-in hybrid get energy? (*burning gasoline for a gas engine, and capturing energy through the brakes to power an electric motor and charge a battery*)

» How does a plug-in hybrid work? (*It works the same as a hybrid except that the battery is charged by plugging into an electrical outlet instead of or in addition to using regenerative braking.*)

» Which of the vehicles described on the page releases the fewest emissions? (*the plug-in electric*)

» Even if electric vehicles are using energy that comes from fossil fuels being burned at a power plant somewhere miles away, what is the environmental benefit of using electric motors instead of gas-burning engines? (*There is less pollution right there where the car is being used. This can mean cleaner air where people and vehicles are, such as congested roadways and cities.*)

Online Resources

SUPPORT—Use an animation to step through how a hybrid vehicle uses both gasoline and electricity to run. Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found.

www.coreknowledge.org/cksci-online-resources

Page 50

After students have finished reading the page, ask: Can you think of a way to make the use of hydrogen fuel cells cleaner in terms of the environmental impact? (*If a renewable energy resource is used to generate the electricity that produces the hydrogen gas and the processing and transportation of that gas is also powered by a renewable energy resource, then it all becomes much cleaner.*)

Page 51

It may be helpful to have students think of walking on a trampoline or a coiled-spring mattress. Explain that the sidewalk described on the page feels a bit like that, because some of the energy that would normally push back against you and allow you to walk as your body expects is instead being converted into other forms. When we walk on an elastic surface or a springy mattress, kinetic energy is stored as potential energy. When we walk on the sidewalk described on the page or we use an exercise bike that converts mechanical energy into electricity, some of the energy we apply is not turned into motion. Ask the following:

» Imagine walking on a sidewalk that "gives" a little bit under your feet. Do you think this is worthwhile if it produces some electricity? (*Answers will vary. Some people will find it awkward or even dangerous to walk on such a surface.*)

» Can you think of some ways that the technology of the sidewalk could be applied to other human activities so that they are less physically difficult? (*Answers will vary but are likely to center on exercise equipment. As long as people's motions feel natural and they get a good workout, they will probably feel good about generating electricity.*)

» A typical treadmill that athletes use to run in place works with an electric motor that makes the "ground" seem to move under the athlete. The athlete must run to avoid falling off the belt. How could this basic setup be reengineered so that the treadmill generates electricity instead of using it? (*Instead of running to stay on, the athlete's motion could move the belt, and the belt could turn an electric generator to generate electricity.*)

Page 52

After students have finished reading the page, ask:

» Is this hydroelectric power, such as that generated by a dam? (*Yes and no. The force of gravity is not the driver here. Wave action is, so it is not the same as what occurs in a hydroelectric dam.*)

» Harnessing wave energy is a bit like harnessing wind energy in terms of where you would need to set up the equipment. Why? (*You would want to harness it in areas with plenty of the energy resources* [*lots of waves or wind*] *but not too much, because too much could damage or destroy the technology that is needed to convert the energy of motion into electrical energy.*)

3. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary terms displayed on the board or chart paper at the beginning of the lesson. Have students write the terms in the upper left parts of index cards and underline them. Students should record a definition and a helpful explanation, examples, or illustrations of each term. Use the support below in discussion to help students flesh out their cards with details.

biofuel **fuel cell** **hybrid**

Word Work

- **biofuel:** (n. a combustible [burnable] fuel made from the remains of recently living organisms) On their cards, have students write what the word part *bio* means (*living*) and what the word *fuel* means (*source of energy*). Then have them write a sentence using the word. (*Biofuels are renewable but help pollute the air.*)
- **fuel cell:** (n. a device in which a chemical reaction takes place to produce electricity, similar to a battery) On their cards, have students write what the word *fuel* means (*a source of energy*) and what the word *cell* means (*battery; a way to generate energy*). Then have them define what a fuel cell is. (*a device in which a chemical reaction takes place to produce electricity*)

- **hybrid:** (n. a combination of two types; a vehicle that uses two different sources of fuel) Have students write on their cards two examples of hybrids from the Student Reader. (*cars that run on gasoline and electricity; cars that run on gasoline and another type of fuel*)

Have students safely store their deck of Core Vocabulary cards in alphabetical order.

4. Check for understanding. 5 MIN

Activity Page

AP 17.1 and Answer Key

Formative Assessment Opportunity

Have students complete Lesson 17 Check (AP 17.1). Collect the assessment and check students' answers to identify concepts with which they are still struggling. See the Activity Page Answer Key for correct answers and sample student responses. Incorporate adjustments as you open the next lesson. Provide additional guidance for students who need more support.

Problem-Based Learning Progress

Review progress students have made in analyzing the costs and benefits of new energy developments. They have

- researched the costs and benefits of new energy developments.
- continued the cost-benefit analysis for the unit culminating project.

Explain that in the final lesson, students will apply what they have learned about cost-benefit analysis to publishing or presenting their findings on which energy resources are best for their community.

PART E

Sharing the Costs and Benefits of Natural Resource Use

Overview

Lesson	Big Question	Advance Preparation
Analysis Report (3 days)	How can we summarize and share the findings in our research?	Gather materials for problem-based learning project. (See Materials and Equipment, page 16.)

Part E: What's the Story?

Students learned in Parts B, C, and D (Lessons 2–17) about the many different types of renewable and nonrenewable resources used to generate energy to power homes, businesses, other buildings, and means of transportation, among other things. Students also learned that each of these resources have costs and benefits associated with them, and students were tasked with researching and making a record of those costs and benefits.

In the capstone lesson, we start by having students decide upon a means of communicating the information they obtained to their peers, parents, and community leaders through a **problem-based learning project**, which they have been working on throughout this unit. Students are then tasked with combining the information they obtained, making a presentation, and practicing that presentation. As part of the latter, students critique and revise their presentations. Finally, students publish their cost-benefit analysis, thus making it a public product that others can learn from. After the presentation is over, students reflect on what they have learned.

So, to repeat, **natural resources used for energy have costs and benefits, and understanding those costs and benefits means obtaining, evaluating, and communicating to the community authentic information**. Help your students obtain, combine, and present information to describe that energy and fuels are derived from natural resources and that their uses affect the environment, and you will lay the groundwork for meeting the NGSS Performance Expectation 4-ESS3-1 as well as help students complete their problem-based learning project.

Analysis Report

Big Question: How can we summarize and share the findings in our research?

Problem-Based Learning Project: Prepare a presentation that compares the costs and benefits of different energy resources and proposes one that is best for the local community.

At a Glance

Learning Objective

✓ Share findings about costs and benefits of natural resource use with a community.

Lesson Activities (3 days)

- go over the project criteria (Day 1)
- decide how to publish the cost-benefit analysis (Day 1)
- combine cost-benefit information (Day 2)
- develop a presentation (Day 2)
- practice presentations (Day 2)
- hold an event for community members (Day 3)
- reflect and thank attendees (Day 3)
- Compare the process of obtaining and using a fossil fuel to that of obtaining and using a renewable resource.

NGSS References

Performance Expectation 4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Disciplinary Core Idea ESS3.A: Natural Resources

Crosscutting Concepts: Cause and Effect

Science and Engineering Practices: Obtaining, Evaluating, and Communicating Information

Obtaining, Evaluating, and Communicating Information is important in this project-based learning culminating lesson as students make a presentation showcasing the costs and benefits of different kinds of natural resources used for energy needs. They have already obtained and evaluated quality information, and now they must communicate it to a classroom of their peers as well as invitees from their families and the community. On Day 1, students determine how they will present their cost-benefit analysis. On Day 2, they combine the information they obtained and evaluated in previous lessons and make and practice their presentation, and on Day 3, they communicate their presentation.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Instructional Resources

Activity Pages

AP 1.1
AP UC.1
AP UC.2
AP UC.3

Activity Pages
Project Evaluation Guide (AP 1.1)

How to Publish or Present Your Cost-Benefit Analysis (AP UC.1)

Cost-Benefit Analysis (AP UC.2)

Energy Resources Project Reflection (AP UC.3)

Decide how you will group students for this performance assessment project. Small groups of three or four students will allow assignment of roles but allow accountability of all team members.

Materials and Equipment

Collect or prepare the following items:

- name tags for students and event attendees
- poster board
- old magazines for images
- internet access and the means to project online article for whole-class viewing

Advance Planning: Problem-Based Learning Project

Advance planning will be needed to carry out the presentation event. Identify invitees from your community, including other students, parents, and school administrators. Decide on a date and time that works for your class and school. Send out invitations as far in advance as possible. Be sure to allow students enough time to practice their presentations, especially if they are using audiovisual tools.

The Core Lesson Three days, 45 min each

1. Day 1: Focus student attention on the Big Question. 10 min

How can we summarize and share the findings in our research? Conclude work on this unit's **Problem-Based Learning Project**. Remind students that this unit is different from all the others because it contains a single culminating project that is designed to help them understand how to deal with a problem. In this lesson, students will use their cost-benefit analysis of the various types of energy resources and make a claim about which is best for the community.

In Lessons 1–17, students learned about the costs and benefits of several different kinds of energy resources, including how they can help or hurt environments and the things living in them. Ask the following:

- What are the energy resources you learned about in this unit? (*fossil fuels, nuclear energy, wind energy, water energy, solar energy, geothermal energy, and others*)
- What are some costs of those energy resources? (*Answers will vary. Some of the energy sources are not renewable and result in pollution.*)
- What are some benefits of those energy resources? (*Answers will vary. Some of the energy sources are renewable and result in less pollution.*)
- How could sharing what we have learned about these energy resources help our community? (*Answers will vary. Our community could turn to energy resources that are renewable and cause less pollution.*)

Explain to students that in this unit culminating project, they will think about which of these energy resources can have the greatest positive impact on their own community. Then students will plan and carry out a presentation to explain to community members what the costs and benefits are of these energy resources and how they compare to each other.

2. Preview the project evaluation criteria. 5 MIN

Activity Pages

AP 1.1
AP UC.1

Have students pull out their Project Evaluation Guide (AP 1.1), which they have had since the first lesson. Go over it with students, and have them keep it on hand as they consider How to Publish or Present Your Cost-Benefit Analysis (AP UC.1). Encourage questions, and be open to answer any questions students may have as they work on this project.

Distribute How to Publish or Present Your Cost-Benefit Analysis (AP UC.1), and go over the directions with students. Point out that there are three parts and that students must pay attention to all three parts before they can publish their analysis. Explain that they will use this checklist as a guide over the next few days. If students were placed in teams throughout this unit, place them in the same teams now as they begin their final lesson. You may wish to assign roles for different steps in the checklist.

3. Facilitate discussion. 25 MIN

Guide a class discussion about the different methods of publication covered on the Activity Page. Students will have some familiarity with at least the poster presentation by this time, but they may have less or no experience with making a booklet or publishing their report/analysis on the school's website. (If your school does not have a website or does not allow student reports/analyses to be published there, then

cross this method out, and tell students to ignore it.) Explain that no matter which method they choose, students will still have to make the analysis visually dynamic and informative. Students will also still have to present it to fellow students, family members, and members of the community. (See **Know the Standards**.)

After students or student groups have made their choices, poll them to determine which method students will use. Write the method on the board or chart paper, and have students circle that method on their sheets. Students should then go over the next sections on the Activity Page to decide how they will craft their publication/presentation. Explain that students will craft their presentations in the next class session.

4. Check for understanding. 5 MIN

Activity Page

AP UC.1 and Answer Key

Summative Assessment Opportunity

Do not collect How to Publish or Present Your Cost-Benefit Analysis (AP UC.1) from students. Students will need to refer to it on Day 2 as they prepare their cost-benefit analysis for publication and make a presentation for the peers, family members, and the community.

1. Day 2: Focus student attention on the Big Question. 5 MIN

How can we summarize and share the findings in our research? Remind students that in the previous class session, they determined a method of publication for their cost-benefit analysis. Before continuing, go back over the definitions of the words *cost* and *benefit*. Ask:

- What is a cost? (*A cost is a drawback, risk, or disadvantage of something.*)
- What is a benefit? (*A benefit is a positive result or outcome of something.*)

Discuss with students why understanding the costs and benefits of something is important. Go back to the example of the longer lunch period. Ask the following:

Know the Standards

Obtaining, Evaluating, and Communicating Information is important to Performance Expectation 4-ESS3-1, which requires that students research sources of information, evaluate those sources to determine their validity, and combine that information to describe how the natural resources humans use to meet their energy needs affect the world around them. The Science and Engineering Practice goes one step further, however, in requiring that students communicate, or publish, their findings. In Day 1 of the capstone lesson, students are asked to decide a method of publication: presenting their analysis as a poster, publishing it as a booklet, or placing it on the internet. All three are forms of publication, which means to make something known. In this case, it is being made known to a specific audience of peers, family members, and community members, who will be asked to reflect on the findings of the analysis.

» Why would a longer lunch period be good? (*gives students more time to eat and burn off their energy*)

» Why would a longer lunch period be bad? (*cuts into learning time*)

Now have students apply this same line of reasoning to other things, such as the kinds of clothes they wear (*Something may cost more to be more comfortable.*) or the vehicles they drive (*Bigger vehicles use more gas but can carry bigger items or more people.*). (See **Know the Science**.)

2. Facilitate student publishing. 25 MIN

Activity Pages

AP UC.1
AP UC.2

Distribute Cost-Benefit Analysis (AP UC.2) to all students. Go over the directions with students, and answer any questions students may have. Then pass out the original costs and benefits Activity Pages that students completed for each energy resource. Have students combine the information they collected in those Activity Pages on the new Cost-Benefit Analysis (AP UC.2) provided in this lesson.

Explain that students should discuss among themselves what they see as the two biggest costs and the two best benefits. Different students will likely come to different conclusions about which costs are the biggest and worst and which benefits are the most positive. If students disagree, have them consider each cost and benefit individually. Encourage students to arrive at a conclusion amicably, perhaps even through the democratic process of voting.

Once students have combined their research, they are ready to make and publish their presentations. Make sure that all students have on hand their How to Publish or Present Your Cost-Benefit Analysis (AP UC.1). Go over the second two parts with students, and have them use these to guide the presentation. Also, depending on which publication method students have chosen, have internet access, poster board, and old magazines on hand. In the case of the old magazines, students may use them to cut out dynamic images for their posters or booklets. Give students ample time to finish their presentation. Have students include in their presentation which energy resource they think would best benefit their community and why. This will be important when students give their presentations to the community on Day 3.

Know the Science

Why is understanding costs and benefits important in science? ***It can save lives!*** Engineers must consider the costs and benefits of every possible solution to a problem. For example, when they design the parts of a building, they have to consider more than just the cost of the material in dollars. They have to consider whether the materials can hold up under certain conditions such as bad weather or even gravity. If the building collapses, people can be hurt or killed and property damaged. The same thing happens with natural resources used to meet our energy needs. Using some natural resources for energy can cause greater harm to the environment than using other natural resources. This harm can result in a loss of plant and animal life, including human life. Scientists want to find energy sources that cause less harm while still offering big benefits (meeting our energy demands).

SUPPORT—Some students may need extra help producing informational/explanatory writing for an intended audience. Work with these students to make sure they include concrete details and use linking words and phrases (e.g., *for example, also, because*). Have students look through their Core Vocabulary cards for this unit and include relevant domain-specific terms in their presentations.

Once students are ready to publish their work, guide them through the process. If the work is to be placed online, someone with a knowledge of the school's website and how to place articles on it may be needed, as students will not likely have this knowledge at the Grade 4 level. If students are putting together a booklet, be sure they have the proper materials to stitch or staple the booklet together. Also remind students that booklets should have a front and back cover as well as a title page.

3. Practice presentations. 15 MIN

Activity Page

AP 1.1

Arrange students in the same teams as on Day 1. Have students get out their Project Evaluation Guide (AP 1.1) and review it again, especially the rows about presenting to an audience. Then have students take turns practicing their talks, with teammates taking the role of the audience. Tell the audience that after the students have finished speaking, audience members may ask questions.

Allow time for each team to use the guide to evaluate their presentations. Students can score themselves, or have the audience do the scoring.

Circulate among the teams to listen to each student speak. Use your own set of rubrics to evaluate each student.

At this point, you will have to make decisions about how many students will speak at the community event. If possible, choose speakers so that the information they have to share is not repeated. Assign roles according to the strengths of students.

CHALLENGE—Some students may enjoy writing opening and closing remarks for the presentation. Allow those students to work in small groups to draft and revise scripts, and invite them to present to the class, expressing themselves clearly and in formal English.

4. Check for understanding.

Activity Page

AP UC.2

Summative Assessment Opportunity

- You will not need to collect Cost-Benefit Analysis (AP UC.2) from students. However, you will need to ensure that students' final analysis is published correctly in the method the students chose (a poster, a booklet, or an internet article on the school's website).
- After the work has been published, discuss with students how they will relay that work to their audience members. If as a poster, students may simply display the poster at the front of the class while giving their presentations. If as a booklet, students may need to make one booklet per audience member. All the booklets should contain the exact same information in the same way. If as an internet

article, students will need to utilize a space for their presentations that allows for internet usage so that their audience can access the article during or after the presentation.

1. Day 3: Hold a community event. 30 MIN

Arrange the classroom or meeting space with chairs facing a part of the room where students can project images. After the audience is seated, have one student introduce the presentation, explaining the purpose and how the class prepared. Allow three or four students to make presentations. Be sure to give the remaining team members other roles, such as escorting visitors, distributing the booklets, or helping visitors access the correct site for the online article. Have another student or two thank the audience for coming.

2. Check for understanding. 15 MIN

Activity Pages

AP 1.1
AP UC.1
AP UC.3
Answer Key

Once the presentation event is completed, have students take out How to Publish or Present Your Cost-Benefit Analysis (AP UC.1). Review the items on the list, and discuss with the class whether all were accomplished and can be checked off. If you changed the steps in the project, have students edit the steps as needed.

Next, have students review Project Evaluation Guide (AP 1.1) again. Ask the following:

- For which of these skills are you now at an expert level? (*Answers will vary.*)
- For which are you at an intermediate level? (*Answers will vary.*)
- For which are you at a beginner level? (*Answers will vary.*)

Distribute Energy Resources Project Reflection (AP UC.3). Give students time to write answers to the questions about their own work during this project.

Summative Assessment Opportunity

- Collect Project Evaluation Guide (AP 1.1), and use it to calculate a project score for each student.
- Collect Energy Resources Project Reflection (AP UC.3), and use it to evaluate students' understanding of the project.

Problem-Based Learning Progress

Review progress students have made in analyzing the costs and benefits of new energy developments, which are renewable resources. They have

- completed cost-benefit analysis.
- prepared a report or presentation.
- published the report or gave the presentation.

By the end of this lesson, students should have published or presented their findings determining which energy resource is best for their community.

UNIT 5

Teacher Resources

Activity Pages

Name _____ Date _____

Activity Page 1.1 Use with Lesson 1.

Project Evaluation Guide

Read and discuss this rubric. Use it to plan and practice your project and presentation. Your teacher will use it to evaluate your work.

Project Rubric			
	Expert	**Intermediate**	**Beginner**
Cost-Benefit Analysis	The cost-benefit analysis describes the risks and benefits associated with humans using natural resources.	The cost-benefit analysis describes the risks and benefits associated with using natural resources but is missing a few important details.	The cost-benefit analysis is missing the most important details.
Presentation Behavior	I speak loudly and clearly, using formal language. I look at my audience when speaking.	I speak loudly and clearly most of the time. Some of my language is formal but not all of it. I do not always look at my audience when speaking.	I speak too softly and am not clear enough for people to understand. My language is not formal. I look away from my audience when speaking.
Presentation Aids	I use media aids during my presentation that add to what I have to say.	I use media aids during my presentation that sometimes were not helpful.	I do not use media aids during my presentation.
Answering Questions	I answer all questions from the audience clearly and completely.	I answer some questions from the audience but not always clearly and completely.	I do not answer questions from the audience.
Teamwork	I always work well with my team. All members of the team get to participate equally.	I sometimes work well with my team. Members of the team sometimes get to participate equally.	I do not work well with my team. Some team members did not get to participate.

Name _____ Date _____

Activity Page 1.2 Use with Lesson 1.

What Is a Cost-Benefit Analysis?

Throughout this unit, you will be gathering the information necessary to create a cost-benefit analysis about how humans use natural resources for energy. You already learned about the meaning of the terms *cost*, *benefit*, and *analysis*. Now it's time to put those terms together to understand what a cost-benefit analysis is!

Answer the questions below.

What is a cost-benefit analysis?

_____

Why do people use cost-benefit analyses?

_____

_____

What can you find in a cost-benefit analysis?

_____

_____

Why is it important to consider the alternatives to a particular decision?

_____

_____

How to Conduct a Cost-Benefit Analysis:

Identify the thing you are trying to decide.
Ask yourself: What decision am I trying to make?

Identify the benefits associated with the decision.
Ask yourself: What good things will come from this decision?

Identify the costs associated with the decision.
Ask yourself: What negative things will come from this decision?

Identify alternatives to the decision:
Ask yourself: What else didn't I think of? What are some other ways to address the issue or problem? Are there other solutions that can be proposed?

Name _____ Date _____

Activity Page 1.3 Use with Lesson 1.

Energy Research Take-Home Letter

Dear Parent or Guardian,

Our class is about to begin an exciting science unit of study called *Using Natural Resources for Energy*. Our science focus will be on exploring the human use of natural resources, including renewable and nonrenewable energy sources. This unit is a little different from our other science units in that it will focus on a single problem. That problem is, "What are the benefits and risks of using renewable and nonrenewable forms of energy?"

This unit will have a strong emphasis on students learning how cost-benefit analyses are used to solve problems, evaluate decisions, or inform policies. Your student will conduct a lot of research on various forms of energy to learn about finding and using information that is reliable and of high quality.

At the conclusion of the unit, our class will give a presentation to members of the community. The event will be held on ____date____ at ____time____ in the _____location_____. We hope you will be able to attend!

Feel free to contact me if you have any questions.

Sincerely,

signature _____

contact information _____

Name _____ Date _____

Activity Page 2.1 Use with Lesson 2.

Lesson 2 Check

Answer the questions to show what you know from this lesson.

coal	gas	natural water	nuclear power	petroleum	sunlight	wind

1. From the word box above, list the renewable energy sources.

_____

2. From the word box above, list the nonrenewable energy sources.

_____

3. What are the benefits of using renewable energy sources?

_____

_____

4. What are the drawbacks of using renewable energy sources?

_____

_____

5. Describe the difference between renewable and nonrenewable resources.

_____

_____

Name _____ Date _____

Activity Page 3.1 Use with Lesson 3.

Costs and Benefits Practice Sheet

What subject did you research?

Costs	Benefits

Name _____ Date _____

Activity Page 3.2 Use with Lesson 3.

Lesson 3 Check

Answer the questions to show what you know from this lesson.

1. Which of the following is an example of consensus? Circle the letter of the correct answer.

a) 98% of the teachers think the students should have twenty-five minutes for lunch instead of twenty.

b) All twelve players of the basketball team scored at least one basket in their win.

c) 20% of voters say they would vote for the president again.

d) Each of Elijah's six aunts pinches his cheeks and says something about how big he's getting when they gather for Thanksgiving each November.

2. Explain why the other options in Question 1 were not examples of consensus.

3. Explain what you would look for in a source of information or authority on an energy resource.

Name _____ Date _____

Activity Page 4.1 Use with Lesson 4.

Formation of Fossil Fuels

Draw an illustration to show how a fossil fuel is formed.

Answer the questions based on your drawing.

Which fossil fuel did you show in your drawing?

Where is your fossil fuel found?

Explain how that fossil fuel is formed.

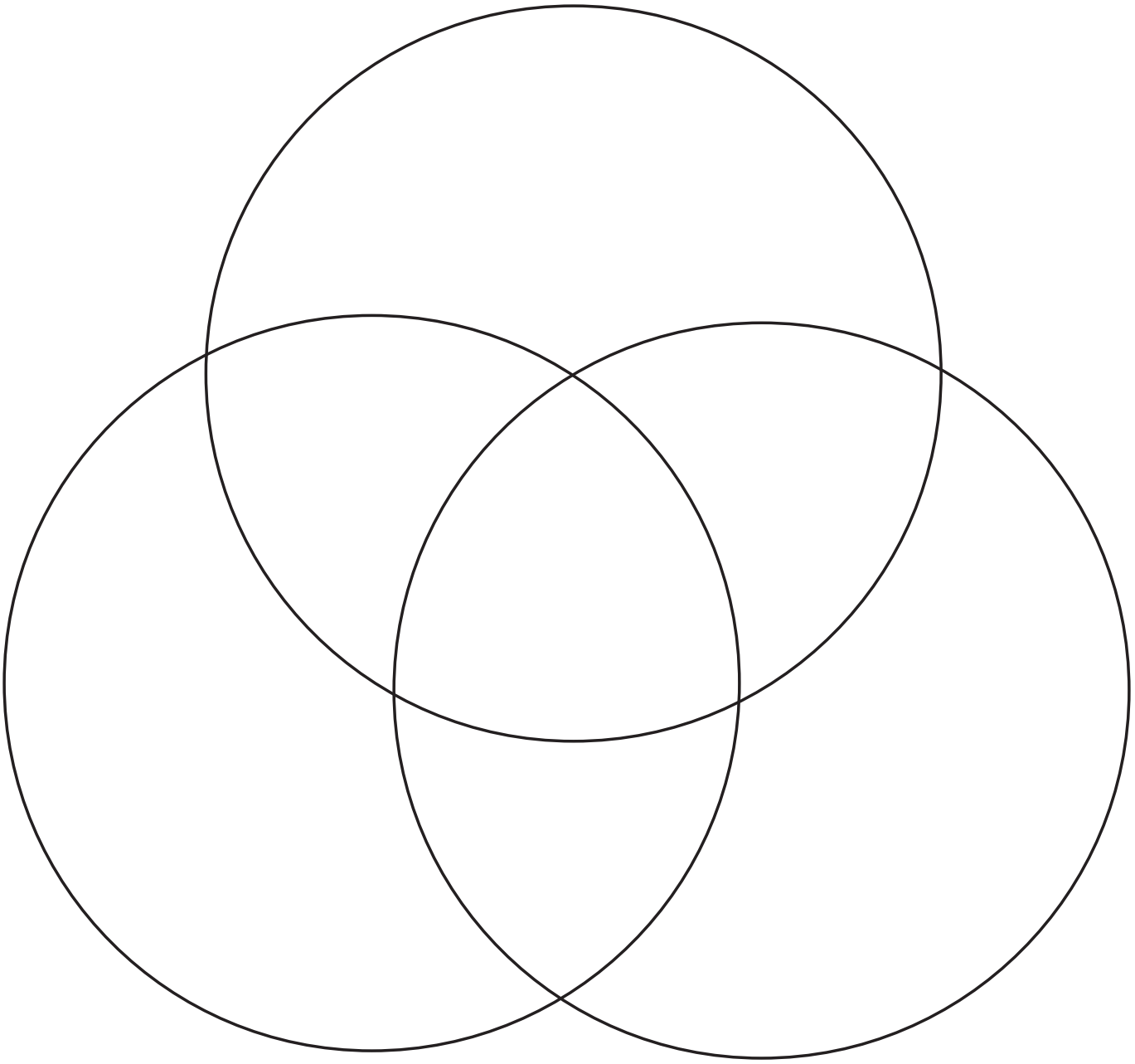
How long does it take this fossil fuel to form?

Name _____ Date _____

Activity Page 4.2 Use with Lesson 4.

Fossil Fuel Diagram

Complete the Venn diagram below. Write the name of one fossil fuel in each circle. Explain how they are different in the large spaces. Explain how they are similar to each other in the small spaces that intersect.



Name _____ Date _____

Activity Page 5.1 Use with Lesson 5.

Fossil Fuels Costs and Benefits

Write a list of the costs and benefits of using fossil fuels.

List the benefits of using fossil fuels:

List the risks associated with using fossil fuels:

What do you think would happen if people could no longer use fossil fuels?

Do you think fossil fuels are necessary? Why or why not?

Name _____ Date _____

Activity Page 5.2 Use with Lesson 5.

Electricity Diagram

Read the steps below for how coal is used to make electricity.

Making Electricity from Coal

1. Coal is mined and sent to the electricity plant.
2. The coal is then crushed up and burned.
3. Burning the coal produces heat. This heat is used to boil water. The boiling water creates steam.
4. The steam rushes past a giant turbine (a fanlike structure). The steam makes the turbine's fan blades turn.
5. The turbine is connected to a generator. Turning the fan blades activates the generator. This produces electricity.
6. The electricity then travels through power lines from the plant to your house.

Draw a diagram that shows how the chemical energy of coal is transformed into electrical energy.

Name _____ Date _____

Activity Page 6.1 Use with Lesson 6.

Costs and Benefits of Fossil Fuels

Use this sheet to summarize your research findings.

Answer the questions below.

1. What was one cost that was common to all three fossil fuels?

_____

_____

2. Which fossil fuel's products are used extensively for vehicles used in transportation?

_____

3. Which fossil fuel is now being extracted from many locations by the process called fracking?

_____

4. What are some costs of strip mining for coal?

_____

_____

_____

5. Use the space below to draw or attach a table that summarizes the costs and benefits of fossil fuels.

Name _____ Date _____

Activity Page 7.1 Use with Lesson 7.

Lesson 7 Check

Answer the questions to show what you know from this lesson.

1. Consider the material required for nuclear power. Why is nuclear power considered nonrenewable?

2. What is it about the material left after nuclear energy has been released that makes nuclear power nonrenewable?

3. How is nuclear power similar to coal power?

4. How is the chain reaction that can occur with uranium-235 different from the reaction that occurs when coal or gas is burned?

5. What are the benefits of nuclear power over fossil fuels in terms of Earth's atmosphere?

6. What are some ways that fossil fuels are used for energy that are not practical for nuclear power?

Name _____ Date _____

Activity Page 8.1 Use with Lesson 8.

Nuclear Power Costs and Benefits

Use this sheet to summarize your research findings.

Answer the questions below.

1. What is the main benefit of nuclear power when compared to fossil fuels?

2. What role does nuclear power play in producing electricity in your community or state?

3. How do the long-term costs of nuclear power compare to those of fossil fuels?

4. What is a cost of nuclear power that is not a concern for the other energy resources (fossil fuels, hydroelectric, geothermal, solar, wind)? Hint: World War II ended in part because of the atom bombs dropped on Japan.

5. Use the back of the page to draw or attach a table that summarizes the costs and benefits of nuclear power.

Name _____ Date _____

Activity Page 9.1 Use with Lesson 9.

Lesson 9 Check

Use this sheet to summarize your research findings.

Answer the questions to show what you have learned in this lesson.

1. In a large wind turbine, what needs to happen to turn wind energy into electricity?

2. Why can a lot of wind be both a good thing and a bad thing for a potential wind farm site?

3. Why is wind power often combined with some other energy source?

4. What do people mean by "grid" when they talk about power or electricity?

5. What would you want to find out about your town or region before researching whether to build a wind farm there?

Name _____ Date _____

Activity Page 10.1 Use with Lesson 10.

Wind Power Costs and Benefits

Use this sheet to summarize your research findings.

Answer the questions below.

1. What are two of the main benefits of wind power when compared to fossil fuels?

2. What are some drawbacks of wind power in terms of the specific wind conditions that are required?

3. What are some environmental drawbacks of wind power?

4. What might be some of the problems with having a large offshore wind farm?

5. Use the back of the page to draw or attach a table that summarizes the costs and benefits of wind power.

Name _____ Date _____

Activity Page 11.1 Use with Lesson 11.

Lesson 11 Check

Answer the questions to show what you have learned in this lesson.

1. What force is responsible for the movement of water in most hydroelectric dams?

_____

2. How are wind turbines and hydroelectric turbines similar?

_____

_____

3. What is an advantage of using glacial meltwater to power a hydroelectric dam? What about a disadvantage?

_____

_____

4. Why are most hydroelectric dams built on rivers fed by rainfall and melting snow? Use the term *cost-effective* in your answer.

_____

_____

_____

5. How do you think climate change could affect the cost-effectiveness of hydroelectric projects?

_____

_____

6. What are some organisms that are adversely affected by hydroelectric dams?

_____

_____

Name _____ Date _____

Activity Page 12.1 Use with Lesson 12.

Hydroelectric Power Costs and Benefits

Use this sheet to summarize your research findings.

Answer the questions below.

1. What is the primary benefit of hydroelectric power when compared to fossil fuels?

2. What are some drawbacks of hydroelectric power?

3. How is hydroelectric power dependent on climate?

4. How can severe flooding affect a hydroelectric power facility?

5. What are some environmental costs that might be "hidden" in a large-scale hydroelectric power project?

6. Use the back of the page to draw or attach a table that summarizes the costs and benefits of hydroelectric power.

Name _____ Date _____

Activity Page 13.1 Use with Lesson 13.

Lesson 13 Check

Answer the questions to show what you know from this lesson.

1. How is sunlight used to generate electricity?

2. What is a solar cell?

3. What are two big challenges to making solar power the major provider of electricity for human activities?

4. How does concentrated solar power technology work similarly to nuclear power?

5. Suppose a large solar farm or a concentrated solar power plant is constructed in a sunny desert. How could climate change affect its efficiency and productivity?

6. A family is thinking about installing solar panels on their roof. A neighbor says it will be a waste of money because the weather is too cold in the winter, so the solar panels won't work well. Is the neighbor right?

Name _____ Date _____

Activity Page 14.1 Use with Lesson 14.

Solar Power Costs and Benefits

Use this sheet to summarize your research findings.

Answer the questions below.

1. What is the primary benefit of solar power when compared to fossil fuels?

_____

_____

2. What are some drawbacks of solar power?

_____

_____

_____

3. How is solar power dependent on the weather?

_____

_____

_____

4. Is solar power completely clean?

_____

_____

_____

5. Use the back of the page to draw or attach a table that summarizes the costs and benefits of solar power.

Name _____ Date _____

Activity Page 15.1 Use with Lesson 15.

Lesson 15 Check

Answer the questions to show what you know from this lesson.

1. If a pipe full of liquid warmed by Earth's interior is directed into a boiler where a much cooler liquid is contained, why does heat move into the cooler liquid?

2. What is the difference between geothermal energy and solar energy that warms Earth's surface?

3. What is the main challenge in developing geothermal energy as a major source of power?

4. What is one technological solution to the challenge you cited in answering Question 3?

5. How can abandoned oil wells be used to tap geothermal energy?

6. A small island in the Pacific Ocean has few sources of energy to generate electricity. Before switching from diesel generators to geothermal energy, what would people need to know about their island?

Name _____ Date _____

Activity Page 16.1 Use with Lesson 16.

Geothermal Energy Costs and Benefits

Use this sheet to summarize your research findings.

Answer the questions below.

1. What is the primary benefit of geothermal energy when compared to fossil fuels?

2. What are some drawbacks of relying on geothermal energy?

3. What are two ways that geothermal energy can be used to warm a home?

4. What kinds of locations have the most geothermal energy available?

5. Use the back of the page to draw or attach a table that summarizes the costs and benefits of geothermal energy.

Name _____ Date _____

Activity Page 17.1 Use with Lesson 17.

Lesson 17 Check

Answer the questions to show what you have learned in this lesson.

1. What is the icelike substance that contains methane and water?

2. What are the similarities and differences between fossil fuels and biofuels?

3. Why are biofuels not widely regarded as a great improvement over fossil fuels?

4. What are the two types of energy used in a hybrid automobile, and how are they provided to make the car move?

5. How can hydrogen gas be made into a fuel?

6. What is the difference between wave motion energy and hydroelectric energy generated by a dam?

Name _____ Date _____

Activity Page UC.1 Use with Unit Capstone.

How to Publish or Present Your Cost-Benefit Analysis

After weeks of work, you are becoming an expert in energy resources. You have looked at many different kinds of energy resources. You have also studied each kind's costs and benefits. Now it is time to help your community by sharing what you know.

Now you have to decide how to publish your cost-benefit analysis.

Underline the method that most interests you:

- Make a poster to show to your audience.
- Write a booklet to pass out to your audience.
- Write a report, and put it on the internet for your audience.

Make sure that your report has the following parts:

- It has images to help make it visually interesting.
- Each energy resource is covered.
- Each energy resource lists at least two costs and two benefits.

Do each of the following before you publish your analysis:

- Choose a date and time for your event.
- Invite community members to your event.
- Set up your event space.
- Practice your presentations.
- Hold your event.
- Thank community members for coming.
- Write your reflection of this project.

Name _____ Date _____

Activity Page UC.2 Use with Unit Capstone.

Cost-Benefit Analysis

Complete the table by writing the two biggest costs and the two best benefits of each energy source.

Energy Resource	Cost	Benefit
Fossil Fuels		
Nuclear Energy		
Wind Energy		
Water Energy		
Solar Energy		
Geothermal Energy		
Other		

Name _____ Date _____

Activity Page UC.3 Use with Unit Capstone.

Energy Resources Project Reflection

Think about what you and your class did during this project. Answer each question.

What were you comparing in this analysis?	
What were some important tasks you did to complete this analysis?	
What was the most important thing you learned?	
What part of the project did you enjoy the most?	
What part was the hardest for you?	
Which energy resource do you think is best for communities and why?	

Activity Pages Answer Key: *Using Natural Resources for Energy*

This answer key offers guidance to help you assess your students' learning progress. Here, you will find descriptions of the expectations and correct answers for each of the Activity Pages of this unit.

What Is a Cost-Benefit Analysis? (AP 1.2) (page 132)

- a study of the costs and benefits associated with an action
- People use cost-benefit analyses to better understand the solution to a problem.
- You can find the strengths and weaknesses of a solution.
- You should consider alternatives to a decision because they may have better results.

Lesson 2 Check (AP 2.1) (page 134)

1. sunlight, wind, natural water
2. coal, gas, nuclear power, petroleum
3. The benefits of renewable resources include: no emissions, better for climate, can decrease pollution, better for health and environment, they are reliable and will not run out
4. The drawbacks of renewable resources include: more difficult to generate as much power; disruption of ecosystems and habitats; intermittent availability of energy
5. Renewable resources can be used over and over. Nonrenewable resources take much longer than a human lifetime to be replaced.

Costs and Benefits Practice Sheet (AP 3.1) (page 135)

Accept all plausible cost-benefit analyses students turn in.

Lesson 3 Check (AP 3.2) (page 136)

1. a
2. Option B wasn't consensus because there was no opinion or statement of fact that was shared among the players. They just scored baskets. Option C involves a rather small percentage, so that isn't a consensus. Option D is more about behavior than any kind of agreement among the aunts.

AP 3.2, continued

3. Sample answer: If it's a person I would look for evidence of expertise, such as years of education and multiple degrees in a relevant subject. I would also look at who they work for. If they are working for a company that sells a particular energy resource or product, then I might be skeptical. If the source is an organization or part of the media, I would look at how large or widely read it is, and I would separate opinion articles from news articles. If it is a U.S. government site I would assume it is probably reliable but would not assume everything it offers is factual.

Formation of Fossil Fuels (AP 4.1) (page 137)

- Student drawings should show plant and animal remains buried under the sea. Students may indicate the heat and pressure that help change the remains.
- Students should identify their fossil fuel.
- Students should identify where the fuel is found.
- Student explanations should indicate heat and pressure change remains to a fossil fuel.
- Students should note that it generally takes millions of years for a fossil fuel to form.

Fossil Fuel Diagram (AP 4.2) (page 138)

Student Venn diagrams could show the different properties of each fossil fuel such as being solid, liquid, or gas. Similarities would include being from the remains of living things and the transformation due to heat and pressure.

Fossil Fuel Costs and Benefits (AP 5.1) (page 139)

- Benefits: can be used to produce many different things besides energy, releases much energy
- Risks: pollution, nonrenewable so they will run out
- The environment might be cleaner but people would have to find more plentiful energy sources.
- Accept all plausible student responses.

Electricity Diagram (AP 5.2) (page 140)

Student diagrams should show coal being burned, releasing heat, which creates steam. In turn, the steam spins a turbine, which spins a generator.

Costs and Benefits of Fossil Fuels (AP 6.1) (page 141)

1. environmental damage, or change, in the form of carbon emissions in the atmosphere

AP 6.1, continued

2. petroleum
3. natural gas
4. destruction of natural habitat, release of coal dust and chemicals into the environment, exposed pit is hazardous and hard for natural habitat to reclaim

Sample table:

	Costs	Benefits
Petroleum	Carbon emissions into atmosphere (global warming) Can spill as harmful pollution Nonrenewable, so extraction is becoming more costly (deeper drilling, etc.)	Abundant resource that can be made into energy-rich fuels as well as plastics and other useful products Relatively easy to transport (does not require compression) Can be burned to power engines in vehicles
Coal	Carbon emissions (worst of the three fossil fuels) into the atmosphere Mercury and other chemicals also emitted Pollution from coal mining, wastewater ponds Mining is dangerous and harmful to landscapes, especially strip mining.	Abundant, cheap form of chemical energy that can be burned to produce heat for direct use or for generating electricity Solid, so it is easy to transport
Natural gas	Methane is a powerful greenhouse gas, and even if burned it results in carbon emissions (global warming). Gas is difficult to contain if not controlled. Highly explosive/flammable Pollution from fracking	Burns more cleanly than petroleum fuels and coal Can be transported by pipeline or compressed for transport by ship

Lesson 7 Check (AP 7.1) (page 142)

1. The material required is rare and difficult to enrich. There is a limited amount available on Earth.
2. It remains radioactive and therefore very dangerous for a very long time. This means the handling and storage of nuclear waste is very expensive and risky.
3. In both, energy from the materials is converted into heat, which is used to boil water into steam, which passes through a turbine that powers a generator, which makes electricity.
4. The nuclear chain reaction can go out of control and release far more energy if an accident occurs.

AP 7.1, continued

5. Nuclear power has no carbon or methane emissions, so it does not enhance the greenhouse effect the way carbon and methane emissions from the fossil fuel industry do.
6. Nuclear power is used in some very large vessels, such as submarines and aircraft carriers, but for the most part a reactor and the other equipment needed take up too much space to be used in vehicles. Nuclear power also does not directly produce fire, whereas other fossil fuels or their products can be burned at small scales and used for a variety of purposes.

Nuclear Power Costs and Benefits (AP 8.1) (page 143)

1. lack of carbon emissions
2. Answers will vary. In some states nuclear power accounts for over 50% of electricity production.
3. Unless accidents occur the long-term costs of nuclear power should be less than those of fossil fuels, because nuclear power does not involve emissions of carbon or other greenhouse gases. However, nuclear waste requires safe, secure

storage for many years. This means nuclear power would cost a lot of money even if all of the nuclear power plants were shut down.

4. Nuclear power can be used to make extremely destructive weapons. The other major energy resources do not have the same capacity for being weaponized.

Sample table:

	Costs	Benefits
Nuclear power	Fissile material is radioactive/dangerous, and so is the waste (spent fuel rods). Very expensive to build a nuclear reactor and power plant Difficult to engineer a reactor for use in transportation Can be used in weapons Chain reaction can be very dangerous if not controlled (Chernobyl, Fukushima accidents)	No carbon emissions Only by-product is heat, which can be safely released into the environment through cooling towers or effluent water Could offer the best hope of replacing fossil fuels for electricity production

Lesson 9 Check (AP 9.1) (page 144)

1. The rotations of the turbine shaft have to be converted to a larger number of rotations that spin inside the generator. This is necessary to generate electricity.
2. A lot of wind means more wind energy that can be converted into electricity, but too much wind can overwhelm the turbine or do damage to it.
3. The wind does not blow all the time, and even if it does it might not blow hard enough to spin a turbine fast enough to make electricity. This means that some other source of energy to make electricity is probably needed or that large batteries are necessary to store the electricity from a wind-only system.
4. The grid is the network of power lines, towers, and other technology that transmits electricity to homes and other buildings.
5. How much wind does the location get on average every day, and for how many hours? What are the potential sites like in terms of terrain, ground, wildlife,

and human activities? How costly would it be to hook up the turbines to the grid? Is battery storage an option? What other sources of energy could be used along with wind?

Wind Power Costs and Benefits (AP 10.1) (page 145)

1. renewable, doesn't produce carbon emissions
2. It requires a certain amount of wind to spin the turbine and generator fast enough to generate electricity, and too much wind can be a problem.
3. Turbines can injure or kill flying wildlife, such as birds and bats.
4. The towers could be dangerous obstacles for boats. A toppled tower could be very expensive to fix. Undersea cables transmitting the electricity to land could break. The large turbine blades could strike migrating seabirds. People could complain about the sight of the turbines.

Sample table:

	Costs	Benefits
Wind power	Utility-scale turbines and wind farms are very expensive to build and maintain. There are some environmental problems, including injuries and deaths of birds and bats and changes to habitats due to tower construction and building/using access roads.	No carbon emissions Renewable energy resource (wind) is abundant in many locations. Farms can be established in places that are relatively unused, such as areas of the ocean or plains, or even on agricultural farms or ranches, allowing people to increase their income or switch from a nonsustainable business to a sustainable one.

Lesson 11 Check (AP 11.1) (page 146)

1. gravity
2. Both are spun by matter moving past the blades.
3. Advantage: steady supply of water; disadvantage: glacier could eventually disappear and the dam will not have enough water to work with
4. A river fed by rainfall and melting snow is a more reliable source of moving water. It isn't dependent on a single mass of ice that might eventually disappear. Over the long run, it is more likely to be cost effective because the source of the water is more likely to be sustained.
5. Severe rainstorms or unusually heavy snowfalls could result in flooding that overwhelms or even breaks a dam. Severe drought could cause rivers and reservoirs to run so dry that dams cannot produce much electricity. Either scenario could make a dam very ineffective in terms of cost.
6. salmon and other migratory fish, trees that depend on nutrients from decaying salmon

Hydroelectric Power Costs and Benefits (AP 12.1) (page 147)

1. It doesn't produce carbon emissions.
2. Impoundment facilities greatly reshape rivers and the landscape both upstream and downstream from them. They also interfere with fish migrations.
3. Hydroelectric power usually relies on the water cycle to replenish supplies of water upstream from the facility. If the water cycle changes, resulting in either more or less precipitation upstream from the facility, the productivity could be changed.
4. If a river or reservoir floods, the dam can fail, resulting in a sudden flood of the downstream area as well as damage or destruction of a very expensive facility and a source of energy.
5. The production and use of thousands of tons of concrete result in a lot of carbon emissions. A lot of energy is used to build such facilities, and that energy is unlikely to be clean.

Sample table:

	Costs	Benefits
Hydroelectric power	Utility-scale facilities are very expensive to build and can alter and disrupt landscapes and lives both upstream and downstream. Migratory fish such as salmon can be blocked from returning to their native streams to spawn, and larval fish can be harmed as they pass through dams toward the ocean.	No carbon emissions It's a form of renewable energy resource (moving water) that is abundant and reliable in many locations, including some coastal areas of the ocean. Little to no pollution of any kind

Lesson 13 Check (AP 13.1) (page 148)

1. Photons in sunlight strike the material in a solar cell, which excites the material's electrons. Electrons freed from atoms can flow as electricity.
2. A solar cell is the basic functional unit of a photovoltaic device.
3. The technology is not very efficient yet. Many areas of Earth's surface do not get enough sunlight, and most locations experience night—no sunlight—about half the time.
4. Both technologies supply heat that is used to generate steam that spins a turbine that powers an electric generator. Solar energy is concentrated and controlled to generate heat just as a nuclear reaction is controlled to generate heat.
5. If a desert starts to receive more clouds due to changes in the region's climate, there would be less sunlight striking the light-absorbing or light-reflecting equipment. This would reduce the electrical output of the facility.

AP 13.1, continued

6. No. If sunlight is available, then the panels will convert it into electricity. Whether the air is warm or cold does not change the photons that travel from the sun to Earth's surface.

Solar Power Costs and Benefits (AP 14.1) (page 149)

1. It doesn't produce carbon emissions.
2. Initial investment can be very high, and there are times when it is not available, both in a day or at certain times of the year, depending on the location.
3. Solar power panels or mirrors for solar thermal power both require a lot of sunlight, which means the sky must be relatively clear.
4. No. There is often a lot of transportation involved in the manufacture, transport, and setup of solar power plants, which means using other energy resources.

Sample table:

	Costs	Benefits
Solar power	Utility-scale facilities are very expensive to build and require a lot of space. Very weather dependent, and some locations do not get enough sunlight even if the weather is clear. Rooftop solar remains too expensive for most people to afford. Storage of solar-generated electricity is expensive.	Renewable energy, extremely abundant Little to no pollution of any kind Homeowners and small-scale solar power generators can generate income by selling electricity to the grid. Low maintenance costs

Lesson 15 Check (AP 15.1) (page 150)

1. Heat moves from warmer to cooler materials.
2. Geothermal energy is heat from Earth's interior. Solar energy comes from the sun in the form of light.
3. It usually requires a site on land where there is an abundant and reliable source of geothermal energy not too far from the surface, such as a hot spring or a reservoir of steam. There just aren't that many sites like this.

AP 15.1, continued

4. Low-temperature geothermal plants can use liquids with lower boiling points to drive a turbine. This means the source of geothermal energy from the ground does not need to be as hot.
5. Wastewater can cycle in and out of the abandoned oil field. Heat from the rock around the well warms the wastewater, and that heat is removed from the water when it is pumped to the surface.
6. They would need to know if there is enough geothermal energy in the crust of the island. If the island is volcanic, then it might work.

Geothermal Energy Costs and Benefits (AP 16.1) (page 151)

1. It doesn't produce carbon emissions.
2. It can be hard to find. Large-scale geothermal energy plants are expensive.
3. Thermal energy at 50°F can be brought directly into a home. Thermal energy of geysers can be converted to electricity, which can then be used to warm a home.
4. Locations that have volcanic activity below them are more likely to have abundant geothermal energy than other locations.

Sample table:

	Costs	Benefits
Geothermal power	Utility-scale facilities are very expensive to build. It can be difficult to find locations with adequate, reliable reservoirs of geothermal energy. Sustainability depends on maintenance of the resource, such as pumping cooled fluids back into the ground.	Renewable energy Little to no pollution Can be used at large or small scale Low-temperature plants can generate electricity from relatively cool geothermal fluids, including recycled wastewater from abandoned oil fields. Does not require a lot of space on Earth's surface Technology can be used to both warm and cool things on the surface (e.g., heat pump technology for homes).

Lesson 17 Check (AP 17.1) (page 152)

1. methane hydrate
2. Both are made of carbon-rich chemicals made by and for living things, but biofuels are made from nonfossilized remains instead of fossilized remains.
3. They are burned like fossil fuels, so they emit carbon into the atmosphere.
4. A gasoline engine makes the car move some of the time, mostly at higher speeds. When the brakes are applied, the electric motor is used to slow the car, and the energy is converted to electricity that gets stored in a battery. The battery powers an electric motor that can also make the car move, mostly at lower speeds.

5. When electricity is run through liquid water, it generates hydrogen gas. This gas can be captured and compressed into a tank that can be placed in a car.
6. Hydroelectric energy is based on water being pulled downhill by gravity or pulled across Earth's surface by gravity between ocean water and the moon and sun. The moving water provides the energy of motion to turn turbines. Wave motion energy is really a product of wind energy making waves, whose up-and-down motion can be converted into electricity.

Appendix A

Glossary

Blue words and phrases are Core Vocabulary terms for the unit, and Student Reader page numbers are listed in parentheses. **Bold-faced words and phrases** are additional vocabulary terms related to the unit that you should model for students during instruction and that are often used within the Student Reader, and these latter terms do not have specific page numbers listed. Vocabulary words are not intended for use in isolated drill or memorization.

A

analysis, n. thorough study of the details of something complex

atom, n. the smallest particle of a specific element

authority, n. an individual recognized as an expert

B

benefit, n. something that produces a helpful outcome

biofuel, n. a combustible (burnable) fuel made from the remains of recently living organisms (48)

biosphere, n. the Earth system that encompasses all living things

C

consensus, n. general agreement

cost-benefit analysis, n. a study of the costs and benefits associated with an action

cost-effective, adj. describing the balance of factors when benefits outweigh costs (33)

D

decompose, v. to separate into more basic parts; to rot

E

efficiency, n. the degree of producing desired results

electricity, n. a form of energy resulting from the flow of charged particles (3)

electron, n. a negatively charged atomic particle

emission, n. something sent forth or released

enriched, adj. describing a material that has been fortified in some way to make it more useful

F

fact, n. a piece of information that is indisputably true

ferment, v. to go through a chemical change breaking down an energy-rich compound

fission, n. the splitting of atomic nuclei, resulting in the release of a great deal of energy

flare, n. a sudden outburst

fossil fuel, n. a fuel formed from the fossilized remains of organisms (2)

fracking, n. a process of using fluids to fracture rock to create access to petroleum resources

fuel cell, n. a device in which a chemical reaction takes place to produce electricity, similar to a battery (50)

G

geothermal energy, n. energy produced by heat that is transferred from Earth's interior (43)

geyser, n. a geothermal spring that intermittently erupts water and steam

greenhouse gas, n. a gas that traps heat in Earth's atmosphere (20)

H

hybrid, n. a combination of two types; a vehicle that uses two different sources of fuel (49)

hydroelectric power, n. electricity generated by the energy in moving water, usually through a dam (31)

I

industrial, adj. related to manufacturing activity

N

natural gas, n. combustible mixtures of gases from fossil fuel formation

nonrenewable resource, n. a resource that cannot be restored as quickly as it is used (1)

nuclear energy, n. energy produced by the splitting of atoms, tiny particles of matter (21)

nuclear waste, n. radioactive by-products generated by materials used in nuclear power plants

O

opinion, n. a belief, impression, or judgment that is not an undisputed fact

P

permafrost, n. a permanently frozen layer of Earth

petrochemical, n. a chemical material derived from petroleum

photon, n. a quantity of electromagnetic energy, modeled as a particle

power grid, n. the network of electricity generation and transfer in a region

pros and cons, n. the benefits and costs of any factor being evaluated

R

radioactivity, n. the property of elements that spontaneously emit energetic particles

regenerative braking, n. technology that generates electricity from energy transferred when brakes slow down a moving vehicle

reliable, adj. suitable to be depended upon

renewable resource, n. a resource that can be restored more quickly than it is used up (1)

S

solar cell, n. a device that converts sunlight to electricity (37)

solar power, n. the use of sunlight to meet energy needs (37)

strip mining, n. removing resources by digging to expose them at Earth's surface level

sustainable, adj. describing the practice of using resources in ways that do not permanently deplete them or cause untenable damage

V

values, n. beliefs about worth or importance

viable, adj. capable of functioning successfully

W

wind farm, n. many wind turbines installed together in an area to generate electricity for a community (28)

Appendix B

Classroom Safety for Activities and Demonstrations

In the Core Knowledge Science program (CKSci), activities and demonstrations are a vital part of the curriculum and provide students with active engagement related to the lesson content. The activities and demonstrations in this unit have been selected and designed to engage students in a safe manner. The activities and demonstrations make use of materials and equipment that are typically deemed classroom safe and readily available.

Safety should be a priority when engaged in science activities. With that in mind, observe the following safety procedures when the class is engaged in activities and demonstrations:

- Report and treat any injuries immediately.
- Check equipment prior to usage, and make sure everything is clean and ready for use.
- Clean up spills or broken equipment immediately using the appropriate tools.
- Monitor student behavior to ensure they are following proper classroom and activity procedures.
- Do not touch your eyes, ears, face, or mouth while engaging in an activity or demonstration.
- Review each step of the lesson to determine if there are any safety measures or materials necessary in advance.
- Wear personal protective equipment (e.g., safety goggles, aprons, etc.) as appropriate.
- Check for allergies to latex and other materials that students may have, and take appropriate measures.
- Secure loose clothing, hair, or jewelry.
- Establish storage and disposal procedures for chemicals as per their Safety Data Sheet (SDS), including household substances, such as vinegar and baking soda.

Copy and distribute the Student Safety Contract, found on the next page, for students to read and agree to prior to the start of the first unit so students are aware of the expectations when engaged in science activities.

Online Resources

For additional support for safety in the science classroom, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Student Safety Contract

When doing science activities, I will do the following:

- Report spills, breakages, or injuries to the teacher right away.
- Listen to the teacher for special instructions and safety directions. If I have questions, I will ask the teacher.
- Avoid eating or drinking anything during the activity unless told to by my teacher.
- Review the steps of the activity before I begin. If I have questions, I will ask the teacher.
- Wear safety goggles when working with liquids or things that can fly into my eyes.
- Be careful around electric appliances, and unplug them, just by pulling on the plug, when a teacher is supervising.
- Keep my hands dry when using tools and devices that use electricity.
- Be careful to use safety equipment like gloves or tongs when handling materials that may be hot.
- Know when a hot plate is on or off and let it cool before touching it.
- Roll or push up long sleeves, keep my hair tied back, and secure any jewelry I am wearing.
- Return unused materials to the teacher.
- Clean up my area after the activity and wash my hands.
- Treat all living things and the environment with respect.

I have read and agree to the safety rules in this contract.

_____ _____/_____/_____/

Student signature and date

_____

Print name

Dear Parent or Guardian,

During science class, we want to create and maintain a safe classroom. With this in mind, we are making sure students are aware of the expectations for their behavior while engaged in science activities. We are asking you to review the safety rules with your daughter or son and sign this contract. If you have any questions, please feel free to contact me.

_____ _____/_____/_____/

Parent or guardian signature and date

Appendix C

Strategies for Acquiring Materials

The materials used in the Core Knowledge Science program (CKSci) are readily available and can be acquired through both retail and online stores. Some of the materials will be reusable and are meant to be used repeatedly. This includes equipment such as scales, beakers, and safety goggles, but also items such as plastic cups that can be safely used again. Often these materials can be cleaned and will last for more than one activity, or even one school year. Other materials are classified as consumable and are not able to be used more than once, such as glue, baking soda, and aluminum foil.

Online Resources

The Material Supply List for this unit's activities can be found online. Follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Ways to Engage with Your Community

The total cost of materials can add up for an entire unit, even when the materials required for activities and demonstrations have been selected to be individually affordable. And the time needed to acquire the materials adds up too. Reaching out to your community to help support STEM education is a great way to engage parents, guardians, and others with the teaching of science, as well as to reduce the cost and time of collecting the materials. With that in mind, the materials list can be distributed or used as a reference for the materials teachers will need to acquire to teach the unit.

Consider some of the following as methods for acquiring the science materials:

- School Supply Drive—If your school has a supply drive at any point in the year, consider distributing materials lists as wish lists for the science department.
- Open Houses—Have materials lists available during open houses. Consider having teams of volunteers perform an activity to show attendees how the materials will be used throughout the year.
- Parent Teacher Organizations—Reach out to the local PTO for assistance with acquiring materials.
- Science Fair Drive—Consider adding a table to your science fair as part of a science materials drive for future units.
- College or University Service Project—Ask service organizations affiliated with your local higher education institutions to sponsor your program by providing materials.
- Local Businesses—Some businesses have discounts for teachers to purchase school supplies. Others may want to advertise as sponsors for your school/programs. Usually you will be asked for verifiable proof that you are a teacher and/or examples of how their sponsorship will benefit students.

Remember: if your school is public it will be tax exempt, so make sure to have a Tax Identification Number (TIN) when purchasing materials. If your school is private, you may need proof of 501(c)(3) status to gain tax exemption. Check with your school for any required documentation.

Appendix D

Advance Preparation for Activities and Demonstrations

Being properly prepared for classroom activities and demonstrations is the first step to having a successful and enriching science program. Advance preparation is critical to effectively support student learning and understanding of the content in a lesson.

Before doing demonstrations and activities with the class

- Familiarize yourself with the activity by performing the activity yourself or with a team, and identify any issues or talking points that could be brought up.
- Gather the necessary materials for class usage. Consider if students will gather their materials at stations or if you will preassemble the materials to be distributed to the students and/or groups.
- Identify safety issues that could occur during an activity or demonstration, and plan and prepare how to address them.
- Review the Teacher's Guide before teaching, and identify opportunities for instructional support during activities and demonstrations. Consider other Support and/or Challenge opportunities that may arise as you work to keep students engaged with the content.
- Prepare a plan for postactivity collection and disposal of materials/equipment.

While engaged in the activity or demonstration

- Address any emergencies immediately.
- Check that students are observing proper science safety practices as well as wearing any necessary safety gear, such as goggles, aprons, or gloves.
- When possible, circulate around the room, and provide support for the activity. Return to the Teacher Guide as students work, to utilize any Support and Challenge opportunities that will make the learning experience most meaningful for your students.

After the activity or demonstration

- Use your plan for students to set aside or dispose of their materials as necessary.
- Have students wash their hands after any activity in which they could come in contact with any potentially harmful substances.

When engaging students in activities and demonstrations, model good science practices, such as wearing proper safety equipment, never eating during an investigation, etc. Good science practices at a young age will lead to students observing good science practices themselves and being better prepared as they move into upper-level science classes.

Appendix E

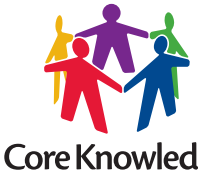
What to Do When Activities Don't Give Expected Results

Science activities and experiments do not always go according to plan. Microwave ovens, super glue, and X-rays are just some of the discoveries made when people were practicing science and something did NOT go according to plan. In your classroom, however, you should be prepared for what to do when activities don't give the expected results or when an activity doesn't work.

When going over an activity with an unexpected result, consider these points in discussion with your students:

- Was there an error in following the steps in order? You or the student may have skipped a step. To help control for this, have students review the steps to an investigation in advance and make a check mark next to each step as they complete it.
- Did students design their own investigation? Perhaps their steps are out of sequence, or they missed a step when performing the activity. Review and provide feedback on students' investigation plans to ensure the work is done in proper sequence and that it supports the lesson's Big Question.
- When measurements were taken, were they done correctly? It is possible a number was written down incorrectly, a measurement was made in error, such as a wrong unit of measure or quantity, or the starting or ending point of a measurement was not accurate.
- Did the equipment or materials contribute to the situation? For example, chemicals that have lost their potency or a scale that is not measuring accurately can contribute to the success or failure of an activity.

One of the greatest gifts a student can learn when engaged in science is to develop a curiosity for *why something happened*. Students may find it challenging or frustrating to work through a problem during an activity, but guiding them through the problem and figuring out *why* something happened will help them to develop a better sense of how to do science.



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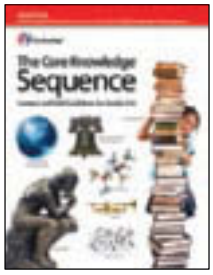
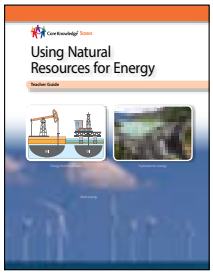


What is the Core Knowledge Sequence?

The *Core Knowledge Sequence* is a detailed guide to specific content and skills to be taught in Grades K–8 in language arts, history, geography, mathematics, science, and the fine arts. In the domains of science, including earth and space, physical, and the life sciences, the *Core Knowledge Sequence* outlines topics that build systematically grade by grade to support student learning progressions coherently and comprehensively over time.



For which grade levels is this book intended?

In general, the content and presentation are appropriate for readers from the middle to upper elementary grades. For teachers and schools following the *Core Knowledge Sequence*, this book is intended for Grade 4 and is part of a series of **Core Knowledge SCIENCE** units of study.

For a complete listing of resources in the
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