WYOMING
STEWARDSHIP
PROJECT

4th Grade

Minerals & Energy Unit

4th Grade Minerals & Energy

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4th Grade Minerals & Energy Standards

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4th Grade Minerals & Energy Standards

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9,10	Lesson 6: Powering Up Wyoming's Economy				
11	Lesson 7: Measuring Up		CV5.3.3		
12	Lesson 8: Chain Reactions				
13,.14	Lesson 9: Good to the Last Drop	CV5.3.1, CV5.3.2	CV5.2.3		
15	Lesson 10: I Pledge to be a Steward				
16	Lesson 11: Wyoming Mineral & Energy Fair		CV5.2.2		

Dear Educator,

I am honored to introduce you to the Wyoming Stewardship Project. I want you to know, this unit was written with you and your students in mind. Developing this project has been a thoughtful process and multi-year commitment to offer lessons for classrooms across the state.

Wyoming educators, in collaboration with field experts and the Wyoming Department of Education, wrote, piloted, and revised the unit you are about to teach in your classroom. We are tremendously grateful for their efforts. These units are not intended to be a burden but were created purposefully to be easy-to-use, cross-curricular, and comprehensive. Units build on each other throughout the grades. However, they can be used independently without loss of integrity.

Found in the Educator Essentials document is everything needed to be prepared to teach this unit. We outline the Higher Order Thinking Skills and how to identify them throughout the units. We have compiled a material list of everything you need to complete all lessons: worksheets, PowerPoints, and video links are included in individual lessons. Additionally, a '101' sheet has been included to give you background information for the highlighted industry in Wyoming.

Our hope for the Wyoming Stewardship Project is to empower students to be our critical thinkers and problem solvers of tomorrow. We believe the stewardship definition captures the overall intent: As Wyoming citizens, we are stewards entrusted with the responsible development, care, and use of our resources to benefit current and future generations.

Thank you again for your effort in the classroom, presenting these lessons to your students, and helping advance this pivotal project for our state. Please don't hesitate to contact us with questions!

Jessie Dafoe
Executive Director
Wyoming Agriculture in the Classroom

Teacher Preparation and Required Materials

The critical work of Higher Order Thinking Skills (HOTS) involves breaking down complex material into parts, detecting relationships, combining new and familiar information creatively within limits set by the context, and combining and using all previous levels in evaluating or making judgments. Within each lesson you'll find reference to the Higher Order Thinking Skills that are part of the work students will be doing using language from Bloom's Taxonomy: Analysis, Synthesis, Application, and Evaluation.

- Analysis skills are used in areas with this symbol:
- Synthesis skills are used in areas with this symbol:
- Application skills are used in areas with this symbol:
- Evaluation skills are used in areas with this symbol:

The following ideas and content will be important to know for this unit:

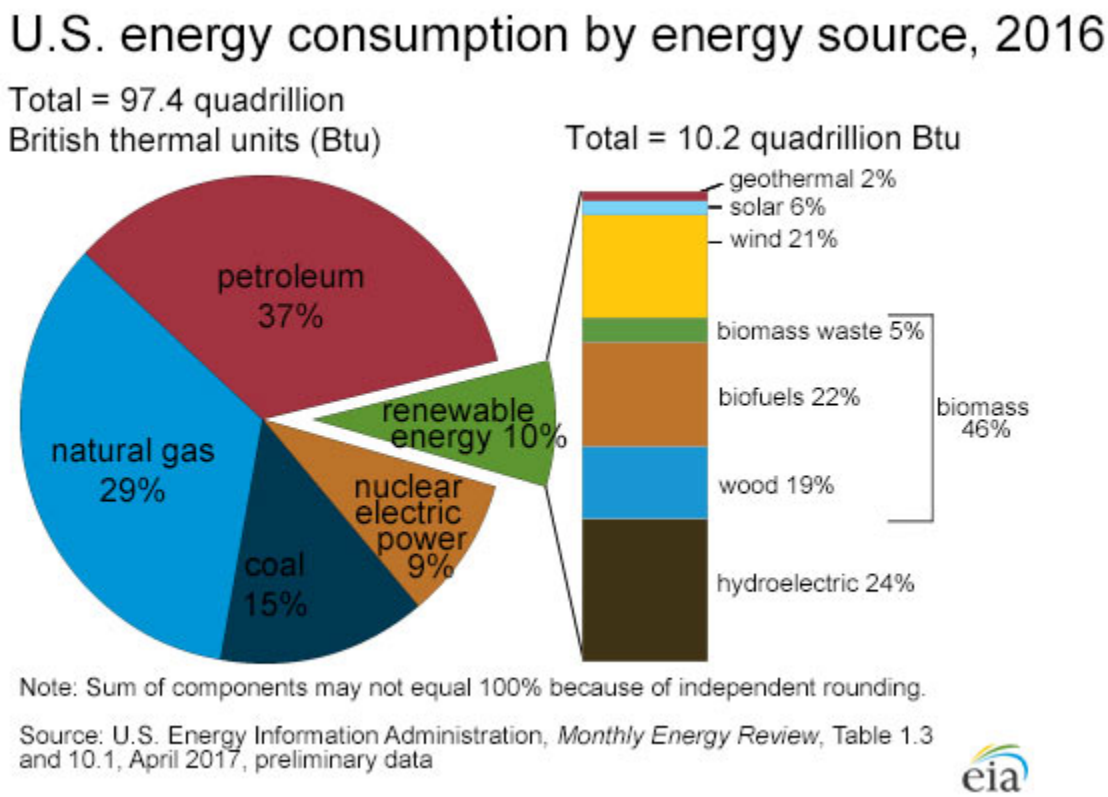
- Wyoming has abundant sources of minerals and energy. They are an important part of our economy and culture. Wyoming is the country's leading producer of coal, bentonite, uranium, and trona.
- How each of Wyoming's energy resources are turned into useable power
- Pros and cons of Wyoming's energy resources
- How enhanced oil recovery systems work

The following materials will be needed for this unit:

- Chart/Poster paper
- Maps from the Wyoming Geographic Alliance, Wyoming Student Atlas. Available at: http://uwmaps.wygisc.org/studentAtlas/index.html?page=1
- Markers, colored pencils, etc.
- White boards and markers (optional)
- White paper
- Masking tape
- Sticky notes
- Chips, tokens, etc. (optional)
- Supplies to build oil recovery model: (one set for whole class)
    - Small disposable plastic containers (1-2 cup) with tight-fitting lid
    - Plastic water bottles for injection reservoir and oil collection (one for the "extracted" oil, and one for water. Additional bottles may be needed for alternate design methods.)
    - Rocks or gravel (Gravel that has been sifted or had the sand removed would work best.)
    - Vegetable Oil
    - ¼ inch plastic tubing (two 30cm pieces)
    - Material to make a watertight seal (ex: Goop, silicone caulk, hot glue)
    - Food coloring for the inlet water *optional
    - Bucket or container for disposal of liquids
    - Seal-able container for disposal of oil
    - Metric measuring cup or graduated cylinder for liquids
    - Water
- Additional materials and liquids of your choice use for design challenge
- Supplies for whatever project method teacher decides his/her class should do (Lesson 11)
- Invitations if class is inviting parents, community members, other classes, administrators, etc. to visit their fair.

Minerals & Energy 101

Energy consumption at a glance:



The Wyoming Stewardship Project reviews all energy sources to provide a full picture of energy and mineral production. We encourage educators to review the overview below and the basics of the energy sources provided before teaching the units. The following statistics are from the Petroleum Association of Wyoming's: *Wyoming Oil and Gas, Facts and Figures, 2018*. These figures help quantify the economic importance of this industry for Wyoming:

Crude oil and natural gas production paid over $292 million in severance taxes, about 55% of all the severance taxes paid by minerals produced in 2017.

Severance Taxes - 2017	
Production Crude Oil	$147,933,678
Natural Gas	$144,407,308
Oil and Gas Total	$292,340,986
Coal	$215,469,300
Trona	$ 18,704,634
All Others	$ 3,397,189
Total All Minerals	$529,912,110

In fiscal year 2017 oil and gas production contributed the following to state and local governments:

Property Taxes	$307.0 million
Severance Taxes	$292.0 million
Federal Royalties	$ 1.2 million
Federal Lease Revenues	$174.0 million
State Royalties	$117.0 million
Sales and Use Taxes	$ 8.2 million
Conservation Mill Levy	$ 3.2 million
TOTAL FOR STATE	$902.6 million

That is a direct payment of nearly $1,542 for every person living in Wyoming.

Wyoming Minerals & Energy Overview

Oil, gas, and mining have been important in Wyoming for over 130 years. The Wyoming mineral and energy industries have been a major contributor to employment and state money (revenue). These include the oil and gas industry, minerals, and power production.

Wyoming has the smallest population of any state but is a top supplier of energy and other mineral resources to the nation. Wyoming produces more

energy than the lowest-ranking 28 states combined. In 1884, the first oil well was drilled near Lander and oil production continues throughout the state today.

Wyoming's clean coal produces electricity in more than 30 states. Wyoming is also the top supplier of uranium for energy across the country. Additionally, Wyoming has large amounts of minerals such as trona, bentonite, and rare earth minerals, which are used in many products we use today, like toothpaste, glass, and magnets. Wyoming mines more bentonite than any other state in the United States and has 70% of the world's known supply. 5 million tons of bentonite were produced in Wyoming in 2014. Wyoming also has the world's largest deposit of trona, supplying about 90% of the nation's soda ash. 17 million tons were mined in 2014. Northeast Wyoming is home to one of the highest grade rare earths deposits in the world.

Ancient seas that once covered what is now Wyoming helped create our natural resources. Seas expanded and retreated many times over millions of years, leaving behind plant and animal matter as well as mineral deposits. Marine sediments worked together to form and preserve hydrocarbon deposits. Under ideal geologic conditions of pressure and temperature, coal, oil, and natural gas deposits were formed and preserved. Historically, humans have used these natural resources since ancient times.

Another important aspect of energy is the generation and transmission process. Generation is the process of converting the energy sources into electricity. After electricity is generated, it is transported through transmission lines. The final stage is distribution, which is the process of carrying electricity from transmission substations to homes and businesses.

Wyoming Oil and Gas Basics

Oil and gas products include crude oil, natural gas, and helium. These are used for reliable heating and power for things like our homes, schools, and businesses. Natural gas produces approximately 34% of the nation's electricity; much of which comes from Wyoming. This industry pays the largest amount of taxes to the state to fund infrastructures, like schools and roads.

According to the Petroleum Association of Wyoming:

- Nationally, Wyoming ranked 6th in production of crude oil in 2017 and 8th in natural gas production during 2017.
- Campbell County was the leading crude oil producer in 2017 followed by Converse and Laramie counties.
- Sublette County was the largest natural gas producer, with Sweetwater and Fremont Counties following.
- During 2017, 355 companies/operators produced Wyoming's crude oil and 228 produced natural gas.

Wyoming Mineral Basics

COAL

Wyoming has an abundant supply of coal, with a total resource of 6,681 million short tons. Coal produced in Wyoming goes to U.S. electricity production with 32 states obtaining coal from Wyoming. Wyoming produced 42% of all coal mined in the United States in 2015. Coal is an important source of income for Wyoming, and is the second largest source of tax revenue for state and local governments. Coal mining companies pay taxes, royalties, and fees to all branches of government, federal, state, and local. Coal's estimated contribution to Wyoming in 2015 was almost $1.2 billion.

TRONA

Trona, which comes out of Sweetwater County, is the number one export for Wyoming, which produces 90% of the nation's soda ash. Wyoming trona is used to create soda ash that is used in a variety of products like glass, baking soda, cosmetics, toothpaste, and soaps.

BENTONITE

According the Wyoming Mining Association, Wyoming produces 70% of the world's supply of bentonite. This mineral is used for a variety of products including drilling fluids, compounds needed for absorption, cat litter, and lipstick.

Wyoming Renewable Basics

The following is taken directly from the U.S. Energy and Information Administration website and is an overview for renewable energy in Wyoming:

Wyoming has some of the largest wind resources in the nation, especially in the southeast corner of the state. Sustained winds are funneled through mountain passes and out across the high prairie, giving Wyoming wind farms high operating capacity factors. The amount of installed wind-powered generating capacity has grown rapidly during the last 10 years, with Wyoming ranked 15th in the nation in 2016 at nearly 1,500 megawatts of wind power capacity. Several large-scale projects are in development, including a 3,000-megawatt project at Chokecherry-Sierra Madre, which may become the largest wind project in the nation. Wyoming officials are actively seeking customers for the state's wind power in California and Colorado, which have significant renewable energy requirements. The Wyoming Infrastructure Authority is encouraging several large transmission projects aimed at transporting Wyoming's wind-generated electricity to Nevada, Arizona, and California.

Most of Wyoming's hydroelectric dams are relatively small, old, and owned by the federal government. Though the state has significant potential solar resources, no utility-scale solar generation has been installed, in part because of Wyoming's relatively low electricity rates. A small amount of distributed small-scale solar photovoltaic (PV) capacity, located mostly on residential rooftops, has been installed around the state. While Wyoming does not have a renewable portfolio standard (RPS) or other requirement to generate electricity from renewable energy, the state does provide net metering for residential, commercial, and industrial customers with renewable energy systems smaller than 25 kilowatts, including solar PV panels, wind turbines, biomass plants, and hydroelectric generators.

Wyoming's geothermal resources are used mainly in Yellowstone National Park and Hot Springs State Park. Geothermal energy is also used in the state to heat buildings, water, and roadways. Wyoming does have adequate geothermal resources to support geothermal heat pumps for supplying heat in new buildings or in retrofits of existing buildings.

https://www.eia.gov/state/analysis.php?sid=WY

Stewardship

As Wyoming citizens, we are entrusted with the responsible development, care, and use of our resources to benefit current and future generations.

www.wyaitc.org

WYOMING STEWARDSHIP PROJECT

Lesson One: What Does Stewardship Mean to You?

Grade Level: 4th Grade

Time: 30-45 minutes

Essential Question: How can we be stewards of Wyoming's minerals and energy to benefit current and future generations?

Objective: Students will gain an understanding of the term stewardship and of their role in being stewards.

Purpose: Students learn the meaning of stewardship and start to learn what it takes to be a steward.

Required Materials/Resources:

- Stewardship Definition Poster (found in the Educator Essentials)
- Word Splash (one per student)
- Images of Stewardship PowerPoint presentation.
- Bumper sticker template (one per student)
- Exit tickets (one per student)

Suggested Teacher Preparation:

- Display the Stewardship Definition Poster
- Display the stewardship words from step 4 where all students can see them.

Standards:
Social Studies: SS5.1.1(Explicit)

ELA: 4.L.6 (Explicit), 4.L.5.c (Practiced/Encountered)

Vocabulary:

- **Benefit** - an advantage or profit gained for something
- **Conservation** - the careful utilization of a resource in order to prevent waste and leave some for future generations
- **Entrust** - to give somebody the responsibility of doing something or of caring for someone or something
- **Generation** - a group of individuals, most of whom are the same approximate age
- **Resource** - a place or thing that provides something useful
- **Steward** - an individual who manages areas or resources
- **Stewardship** - As Wyoming citizens, we are stewards entrusted with the responsible development, care, and use of our resources to benefit current and future generations.

Instructional Procedure/Steps:

1. Display the Stewardship Definition Poster from the Wyoming Agriculture in the Classroom Wyoming Stewardship Project: **As Wyoming citizens, we are stewards entrusted with the responsible development, care, and use of our resources to benefit current and future generations.**

2. Play the Images of Stewardship PowerPoint presentation. After each slide, have students pair share to discuss how each photograph displays stewardship. Before moving on to the next slide, have a few students share out their thinking. If students are unsure about how individual images display stewardship, refer to the image guide and talking points included at the end of the PowerPoint.

3. Pass out a copy of the Word Splash sheet to each student. Have students choose two or more of the words that connects with stewardship. Give students 5-10 minutes to

TEACHER NOTE: The included talking points on the final slide are examples to help start conversations. Students may have their own ideas and suggestions of how the images show stewardship depending on their background knowledge.

choose and circle their words. At the bottom of their paper, students should write a brief explanation of how the words relate to stewardship.

4. Place students into small groups. Have groups define or create synonyms/examples for the key terms below. When students have finished brainstorming, have groups share out their ideas. As students share out, be sure they understand each of these key terms:
    - **benefit:** *advantage, profit*
    - **conservation:** *care, responsible use*
    - **entrusted:** *responsible, commit*
    - **generation:** *age group, grandparents, parents*
    - **resources:** *Wyoming resources, wildlife, people, land, minerals & energy, water, agriculture*
    - **stewards:** *caretakers, managers*

5. When students are finished discussing the vocabulary, pass out the bumper sticker templates. Have students create a stewardship bumper sticker using words or images from the lesson. Have students share out their bumper stickers and display them in the classroom.

6. Pass out exit tickets. Say: **"On your exit ticket, write an example of how you can be a steward in your everyday life."** *Examples can be in the classroom, on school grounds, their neighborhoods, parks, etc.*

Assessment: Check students' bumper stickers and informal exit tickets to see if they include various aspects of stewardship (conservation, education, advocacy). If they don't, be sure to draw some of those concepts forward in the upcoming lessons.

Credits/Sources: Photo credits are listed in the PowerPoint presentation.

TEACHER NOTE: You may also want to keep the bumper stickers for future reference if students participate in the Wyoming Agriculture in the Classroom bookmark contest. They can use their same idea and transfer it to the bookmark template for the contest.

Word Splash

Name:

Circle two or more words, and explain how each is connected to stewardship on the lines below.

caretaker

future

manager

environment

responsible

conservation

commit

LAND

wildlife

use

Stewardship
Bumper Sticker Template

Name: _____

Exit Tickets

Name:_____ Date:_____

Give an example of ***stewardship***:

Name:_____ Date:_____

Give an example of ***stewardship***:

Name:_____ Date:_____

Give an example of ***stewardship***:

Name:_____ Date:_____

Give an example of ***stewardship***:

Name:_____ Date:_____

Give an example of ***stewardship***:

Name:_____ Date:_____

Give an example of ***stewardship***:

WYOMING STEWARDSHIP PROJECT

Lesson Two: Looking Back

Grade Level: 4th Grade

Time: 45 minutes

Essential Question: How can we be stewards of Wyoming's minerals and energy to benefit current and future generations?

Objective: Students will read an informational text as an introduction to the mining and energy industry in Wyoming.

Purpose: Students learn about the importance of minerals and energy in Wyoming.

Required Materials/Resources:

- Minerals and Energy in Wyoming text (one per student) (Sources 1-13)
- Word Sort activity (one copy per pair of students)

Suggested Teacher Preparation:

- Read through the "Minerals and Energy in Wyoming" text and become familiar with the information it contains.

Standards:

ELA: 4.RI.2, 4.RI.4, 4.RI.10 (Practiced/Encountered)

TEACHER NOTE: Even though coal is technically classified as a fossil fuel because it is composed of organic material, it is often referred to as a mineral.

Vocabulary:

- **Bentonite** - a kind of absorbent clay formed by the breakdown of volcanic ash
- **Coal** - A black/dark brown rock made from old plant matter found mainly underground. Coal is mined and used as fuel.
- **Crude oil** - unrefined petroleum
- **Hydropower** - electricity produced from machines that are run by moving water
- **Industry** - a group of businesses that provides a particular product or service
- **Infrastructure** - the basic physical and organizational structures and facilities (e.g., buildings, roads, pipelines, and transmission lines) needed for the operation of a society or enterprise
- **Mineral** - a substance (such as quartz, coal, petroleum, salt, etc.) that is naturally formed under the ground
- **Natural gas** - odorless gas that is taken from under the ground and used as fuel and to make materials
- **Revenue** - money that is made by or paid to a business or an organization
- **Trona** - a gray mineral that occurs as an evaporate in salt deposits and consists of a hydrated carbonate and bicarbonate of sodium
- **Uranium** - a gray, dense radioactive metal used as a fuel in nuclear reactors

TEACHER NOTE: A possible alternative activity would be to have students interactively manipulate the words from the word bank into the correct column of the chart on an interactive whiteboard.

Instructional Procedure/Steps:

1. Pass out the "Minerals & Energy in Wyoming" text to students. Either read the text aloud or call on students to read it aloud. Have students follow along while reading with their own copies.

2. Discuss key vocabulary and concepts with the class as the text is read.

3. When students have finished reading the text, pass out the Word Sort activity. Have pairs of students complete the Word Sort activity. Students place each term under its correct heading. When students are finished, collect the

Word Sorts.

4. Close the lesson by having students discuss the questions listed below. Allow students to respond before moving on to the next question.
    - **"What personal connections can you make to minerals and energy in Wyoming?"**
    - **"In the text, can you track your morning activities (alarm, phone, light, warm shower) to the resources that may have made them possible?"**
    - **"What other aspects of your daily lives are you aware of being impacted by Wyoming's minerals or energy?"**
    - **"Does anyone have a family member who works in the industry?"**

TEACHER NOTE: Some students may also make the case that coal, uranium, oil, and gas could go in the power production box. Ask students to justify their rationale for putting them in either column.

Assessment: Use the key below to score students' Word Sort sheets.

WORKSHEET KEY

Oil & Gas	Minerals	Power Production
crude oil	trona	solar energy
gas	uranium	hydro
state's largest amount of generated taxes	rare earth minerals	wind
carbon dioxide	bentonite	power plants
helium	coal	

Credits/Sources:

1. National Mining Association. (2016). *Facts, Stats and Data.* Retrieved June 26, 2017, from http://nma.org/facts-stats-and-data/
2. Wyoming State Geological Survey. (n.d.) *Wyoming's Oil & Gas Facts*. Retrieved June 26, 2017, from http://www.wsgs.wyo.gov/energy/oil-gas-facts
3. U.S. Energy Information Administration - EIA. (2017, April 18). *Frequently Asked Questions: What is the U.S. electricity generation by energy source?*. Retrieved June 26, 2017, from https://www.eia.gov/tools/faqs/faq.php?id=427&t=3
4. U.S. Energy Information Administration - EIA. (2016, November 23). *Frequently Asked Questions: Which States Produce and Consume the Most Natural Gas?*. Retrieved June 22, 2017, from https://www.eia.gov/tools/faqs/faq.php?id=46&t=8
5. Wyoming Mining Association. (2016, April 6). *Economics*. Retrieved June 22, 2017, from https://www.wyomingmining.org/minerals/economics/
6. Wyoming State Geological Survey. (n.d.). *Wyoming Industrial Minerals.* Retrieved June 22, 2017, from http://www.wsgs.wyo.gov/minerals/industrial-minerals
7. U.S. Energy Information Administration - EIA. (2017, June 15) *Independent Statistics and Analysis*. Retrieved June 22, 2017, from https://www.eia.gov/state/data.php?sid=WY
8. U.S. Energy Information Administration - EIA. (2017, June 15). *Independent Statistics and Analysis.* Retrieved June 22, 2017, from https://www.eia.gov/state/data.php?sid=WY
9. U.S. Energy Information Administration - EIA. (2017, June 15). *Independent Statistics and Analysis.* Retrieved June 22, 2017, from https://www.eia.gov/state/data.php?sid=WY
10. Wyoming Mining Association. (n.d.). *2017-2018 Concise Guide to Wyoming Coal*. Retrieved October 1, 2018, from http://www.wyomingmining.org/wp-content/uploads/2013/10/2017-18-Concise-Guide-to-Wyoming-Coal.pdf
11. Wyoming Mining Association. (2016, April 6). *Trona.*Retrieved June 22, 2017, from https://www.wyomingmining.org/minerals/trona/

12. Wyoming Mining Association. (2016, April 6. *Bentonite.* Retrieved June 22, 2017, from https://www.wyomingmining.org/minerals/bentonite/
13. Stafford, J. Wyoming State Geological Survey (2012, February). *Wyoming's Electrical Generation* (Rep.). Retrieved June 22, 2017, from website: http://www.wsgs.wyo.gov/products/wsgs-2012-electricalgeneration-summary.pdf

Minerals & Energy in Wyoming

My alarm went off at 6:00 this morning. I checked my cell phone, turned on the light, and took a shower. How many of you started your day like this? How many of these things do you think are a result of Wyoming products?

Wyoming Resources

Oil, gas, and mining have been important in Wyoming for over 130 years! In 1884, the first oil well was drilled near Lander, and oil drilling continues throughout the state today. Historically, the Wyoming mineral and energy industries have been a major contributor to employment and state money (revenue). These include the oil and gas industry, minerals, and power production.

Wyoming Oil and Gas

Oil and gas products include crude oil, natural gas, and helium. These are used for reliable heating and power for things like our homes, schools, and businesses. Natural gas produces approximately 34% of the nation's electricity, much of which comes from Wyoming.

Oil rig in Wyoming
Wyoming State Historic Preservation Office

Wyoming produces 6% of the nation's natural gas. We are ranked number 4 in production, with Texas ranked number 1 at 26%.

This industry pays the largest amount of taxes to the state to fund infrastructures, like schools and roads.

Wyoming Minerals

The minerals mined in Wyoming include coal, uranium, trona, bentonite, and rare earth minerals.

Wyoming has an abundant supply of coal with a total resource 6,681 million short tons. Coal produced in Wyoming goes to U.S. electricity production with 32 states obtaining coal from Wyoming. Wyoming produced 42% of all coal mined in the United States in 2015. Coal is an important source of income for Wyoming and is the second largest source of tax revenue for state and local governments. Coal mining companies pay taxes, royalties, and fees to all branches of government, federal, state, and local. Coal's estimated contribution to Wyoming in 2015 was almost $1.2 billion.

Coal truck in the mine at Hanna, Wyoming
Wyoming State Historic Preservation Office

Trona, which comes out of Sweetwater County, is the number one export for Wyoming producing 90% of the nation's soda ash. Wyoming trona is used to create soda ash that is used in a variety of products like glass, baking soda, cosmetics, toothpaste, and soaps.

According to the Wyoming Mining Association, Wyoming produces 70% of the world's supply of bentonite. This mineral is used for a variety of products including drilling fluids, compounds needed for absorption, cat litter, and lipstick.

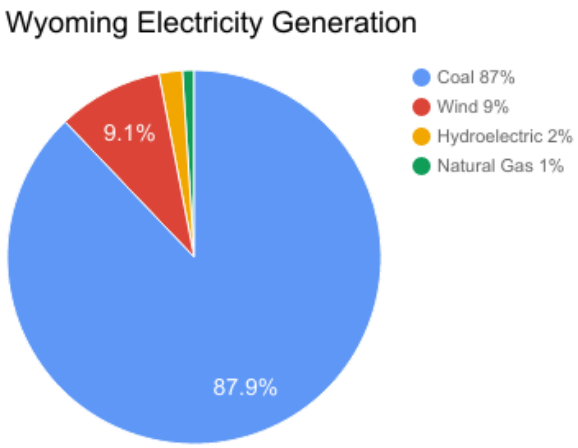
Minerals & Energy in Wyoming

Wyoming Power

Power Production includes coal and natural gas power plants, hydroelectric, and wind energy.

The energy produced through these resources is transmitted throughout the entire country from Wyoming!

The combination of all these resources contribute to the economy of Wyoming but also gives you the personal resources to wake up to an alarm, have a cell phone, turn on your lights, and take a warm shower!



Source: U.S. Energy Information Administration State Energy Profiles. (24 March 2016). Wyoming Electricity Generation. Retrieved June 22, 2017 from http://www.eia.gov/electricity/state/wyoming/

Minerals & Energy in Wyoming
Word Sort

trona	helium	state's largest amount of generated taxes
hydro	rare earth minerals	bentonite
crude oil	wind	solar energy
power plants	gas	uranium
carbon dioxide	coal	

Oil & Gas	Minerals	Power Production

Lesson Three: Abundant Energy Resources

Grade Level: 4th Grade

Time: 60 minutes. This could be extended into two days. (Group research occurs on the first day; presentations occur on the second day.)

Essential Question: How can we be stewards of Wyoming's minerals and energy to benefit current and future generations?

Objective: Students will gain an understanding about Wyoming's minerals and energy resources by creating anchor charts for future work.

Purpose: Students learn about Wyoming's different minerals and energy resources.

Required Materials/Resources:

- Mineral and Natural Resource cards (one per student)
- Wyoming Energy Resources graphic organizer (one per student)
- Map of Wyoming Hydropower plants (one copy for every student in the group) (Source 2)
- Chart paper (one per group)
- Markers, colored pencils, etc.

TEACHER NOTE: Save the Resource Cards. They will be used again in Lesson 5.

- Resource Maps from the Wyoming Student Atlas (one copy of a group's map for every student in a group) - (Source 1). Page numbers are located in the upper right-hand corner. http://uwmaps.wygisc.org/studentAtlas/index.html?page=1
    - Oil - page 39
    - Natural Gas - page 39
    - Coal - page 40
    - Uranium - page 41
    - Wind - page 42

Suggested Teacher Preparation:

- Familiarize yourself with the Resource Maps from the Wyoming Student Atlas about each mineral or energy resource. Request hard copies in advance from the Wyoming Geographic Alliance (wga@uwyo.edu, 307-766-3213) if you want to have them for future use or if you cannot access the digital version.
- Have groups access their resource maps on electronic devices OR make copies of each resource map for its matching student group. (For example, each student in the coal group receives a copy of the coal map.)
- Copy and cut apart enough Mineral and Natural Resource cards, so there is one for each student. (You may need to make multiple copies of some images based on the size of your class. These cards will determine small groups and the resource that each group is studying. The cards have 6 energy sources (groups) with four pictures/members for each group.)

Standards:

Social Studies: SS2.5.2 (Practiced/Encountered)

ELA: 4.RI.2, 4.SL.4 (Practiced/Encountered)

CVE: CV5.2.2 (Practiced/Encountered)

Vocabulary:

- **Energy** - power derived from the utilization of natural resources, especially to provide light and heat or to power machines; useable power
- **Natural resources** - sources of life, materials, or energy that we are able to get naturally from the earth

Instructional Procedure/Steps:

1. Ask: **"What does the term 'natural resources' mean?"** After allowing students to respond, provide students with the definition: **"Natural resources are sources of life, materials, or energy that we are able to get naturally from the earth."**

2. Ask: **"What does the word energy mean?"** After allowing students to respond, provide students with the definition: **"Energy is usable power**." Connect this definition to students' previous responses.

3. Pass out a Mineral and Natural Resource card to each student. Have students move around the room to find other students who have an image related to the same natural resource. This will determine the small groups students will work in.

4. Once students are in groups, give every student a copy of their resource map. The resource map each group receives should be the one related to their Mineral and Natural Resource card. Have groups analyze their map and the text on it to become experts on their Wyoming resource. When groups are finished learning about their resource, pass out a piece of chart paper to each group. Each group should create a poster to share their findings with the rest of the class. Posters should include:
    - A description about what the resource is.
    - Facts about how the resource is unique or important to Wyoming, and
    - Primary locations in Wyoming where the resource is found.

TEACHER NOTE: Students may name resources such as water, plants, etc. If they haven't named any mineral or energy resources, ask them to think back to the text they read in Lesson 2, and name resources that were mentioned there.

In this task, students will be engaged in the higher order thinking skills of analysis.

TEACHER NOTE: In order to maximize engagement, teachers may opt to assign "jobs" within groups such as secretary, time manager, discussion director, etc. For the location aspects, it is acceptable for students to only name the region: northwest, southwest, etc.

TEACHER NOTE: Teachers may want to discuss with students that the term energy can have multiple meanings. "Useable power" is the definition used in this unit.

TEACHER NOTE: As groups are sharing, point out that the locations of mineral resources are determined by geology. Humans can't control where they are located.

Students do not need to provide in-depth information about their assigned resources at this point. This activity just provides an overview. More in-depth information will be added in Lesson 4.

5. After posters are completed, pass out the Wyoming Energy Resources graphic organizers. Have groups either present their poster to the whole class, or have students complete a gallery walk (Source 3). As students learn about the various resources, they should complete their graphic organizers with information from the other groups' posters.

6. Display posters throughout the classroom as anchor charts.

Assessment: Collect students' completed graphic organizers. Check them for accuracy of information. For group posters, use the requirements listed in step four as a checklist to evaluate posters for correct information.

Credits/Sources:

1. Hammerlink, J.D., Webster, G.R., & Berendsen, M.E. (2014). *Wyoming Student Atlas: Exploring our Geography.* Laramie:Wyoming: University of Wyoming. http://uwmaps.wygisc.org/studentAtlas/index.html?page=1
2. Stafford, J. Wyoming State Geological Survey (2012, February). *Wyoming's Electrical Generation: Summary Report.* Retrieved June 22, 2017, from http://www.wsgs.wyo.gov/products/wsgs-2012-electricalgeneration-summary.pdf
3. Facing History and Ourselves. (2018). *Gallery Walk*. Retrieved October 2, 2018, from https://www.facinghistory.org/resource-library/teaching-strategies/gallery-walk
4. Photo credits are listed on images.

Wyoming Energy Resources

Coal at a Power Plant

Coal Mining

Source: Wyoming Mining Association

Coal Mining

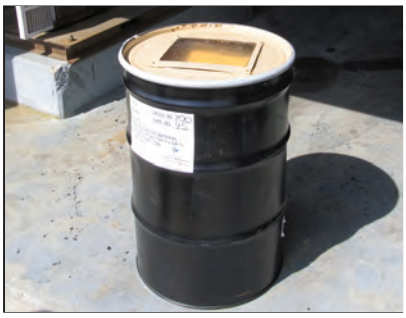
Source: Wyoming Mining Association

Coal Mining

Source: Wyoming Mining Association

Uranium

Source: United States Geological Survey



Uranium

Source: Wyoming Mining Association

Uranium

Source: Wyoming Mining Association

Uranium Mining

Source: Wyoming Mining Association

Oil Drilling

Source: Bureau of Land Management

Oil Refinery

Oil Rig

Source: Wyoming Petroleum Association

Oil/Gasoline

Wyoming Energy Resources

Natural Gas Pipeline

Natural Gas

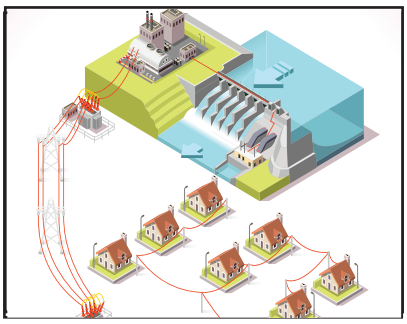
Natural Gas Fueling Station

Natural Gas Fueling Pipeline

Hydropower

Hydroelectric Dam

Hydropower



Hydroelectric

Wind Power

Wind Power

Wind Power

Wind Power

Wyoming Energy Resources

Name:

	Description	Location
Oil		
Natural Gas		
Hydroelectric		
Wind		
Coal		
Uranium		

Wyoming Energy Resources

Hydropower Plants

KEY

Hydroelectric Power Plant

Wyoming has a long history of using water to generate electricity, dating back to the early 1900s. While hydropower generation is considered small and seasonal, it represents a consistent and established electricity source. There are 15 hydropower plants on 10 reservoirs. Thirteen of these are operated by the Bureau of Reclamation and two by private companies. The total hydropower generation capacity in Wyoming is 299.6 MW.

Stafford, J. (2012, February). Wyoming's Electrical Generation (Rep.). Retrieved June 22, 2017, from Wyoming State Geological Survey website: http://www.wsgs.wyo.gov/products/wsgs-2012-electricalgeneration-summary.pdf

Lesson Four: Making Resources Work

Grade Level: 4th Grade

Time: Part 1: 60 minutes; Part 2: 60 minutes (which can be broken into two 30-minute sessions); Part 3: at least 30 minutes but will vary based on length of student presentations

Essential Question: How can we be stewards of Wyoming's minerals and energy to benefit current and future generations?

Objective: Students will highlight the key points of how different energy resources are developed and who contributes to the process.

Purpose: Students learn about the development of Wyoming's minerals and energy.

Required Materials/Resources:

- Development & Use of Energy Resources graphic organizer (one per student)
- Production of Minerals: Oil sample posters (one set for teacher to model oil "tour") (Sources 2, 13)
- Electronic devices

For the teacher:

Oil:

- Video: https://www.youtube.com/watch?v=RNbZQI5isXk *MidAmerican Energy Combustion Fueled Power Plant Virtual Tour* (Source 1) *Video length: 7 minutes 6 seconds*
- Oil Basics (Source 8) https://www.eia.gov/kids/energy-sources/oil/

TEACHER NOTE: Each energy resource has a video resource and a website/text resource. Full links are provided at https://wyaitc.org/curriculum/student-resources/ (Source 14). Either print accompanying text resources for students or have devices available for students to view the texts electronically.

For students:

All 6 energy resources:

- Elementary Energy InfoBook (Source 11) https://www.need.org/wp-content/uploads/2019/10/Elementary-Energy-Infobook.pdf

Uranium:

- Video: https://www.youtube.com/watch?v=258xiAv_8FQ *Uranium Mining with Baking Soda* (Source 4) *Video length: 1 minute 37 seconds*
- Video: https://www.youtube.com/watch?v=Ta3z3pGK0vU *What is Nuclear Energy?* (Source 5) *Video length 2 minutes 27 seconds*
- Video: https://www.youtube.com/watch?v=oT2LHGG-9Ko *Powering America: Uranium Mining and Milling* (Source 12) *Video length: 6 minutes 32 seconds*
- Uranium (nuclear) Basics (Source 6) https://www.eia.gov/kids/energy-sources/uranium/

Natural Gas:

- Video: https://www.youtube.com/watch?v=RNbZQI5isXk *MidAmerican Energy Combustion Fueled Power Plant Virtual Tour* (Source 1) *Video length: 7 minutes 6 seconds*
- Natural Gas Basics (Source 7) https://www.eia.gov/kids/energy-sources/natural-gas/

Coal:

- Video: https://www.youtube.com/watch?v=2IKECt4Y3RI *MidAmerican Energy Coal-Fueled Power Plant Virtual Tour* (Source 15) *Video length: 6 minutes 59 seconds*
- Coal Basics (Source 2) https://www.eia.gov/kids/energy-sources/coal/
- Coal Safety & Reclamation (Source 3) https://www.wyomingmining.org/minerals/coal/coal-safety-reclamation/

Hydroelectric:

- Video: https://www.youtube.com/watch?v=mLUUZ7xIoN4 *MidAmerican Energy Hydroelectric Power Plant Virtual Tour* (Source 14) *Video length: 10 minutes 27 seconds*
- Hydropower Basics (Source 9) https://www.eia.gov/kids/energy-sources/hydropower/

Wind Energy:

- Video: https://www.youtube.com/watch?v=FE5FqNGn53E *MidAmerican Energy Wind Farm Virtual Tour* (Source 16) *Video length: 7 minutes 20seconds*
- Wind Basics (Source 10) https://www.eia.gov/kids/energy-sources/wind/

Suggested Teacher Preparation:

- View the sample resources on oil, which will be the energy resource modeled by the teacher.
- Find supplemental information from the oil text resource to fill in additional information on the graphic organizer once video virtual tour information has been added.
- Be able to display the oil sample posters.
- Review all videos and websites before lesson to become familiar with the development processes and uses of each of the resources. Teachers may also opt to decide on start and stop point for viewing the videos, as video lengths vary. Be knowledgeable enough to decide if students have completed their graphic organizers for their assigned topics in step 6.
- Decide how students will present their research (see step 7).

Standards:

Science: 4-PS3-2 (Explicit)

Social Studies: SS5.3.1 (Explicit)

ELA: 4.W.7 (Explicit), 4.RI.9, 4.SL.1.c, 4.SL.1.d, 4.SL.2, 4.SL.4 (Practiced/Encountered)

CVE: CV5.2.2 (Practiced/Encountered)

Vocabulary: Student groups will encounter vocabulary unique to their resource as they gather information on their topic.

Instructional Procedure/Steps:

Part One: Teacher modeling of research and project development

1. Play oil video.

2. When the video is finished playing, model for students the process of completing the Development & Use of Energy Resources graphic organizer. The posters provided for the "tour" can be a guide for which information is important. While modeling the completion of the graphic organizer, talk aloud about why what is documented is an important fact and how it is a part of the development process.

3. When you have finished inputting information from the video, identify any spots where additional information is needed, and model the process of using the text resource to supplement the information. Emphasize that facts are tied to answering the question: **"How is this resource developed, used, and cared for?"**

4. Once the graphic organizer is completed, say: **"The next part of your task will be putting the information into a presentation that helps others learn about the process your natural resource goes through to become energy. Since we can't easily visit a mine, oil/natural gas field, wind farm, hydroelectric dam, or a power plant for a tour of the whole process, we will be creating a visual tour."** Model the visual tour using the oil sample posters.

Part Two: Student research and project development

5. Assign students to groups. Each group will look at a major energy resources in Wyoming: natural gas, coal, wind, hydroelectric, or uranium.

6. Assign groups an energy resource and provide them with the video and text resources. Groups study the provided resources to learn about the development and use of their assigned energy resource. When finished, each group will decide which steps in the process need to be included in their virtual tour. Students will complete their graphic organizers and check in with the teacher to see if they have included important information and/or if any key facts have been left out. Give groups suggestions on what needs to be added if they are missing information.

7. Once groups have revised their notes and received teacher approval, groups begin on the teacher-decided method of presentation.

Part Three: Presentations of energy development "tours"

8. Provide group with 10-15 minutes to finish preparations and practice their presentations.

9. Have each resource group take a turn presenting their natural resource to the rest of the class. As groups travel to each "stop" on their tour, have the "tour guide" take on the role of someone who would be associated with that part of the process (e.g., miner, engineer, refinery worker, etc.)

10. After all groups have presented, ask students the questions below. Allow students to respond before moving on to the next question.
    - **"Did you see any similarities in the development of the different energy resources?"**
    - **"Was stewardship a part of the process to create energy?"**
        - *If yes,* have students describe how.

TEACHER NOTE: Remind students they need to clearly explain how the raw resource is converted to energy and incorporate the "who" of mining and energy production during their tour. These are important because they relate the content back to the science standard 4-PS3-2 and knowing who is involved. In the "Cared for" section of the graphic organizer, students should also mention ideas about how the resource is stewarded.

- *If no,* say: **"We must remember this resource, so we can return to its stewardship piece in Lesson 9."**

Assessment: Check students' graphic organizers for accuracy and completion. Presentations should address how the resource is developed, how it is used, how it is cared for, **and** who is involved in the development process. The graphic organizers/presentations will also be incorporated into students' final projects at the end of the unit, so either teacher or students should keep them for later use.

Possible extension activities: Have someone who works in one of the industries explored come in to talk about the process of mineral or energy production. Take a field trip to a power plant, wind farm, refinery, etc.

Credits/Sources:

1. MidAmerican Energy. (2015, April 29). *MidAmerican Energy Combustion-Fueled Power Plant Virtual Tour*. Retrieved June 11, 2020 from https://www.youtube.com/watch?v=RNbZQI5isXk
2. U.S. Energy Information Administration. (n.d.). *Coal Basics*. Retrieved July 20, 2021, from https://www.eia.gov/kids/energy-sources/coal/
3. Wyoming Mining Association. (2017) *Coal Safety & Reclamation.* Retrieved June 26, 2017, from https://www.wyomingmining.org/minerals/coal/coal-safety-reclamation/
4. University of Wyoming Extension Office. (2013, July 26). *Uranium Mining . . . with Baking Soda.* Retrieved June 26, 2017, from https://www.youtube.com/watch?v=258xiAv_8FQ
5. National Geographic. (2017, October 12). *What is Nuclear Energy?* Retrieved July 20, 2021, from https://www.youtube.com/watch?v=Ta3z3pGK0vU
6. U.S. Energy Information Administration. (n.d.). *Uranium (nuclear) Basics*. Retrieved July 20, 2021, from https://www.eia.gov/kids/energy-sources/uranium/
7. U.S. Energy Information Administration. (n.d.). *Natural Gas Basics*. Retrieved July 20, 2021, from https://www.eia.gov/kids/energy-sources/natural-gas/

8. U.S. Energy Information Administration. (n.d.). *Oil Basics*. Retrieved July 20, 2021, from https://www.eia.gov/kids/energy-sources/oil/
9. U.S. Energy Information Administration. (n.d.). *Hydropower Basics*. Retrieved July 20, 2021, from https://www.eia.gov/kids/energy-sources/hydropower/
10. U.S. Energy Information Administration. (n.d.). *Wind Basics*. Retrieved July 20, 2021, from https://www.eia.gov/kids/energy-sources/wind/
11. The NEED Project. (2019-2020). *Elementary Energy InfoBook* (Publication). Retrieved October 14, 2020, from https://www.need.org/wp-content/uploads/2019/10/Elementary-Energy-Infobook.pdf
12. The Heritage Foundation. (2012, July 13). *Powering America: Uranium Mining and Milling.* Retrieved June 26, 2017, from https://www.youtube.com/watch?v=oT2LHGG-9Ko
13. Wyoming Agriculture in the Classroom. (2019) *Student Resources: 4th Grade Minerals & Energy.* https://wyaitc.org/curriculum/student-resources/
14. MidAmerican Energy. (2013, October 4). *MidAmerican Energy Hydroelectric Plant Virtual Tour.* Retrieved October 14, 2020, from https://www.youtube.com/watch?v=mLUUZ7xIoN4
15. MidAmerican Energy. (2013, August 7). *MidAmerican Energy Coal-Fueled Power Plant Virtual Tour.* Retrieved October 14, 2020, from https://www.youtube.com/watch?v=2IKECt4Y3RI
16. MidAmerican Energy. (2015, April 29). *MidAmerican Energy Wind Farm Virtual Tour.* Retrieved October 14, 2020, from https://www.youtube.com/watch?v=FE5FqNGn53E

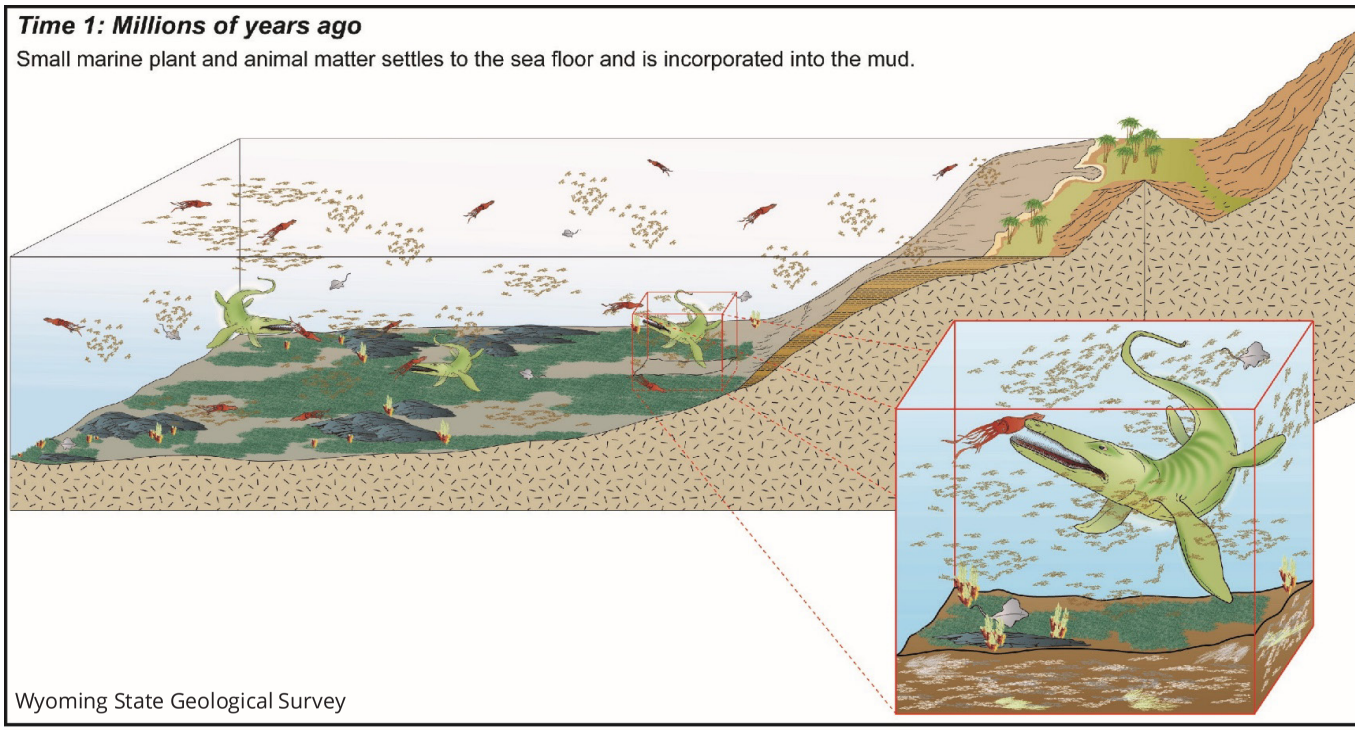
Development & Use of Energy Resources

Stops on the tour for our Virtual Field Trip.
Record key information about how the resource is developed, used, and cared for.

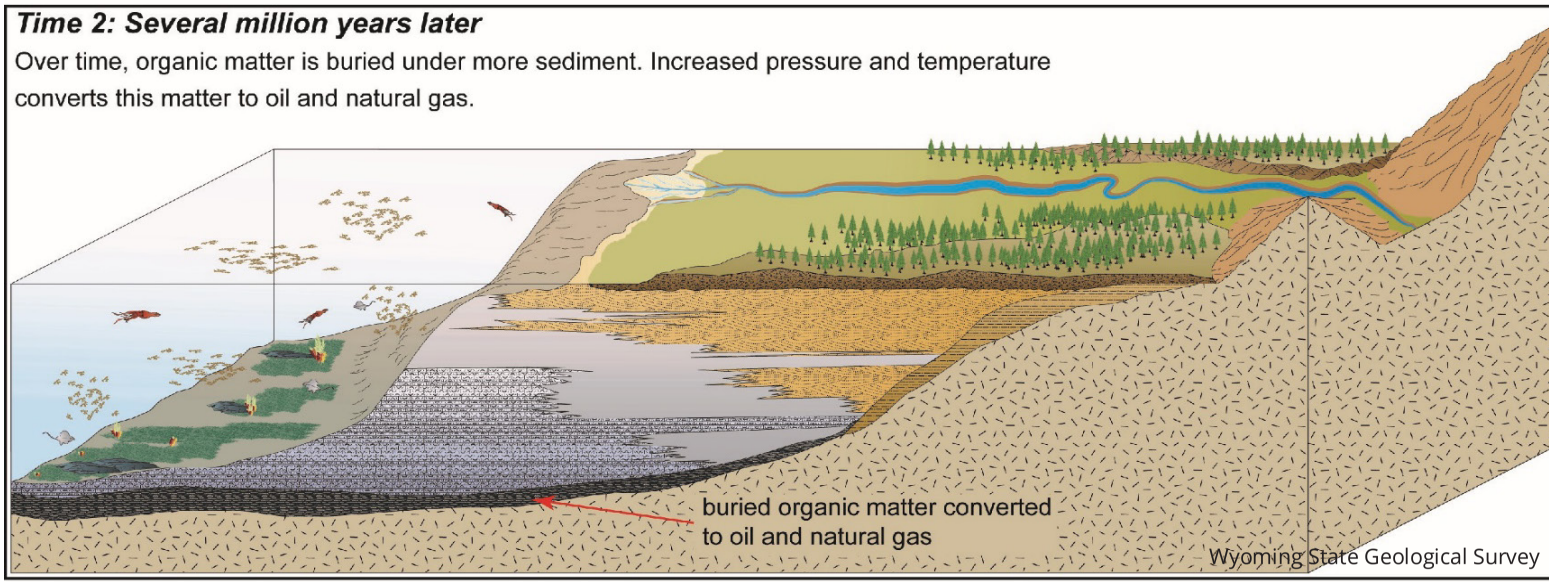
Group Members' Names: _____

Topic: _____

Developed
By who?
Facts:
Used
By Who:
Facts:
Cared For
By Who:
Facts:



Millions of years ago, oil was formed from the remains of tiny sea plants and animals.



Oil is buried underground in tiny pockets in rocks. Oil wells are drilled to pump out the oil. Some oil rigs are out in the ocean and some are on land. People involved include geologists, engineers, and rig workers.

Oil is transported by railway, ship, or pipeline to refineries. People involved include transportation workers.

At the refinery, oil is separated into different components, and made into fuels. People involved include refinery workers.

Fuel is transported to gas stations. People involved include truck drivers and rail workers.


Tony Webster - Creative Commons

Buhler013 - Creative Commons

We use gasoline to power our cars. Petroleum is also used to make other fuels; lots of materials such as plastics, paints, and many other items. People involved include consumers.

Once drilling is completed, the companies work to reclaim the land. People involved include environmental engineers.

Lesson Five: Powering Up the Country

Grade Level: 4th Grade

Time: 45-60 minutes

Essential Question: How can we be stewards of Wyoming's minerals and energy to benefit current and future generations?

Objective: Students will identify renewable and nonrenewable resources.

Purpose: Students learn the difference between renewable and nonrenewable resources and how they both relate to stewardship.

Required Materials/Resources:

- Introductory options:
  - Non-renewable energy slideshow. (Source 1) - This is a slideshow that you can go through at your own pace. http://www.nationalgeographic.org/encyclopedia/non-renewable-energy/
  - Video: https://www.youtube.com/watch?v=pBTnVoEIb98 *Stop Motion Film: Renewable vs NonRenewable Energy Sources* (Source 2) *Video length: 4 minutes 17 seconds*
- Energy Consumption in the U.S. worksheet (one per student) (Source 3)

TEACHER NOTE: The U.S. mix of energy production changes from year to year. The most current statistics can be found at the U.S. Energy Information Administration website https://www.eia.gov/energyexplained/?page=us_energy_home (Source 3). An optional additional activity is that students can use the data in the chart to create their own graphs rather than looking at those provided.

- Energy Consumption/Production graphs (optional) - (one set to display) (Source 3)
- Mineral and Natural Resource cards from Lesson 3 (one card from each of the six energy resources per small group)
- Energy Sort page (one per small group)
- Renewable or Nonrenewable? graphic organizer (one per student)
- Exit ticket (one per student)

Suggested Teacher Preparation:

- View introductory options and select one.
- Prepare card sets for small groups. Each group will receive a total of six cards.
- Assign students to groups.

Standards:

Science: 4-ESS3-1 (Explicit)

ELA: 4.SL.1.d (Practiced/Encountered)

Vocabulary:

- **Conservation** - the careful utilization of a resource in order to prevent waste and leave some for future generations
- **Nonrenewable resources** - resources that cannot be replenished (made again) in a short period of time
- **Renewable resources** - resources that are capable of being replenished

Instructional Procedure/Steps:

1. Display chosen introductory option as a warm up.

2. Review vocabulary and key concepts from previous lessons. Students can reference the posters that they created. Assign students to small groups.

3. Pass out sets of the Mineral & Natural Resources cards from Lesson 3 and one copy of the Energy Sort page to each group. Groups sort their cards. When groups are finished, discuss as a whole group the placement of each

resource and why it belongs in the category that it does.

4. Pass out the Energy Consumption in the U.S. worksheets. Have students analyze the data and discuss their takeaways. The teacher can then opt to display the Energy Consumption/Production graphs as an additional tool for building student understanding of what portion of our energy comes from each source.

In this task, students will be engaged in the higher order thinking skills of analysis.

5. Reconvene the whole class, and have students discuss/share their observations of the data. Ask: **"What are the implications of having such a large portion of our energy coming from nonrenewable sources?"** If necessary, review meanings of the vocabulary terms conservation and stewardship.

In this task, students will be engaged in the higher order thinking skills of synthesis.

6. Pass out the Renewable or Nonrenewable? graphic organizers and draw students' attention to the conservation. Remind students of their presentations from a previous lesson and to include any stewardship efforts that they learned about when they did their research. (e.g., part of the process for mining coal is reclaiming the land after the mine is no longer in use.)

7. After students have completed their graphic organizers, have students pick a nonrenewable resource and conservation idea from their sheet. Have students turn and talk to a partner or visit with a small group explaining why it is important.

8. Pass out and have students complete an exit ticket to demonstrate their understanding of renewable and nonrenewable resources.

Assessment: Collect completed Renewable or Nonrenewable? graphic organizers, and check for student understanding of conservation. Collect exit tickets, and check for student understanding of renewable and nonrenewable resources.

Credits/Sources:

1. Morse, E. National Geographic. (2013, February 14). *Non-renewable energy*. Retrieved June 26, 2017, from https://www.nationalgeographic.org/encyclopedia/non-renewable-energy/
2. Crabtree, R. (2012, February 6). *Stop Motion Film: Renewable vs NonRenewable Energy Sources*. Retrieved June 26, 2017, from https://www.youtube.com/watch?v=pBTnVoEIb98
3. U.S. Energy Information Administration-EIA. (2017, May 19). *Americans use many types of energy*. Retrieved October 2, 2018, from https://www.eia.gov/energyexplained/?page=us_energy_home

Energy Consumption in the U.S.

Energy can be categorized into nonrenewable and renewable resources.
Looking at the chart below, write your thoughts and observations about the types of energy consumed.

U.S. Energy Consumption by Source 2017

Nonrenewable Energy	Renewable Energy
Petroleum 28% uses: transportation, manufacturing	**Biomass** 5.06% uses: heating, electricity, transportation
Natural Gas 31.8% uses: heating, manufacturing, electricity	**Hydropower** 2.81% uses: electricity
Coal 17.8% uses: electricity, manufacturing	**Wind** 2.36% uses: electricity
Uranium 9.6% uses: electricity	**Solar** 0.67% uses: heating, electricity
	Geothermal 0.22% uses: heating, electricity

Thoughts and observations about the chart:

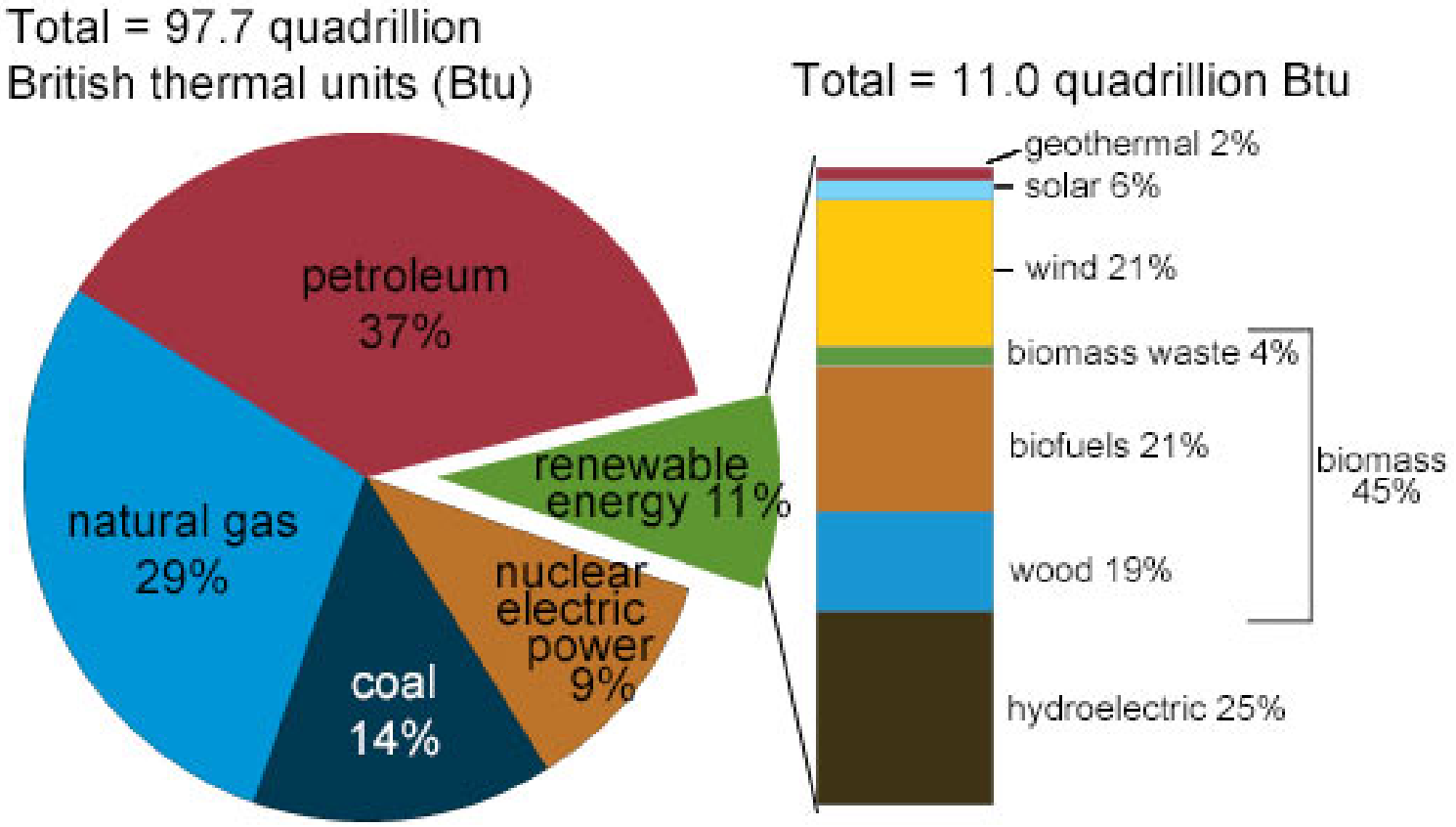
_____

_____

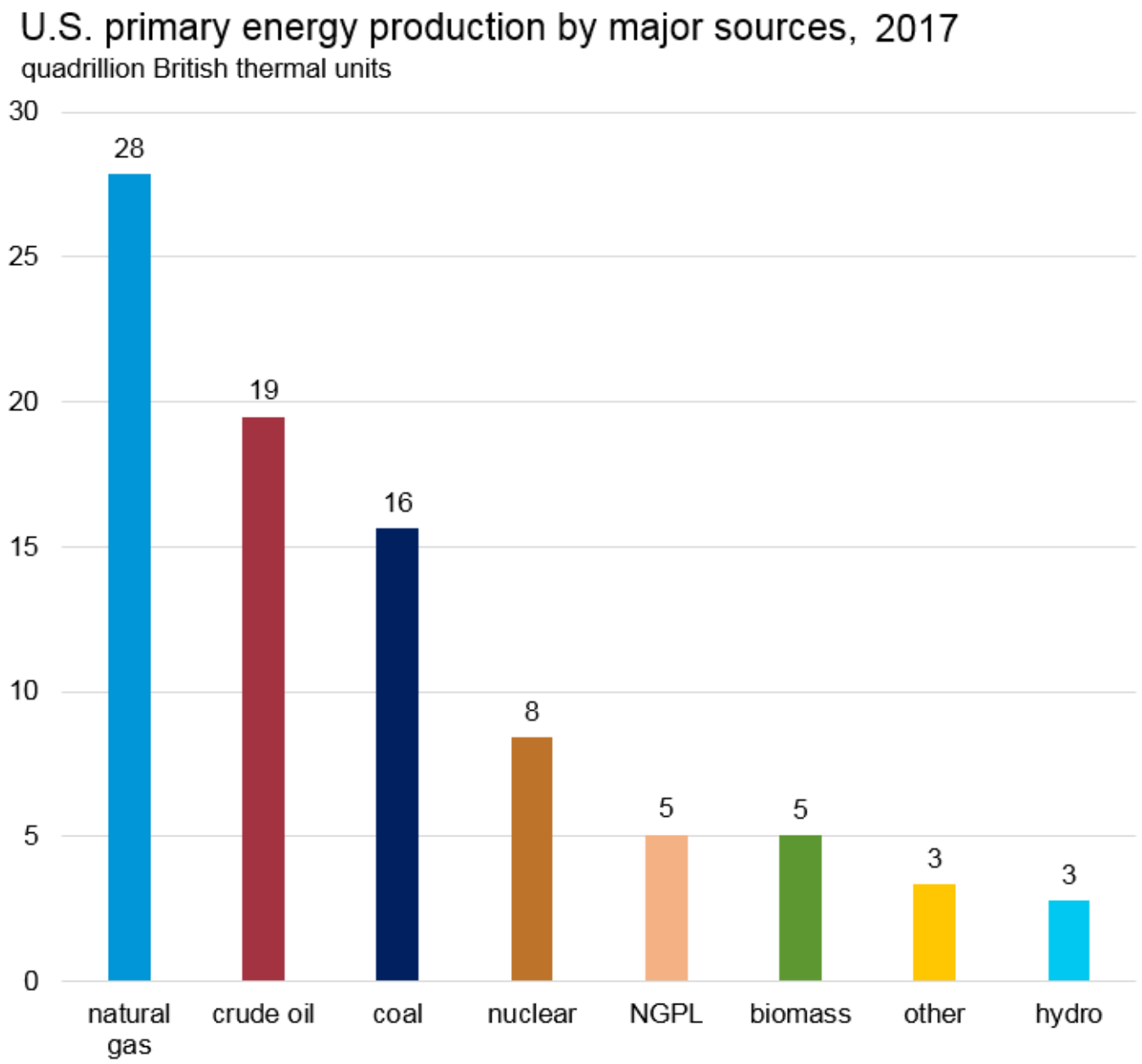
_____

_____

U.S. energy consumption by energy source, 2017



Note: Sum of components may not equal 100% because of independent rounding.
Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.3 and 10.1, April 2018, preliminary data



Note: NGPL is natural gas plant liquids; other is geothermal, solar, and wind; hydro is conventional hydroelectric.
Source: U.S. Energy Information Administration, *Monthly Energy Review*, April 2018, preliminary data

Energy Sort

Using the pictures from the previous lesson, sort the energy source according to renewable and nonrenewable energy.

Renewable	Nonrenewable

Renewable or Nonrenewable?

	Renewable or Nonrenewable (circle one)	Uses	Conservation Ideas
Coal	Renewable Nonrenewable		
Oil	Renewable Nonrenewable		
Wind	Renewable Nonrenewable		
Uranium	Renewable Nonrenewable		
Natural Gas	Renewable Nonrenewable		
Hydropower	Renewable Nonrenewable		

Renewable & Nonrenewable Resources

Exit Ticket

Name: _____ Date: _____

Give an example of two energy sources that are renewable:
1.

2.

Give an example of two energy sources that are nonrenewable:
1.

2.

What is the difference between renewable and nonrenewable?

Renewable & Nonrenewable Resources

Exit Ticket

Name: _____ Date: _____

Give an example of two energy sources that are renewable:
1.

2.

Give an example of two energy sources that are nonrenewable:
1.

2.

What is the difference between renewable and nonrenewable?

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Lesson Six: Powering Up Wyoming's Economy

Grade Level: 4th Grade

Time: 60-90 minutes (Split into two parts if necessary.)

Essential Question: How can we be stewards of Wyoming's minerals and energy to benefit current and future generations?

Objective: Students will study the impact of minerals and energy on Wyoming's culture and economy.

Purpose: Students learn how important mineral and energy resources are to Wyoming's culture and economy.

Required Materials/Resources:

- Powering Up Wyoming's Economy Cloze activity sheet (one per student) (Sources 1-12)
- Powering Up Wyoming's Economy Cloze activity sheet Answer Key (one for the teacher)
- Electronic devices to play Kahoot quiz OR white boards/paper and markers (see Part 1: Steps 3 & 4)
- Powering Up Wyoming's Economy Kahoot quiz https://play.kahoot.it/#/k/874063d4-5691-4745-a855-140a0eabca42
- Panel Discussion Question sheet (one per student)
- Roles sheet for panel discussion (one per group)
- Chart paper
- Markers

Suggested Teacher Preparation:

- Try out and prepare the Kahoot game for class use. (A teacher device will need to be connected to a projector to display the game questions for the students. Teacher will click on the link https://play.kahoot.it/#/k/874063d4-5691-4745-a855-140a0eabca42 and then click play. At this point, a 6-digit game code will generate. Students use their devices (any electronic device with internet access will work - iPad, computer, tablet, etc.) to log on to Kahoot.it. They will be asked to type in the six-digit code and their name to join the game.
- Secure electronic devices for students to play the Kahoot game or gather other materials needed for sharing the questions and results
- Arrange desks or tables for panel discussion.
- Review the "Powering Up Wyoming's Economy" Answer Key. Understand the big picture of how minerals and energy play a role in Wyoming's economy and culture.
- Prepare brainstorming anchor chart.

Standards:

Science: 4-ESS3-1 (Practiced/Encountered)

Social Studies: SS5.3.2 (Explicit), SS5.2.1, SS5.4.1 (Practiced/Encountered)

ELA: 4.SL.1.a, 4.SL.1.c, 4.SL.4 (Practiced/Encountered)

Vocabulary:

- **Culture -** a way of thinking, behaving, or working that exists in a place or organization
- **Economy -** financial system of interaction and exchange
- **Impact -** have a strong effect on someone or something

Instructional Procedure/Steps:

1. Say: **"Brainstorm all the ways that you have used or been impacted by energy in the last 48 hours."** Record responses on chart paper.

2. Guide students in a whole group discussion by asking the questions below. Allow students to respond before moving on to the next question.
    - **"Who pays for schools and government buildings to be built?"**
    - **"Who pays for teachers', firefighters', and police officers' salaries?"**
    - **"How does the state of Wyoming receive money?"**
    - **"If the state was not able to make money off our resources, what would happen? For example, what would be the impact to our schools, our libraries, etc.? What jobs would be impacted?"**

3. Pass out the Powering Up Wyoming's Economy Cloze activity sheets. Begin the Kahoot quiz. (See Suggested Teacher Preparation above.)

4. When all students have joined, start the game by displaying the first question. Have students read the question and select the answer they think is correct via iPad, computer, or other device. If these options are unavailable, students can respond using a personal whiteboard, paper, etc.

5. Have students fill in the blanks on their Cloze activity sheets as you play the game. Question 1 on the game matches question 1 on the students' Cloze activity sheet and answer key. By the end of the game, students should have all blanks completed. *Follow the answer key for filling in the blanks because not all blanks will be filled with the game alone.*

6. *Stop here if you want to complete the lesson in two parts.*

7. Separate students into 5 groups and pass out role cards to each group. Explain to students that each group will be thinking like a different type of person: farmer, student, miner, business person, teacher. As a group, have students review their Powering Up Wyoming's Economy

TEACHER NOTE: The amount of teacher input in this discussion will vary based on students' previous exposure to these concepts. Students need to understand that public services and resources are funded through tax money, and that a large portion of Wyoming's money comes from the mineral and energy industry.

Cloze activity sheets. Say: **"Select 5 to 7 facts from the worksheet that you feel most impact or are most relevant to your assigned person."**

In these tasks, students will be engaged in the higher order thinking skills of evaluation and synthesis by comparing, rating, and `inferring`.

8. Pass out the Panel Discussion question sheets. Using the group's chosen facts and their knowledge from previous lessons, have each group discuss and write the answers on their Panel Discussion question sheets from their assigned role's point of view.

9. When groups are finished answering their discussion questions, set up the panel discussion. Have a student from each role/group represent their Wyoming citizen to answer a question by the teacher from the Panel Discussion question sheet.
    - Have one student from each role/group come forward. Have students display their role card.
    - Ask a question from Panel Discussion question sheet. Each student on the panel takes a turn answering the question as it relates to their role. Students can use their discussion sheets as an aid.
    - When everyone on the panel has responded to the question, another person from the group will tag in to respond to the next question.
    - Repeat until all questions have been discussed. Make sure every student in each group has the opportunity to respond to at least one question.

10. After the panel discussion, revisit the brainstorming chart from the start of the lesson, and have students add additional information based on the Kahoot Cloze activity and panel discussion.

Assessment: Collect completed Cloze activity sheets, and check for accuracy. Listen to the panel discussion and assess students' individual understanding of the lesson content specifically the ways people are impacted by Wyoming's energy and natural resources.

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Powering Up Wyoming's Economy
CLOZE Activity

As we play the Kahoot game, fill in the correct answers for each fact.

Coal

Wyoming ranks _____ in the nation for coal production.

The amount of coal available in the U.S. could provide energy for over ____ years.

Coal contributes over 1 billion dollars in taxes to Wyoming each year. This money is used to: _____.

_____ pound of coal supplies enough electricity to light ten 100-watt light bulbs for one hour.

The average _____ uses the equivalent of 20 lbs. of coal each day.

In 2016, _____ people were employed by Wyoming coal mines.

Oil

Nationally, Wyoming ranked _____ in production of crude oil in 2015.

Petroleum pipelines are located in all of the state's _____ counties.

In 2015, oil and gas production contributed _____ billion dollars to state and local governments.

In 2015, over _____ people were employed by the oil and gas industry.

Natural Gas

Wyoming ranked _____ in the nation in the production of natural gas in 2015.

Natural gas has many different uses. The most common are _____ _____.

Sublette and Campbell counties have experienced _____ growth due to oil, gas, and coal extraction.

Powering Up Wyoming's Economy
CLOZE Activity

As we play the Kahoot game, fill in the correct answers for each fact.

Wind

Generating wind power creates no _____ and uses virtually no _____.

One _____ turbine doesn't make much electricity.

Most wind farms have many wind turbines. That land can still be used to

_____.

Hydro

Hydropower is the world's largest contributor of all _____ resources.

Wyoming has _____ hydro-electric power plants capable of producing over 280 megawatts.

Reservoirs created by hydro plants can be used for _____

_____.

Uranium

Wyoming has the _____ uranium reserves in the country.

About one pound of uranium can produce the same amount of energy as

_____ pounds of coal.

Uranium is a _____ found in rocks in the _____.

Powering Up Wyoming's Economy Quiz
(Teacher Copy)

Teacher Directions: The question number noted on the teacher copy corresponds to the question number of the Kahoot game. Teacher will need to stop and discuss each question/statement, so students can successfully complete the cloze activity.

Coal

Question 1 - Wyoming ranks **1st** in the nation for coal production.

Question 2 - The amount of coal available in the U.S. could provide energy for over **250** years.

Question 3 - Coal contributes over 1 billion dollars in taxes to Wyoming each year. This money is used to: **fund the state government**, **pay teachers**, and **build new schools**.

Question 4 - One pound of coal supplies enough electricity to light ten 100-watt light bulbs for one hour.

Question 5 - The average **person** uses the equivalent of 20 lbs. of coal each day.

Question 6 - In 2016, **5,682** people were employed by Wyoming coal mines.

Oil

Question 7 - Nationally, Wyoming ranked **8th** in production of crude oil in 2015.

Question 8 - Petroleum pipelines are located in all of the state's **23** counties.

Question 9 - In 2015, oil and gas production contributed **2.1** billion dollars to state and local governments.

Question 10 - In 2015, over **20,402** people were employed by the oil and gas industry.

Natural Gas

Question 11 - Wyoming ranked **5th** in the nation in the production of natural gas in 2015.

Question 12 - Natural gas has many different uses. The most common are **heating**, **manufacturing,** and **electricity**.

Question 13 - Sublette and Campbell counties have experienced **rapid** growth due to oil, gas, and coal extraction.

Wind

Question 14 - Generating wind power creates no **emissions** and uses virtually no **water**.

Question 15 - One **wind** turbine doesn't make much electricity.

Question 16 - Most wind farms have many wind turbines. That land can still be used to **farm** or **graze animals**.

Hydro

Question 17 - Hydropower is the world's largest contributor of all **renewable** resources.

Question 18 - Wyoming has **11** hydro-electric power plants capable of producing over 280 megawatts.

Question 19 - Reservoirs created by hydro plants can be used for **swimming, fishing, boating,** and **other sports**.

Uranium

Question 20 - Wyoming has the **largest** uranium reserves in the country.

Question 21 - About one pound of uranium can produce the same amount of energy as **20,000** pounds of coal.

Question 22 - Uranium is a **mineral** found in rocks in the **ground**.

Panel Discussion

Role: _____

What are some of the benefits of this energy resource?

What are some challenges of this energy resource?

Which energy resource has the biggest impact on your life? Why?

Which energy resource could you live without? Why?

How would your life change if the most important resource was no longer available?

How would your life change if the price of that resource doubled?

How would you steward natural resources to benefit all Wyoming's citizens?

Wyoming Stewardship Project

Roles

FARMER

STUDENT

TEACHER

BUSINESS PERSON

MINER

Lesson Seven: Measuring Up

Grade Level: 4th Grade

Time: 60-90 minutes

Essential Question: How can we be stewards of Wyoming's minerals and energy to benefit current and future generations?

Objective: Students will:

- Analyze the pros and cons of both renewable and nonrenewable energy resources.
- Express why it is necessary to use our energy resources wisely and incorporate a variety of energy resources into the production of energy.

Purpose: Students recognize the pros and cons of energy resources and that, as stewards, we must use all energy resources wisely since no single energy resource is sufficient to meet state, national, and global energy needs.

Required Materials/Resources:

- Energy Pro & Con sheets (one set for each student) - (sources 1-15)
- Energy Resource labels
- Masking tape
- Electronic devices for Padlet (www.padlet.com) **OR** sticky notes
- Poster paper
- Markers, colored pencils, etc.
- Chips, tokens, etc. (optional)

TEACHER NOTE: This lesson is to help students understand that ALL energy sources have both pros **and** cons and that weighing pros and cons is a complex process. It is also important for students to have the opportunity to practice sharing their opinion, giving an explanation for it, and disagreeing with others in a safe and respectful environment.

TEACHER NOTE: Save the Energy Pro and Con sheets for Lessons 8 and 10.

Suggested Teacher Preparation:

- Review Energy Pro & Con sheets.
- Use masking tape to create a pro/con/neutral line on the classroom floor.
- Label one end of the line CON, the opposite end PRO, and the middle as NEUTRAL.
- Post Energy Resource labels in different sections of the classroom.
- If using the Padlet option, create an account at www.padlet.com, and set up student electronic devices.
- Arrange student groups for steps 7 and 8.

Standards:

Science: 4-ESS3-1 (Explicit)

ELA: 4.L.6, 4.SL.1.d (Practiced/Encountered)

CVE: CV5.3.3 (Practiced/Encountered)

Vocabulary:

- **Con** - the unfavorable factors or reasons; disadvantages
- **Pro** - the favorable factors or reasons; advantages

Instructional Procedure/Steps:

1. Divide the classroom into six sections by labeling each area to represent one of the energy sources: nuclear, coal, natural gas, oil, wind, and hydro.

2. Say: **"Look at the energy resource signs posted around the room. When I say, 'Go,' move to the energy resource you think is best, and stand in that section of the room."** At this point, the instruction is deliberately vague. After students have formed their groups, have students discuss why they selected the resource they did. Have one group spokesperson share out each group's thinking with the whole class.

3. Choose an energy resource for the whole class to work with: coal, oil, natural gas, nuclear, wind, or hydro. Pass out the Energy Pro & Con sheet for that energy resource. Say: **"Individually, you will now mark your sheet to show whether each fact is a pro, a con, or a neutral fact. Also, think about how important each fact is in considering the bigger picture of energy. The numbers located at the end of many of the facts are footnotes that provide source information. They don't have any bearing on whether the fact is positive or negative."** If necessary, define pro and con.

4. Once students have marked all facts on the selected sheet, direct students' attention to the line in the middle of the classroom. Say: **"One end of the line represents that the energy resource is positive, and the other represents that the resource is negative. The middle of the line is neutral. You will use your individual evaluation of the pros and cons of the energy source to place yourself on the line. You can stand anywhere on the line."**

5. Say: **"Place yourselves on the line to show whether you feel the energy resource is mostly positive, mostly negative, somewhat positive, etc."** When all students have found a place on the line, ask a couple of students to share their thinking about why they chose the position they did.
    - Possible strategies to use as students discuss their positioning:
        - Fold the line (Pros discuss with cons.)
        - Shift the line (Middle of the line goes down to one end or the other, so neutrals are matching with pros or cons.)
        - Chips in (Students are each given a predetermined number of chips. When a student wants to participate, he/she puts in a chip. When the student is out of chips, he/she is out of turns. All students are encouraged to spend all their chips.)

In this task, students will be engaged in the higher order thinking skills of evaluation through comparing and rating different facts. They then use that information to make an overall judgement about the pros and cons of various resources.

        - 10-word summary (Students share a 10-word summary with a partner telling what they learned or why they are standing where they are. The number of words can change for different rounds of discussion.)
    - After students discuss, ask students if they would like to move based on someone else's argument, or tell students to go to a different spot on the line and justify an alternate point of view.

6. Repeat steps 3-5 using a second energy resource. If you started with a nonrenewable resource, pick a renewable one, or vice versa.

7. When the whole group has repeated the procedure for a second resource, have students work in small groups to review, rate, and discuss two additional energy resources. Structure groups so that all four of the remaining resources are addressed by at least one group. Monitor discussions to ensure that students are actively listening to one another and disagreeing respectfully.

8. End the lesson with a class discussion. Arrange students in groups of 4, so there is a mix of members who reviewed different energy resources in the preceding step. Pose the following questions, and ask the small groups to discuss:

    - **"What did you learn as you did this activity?"**
    - **"Were there any resources that had only pros? Only cons? Why do you think that is?"**
    - **"How did your thinking about energy resources change as we looked at the pros and cons of each?"**

In this task, students will be engaged in the higher order thinking skills of analysis.

- **"Do you think it's realistic for us to try and use just one energy resource? What might be the benefit of using multiple resources? What might be the challenges?"**
- **"How does knowing the pros and cons of each energy source relate back to our essential question: How can we be stewards of Wyoming's minerals and energy to benefit current and future generations?"**

In this task, students will be engaged in the higher order thinking skills of evaluation.

9. After giving small groups 5-10 minutes to discuss these questions, bring the whole class together to discuss the last two questions. Use the discussion as an opportunity to reinforce the complexity of the industries and of making stewardship decisions regarding the industries: Again, ask:
    - **"Do you think it's realistic for us to try and use just one energy resource? What might be the benefit of using multiple resources? What might be the challenges?"**
    - **"How does knowing the pros and cons of each energy source relate back to our essential question: How can we be stewards of Wyoming's minerals and energy to benefit current and future generations?"**
    - **"Is the energy resource you chose at the beginning of this lesson still your first choice?"**

10. Ask students to reflect on the lesson using one of the following options:
    - Create a poster for students to post a sticky note with their "ah-ha" statements or take away messages. OR
    - Use the app "Padlet" (a sample padlet is set up here: https://padlet.com/andreahayden97/eak0hrl7ltk0 password: energy). Once all students have posted their thoughts, you can print off the padlet and have a hard copy to post in the

classroom, use as student notes, use for teacher assessment info, etc.

Assessment: Collect students' Energy Pro & Con sheets and evaluate for understanding of pros and cons. (Keep these as they will be used again in later lessons.) Listen to the whole group discussion and review students' reflections to check students' understanding of the lesson concepts.

Possible extension activities:

1. Have students play "Power Up" from NASA: climatekids.nasa.gov/power-up/. (Source 16) This is a game where students are given the challenge of powering a city given a certain amount of money. They can try out different strategies. Teachers can instruct students to use different constraints (choose the cheapest, the most environmentally friendly, etc.) and then compare and contrast the outcomes.
2. Have students view "From Fossil Fuels to Renewables," a video made by a Wyoming high school student that was a national winner in C-SPAN's 2017 Student-Cam competition. It features Governor Mead, Senator Enzi, and a number of Wyoming scientists discussing energy in Wyoming. *Video length 7 minutes 43 seconds.* https://www.c-span.org/video/?426777-1/fossil-fuels-renewables (Source 17)

Credits/Sources:

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Energy Pro & Con

COAL

Energy produced from coal is inexpensive.	
The amount of coal available to be mined in Wyoming could provide energy for the next 150 years.	
Coal is a nonrenewable resource.	
Wyoming is the nation's top coal producer. [1]	
Coal contributes over $1 billion in taxes to the state. [1] Royalties for coal supports the building of new schools. [4]	
Wyoming coal is low-sulfur and more environmentally friendly than other forms of coal. [4]	
Coal contributes 31% of CO_2, more that any other source. [EPA]	
Coal is a dispatchable energy source that can be turned on and off to meet demand. [18]	
Coal can be accessed through underground mining or surface mining. [3]	
After coal is mined, they put back the dirt and rock, and plant trees and grass. This is called reclamation. [3]	
In 2015, 6,646 people were employed by Wyoming coal mines. [4]	
A pound of coal supplied enough electricity to light ten, 100-watt light bulbs for one hour. [4]	

Overall view of this energy resource:

Negative _____ Positive

Energy Pro & Con

OIL

In 2015, Wyoming's petroleum industry directly employed over 20,400 people. [2]	
In 2015, oil and gas production contributed $2.1 billion to state and local governments. [2]	
In 2015, 751 wells were drilled and completed. Of that number, 38% found oil, 53% found gas, and 9% were dry holes. [2]	
Nationally, Wyoming ranked 8th in production of crude oil in 2015. [2]	
Petroleum pipelines are located in all of the state's 23 counties. [2]	
It costs about $4.5 million to $5.5 million to drill a well. (Wyoming Tribune Eagle)	
Oil is a nonrenewable resource.	
Drilling can lead to spills.	
Oil companies create environmental plans.	

Overall view of this energy resource:

Negative _____ Positive

Energy Pro & Con

NATURAL GAS

Wyoming ranked 5th in the nation in the production of natural gas in 2015. [2]	
In 2015, Wyoming had 41 operating gas plants processing nearly 87% of the state's gas production. [2]	
The extraction of natural gas releases methane into the air.	
When used to generate electricity, natural gas emits less than half of the carbon dioxide that coal does. [8]	
Natural gas is a mixture of gases you can't see, smell, or taste. [3]	
Natural gas is a nonrenewable resource.	
Natural gas has many different uses. The most common are heating, manufacturing, and electricity. [3]	

Overall view of this energy resource:

Negative ——————————|——————————— Positive

Energy Pro & Con

WIND

Wyoming is ranked 15th in the country for the number of wind turbines it has installed. [13]	
Generating wind power creates no emissions and uses virtually no water. [14]	
Wind is a renewable energy source that can be used to make electricity. [3]	
One wind turbine doesn't make much electricity. Most wind farms have many wind turbines and can take up a lot of land. [3]	
The land that wind farms are on can still be used to farm or graze animals. [3]	
Wind power is accessible for homeowners and businesses to set up their own power grids and even sell electricity to the power company. [6]	
Wind provides intermittent power because the amount of electricity produced varies due to factors that cannot be controlled. [18]	
The wind turbines don't run all the time. Sometimes the wind doesn't blow at all, and sometimes the wind blows too hard. Most wind turbines run between 65-90% of the time. [3]	
Wind electricity makes up about 5.6% of the nation's electricity. [10]	
Some types of wind turbines and wind projects cause bird and bat deaths. [6]	
Electricity from wind energy must be stored (i.e. in batteries). [6]	

Overall view of this energy resource:

Negative _____ Positive

Energy Pro & Con

HYDROPOWER

Hydropower is a clean source of energy. [3]	
When dams are built, they flood a lot of land. [3]	
Sometimes, when the flow of rivers change, fish can't swim upriver to lay their eggs, so dams have fish ladders and other devices to help fish move up the river. [3]	
Yellowstone National Park generates $^{1}/_{3}$ of its electricity from a hydroelectric plant. [9]	
Hydropower is the world's largest contributor of all renewable resources, making up 6.7% of electricity production worldwide. [7]	
Damming a river to produce hydropower can disrupt the local ecosystem causing flooding, changing fish passages, and impacting wildlife habitats. [7]	
Hydropower is a renewable source of energy.	
Hydropower relies on the water cycle. [3]	
Reservoirs can be used for irrigation, swimming, fishing, boating, and other sports. [3]	

Overall view of this energy resource:

Negative _____ Positive

Energy Pro & Con

URANIUM

Wyoming has the largest uranium reserves in the country. [1]	
Nuclear energy is the cleanest energy. [1]	
Disasters in nuclear energy plants rarely occur, but when they do, they are devastating. [5]	
Nuclear fission can release one million times more energy than fossil fuels. [7]	
Nuclear fission generations radioactive waste that can remain hazardous to both human health and the environment for thousands of years. [7]	
Uranium is a nonrenewable energy source.	
After uranium is used, it is still radioactive. [3]	
Radiation is dangerous and has to be dealt with carefully. [3]	
About one pound of uranium can produce the same amount of power as 20,000 pounds of coal. [4]	
Presently, the uranium produced in Wyoming is mined in-situ (meaning "in place"), an environmentally friendly process involving minimal surface disturbance.	

Overall view of this energy resource:

Negative _____ Positive

Energy Resource Labels

Coal

Energy Resource Labels

Oil

Natural Gas

Nuclear

Energy Resource Labels

Wind

Hydro

Lesson Eight: Chain Reactions

Grade Level: 4th Grade

Time: 60 minutes

Essential Question: How can we be stewards of Wyoming's minerals and energy to benefit current and future generations?

Objective: Students will examine cause/effect relationships related to each type of energy resource.

Purpose: Students learn that there are many causes and effects related to Wyoming's energy resources and being a steward impacts those causes and effects.

Required Materials/Resources:

- Energy Pro & Con sheets from previous lesson
- Cause and Effect Relationships graphic organizers: one cause with multiple effects, one effect with multiple causes, cause and effect chain (two copies of each organizer per student)
- Predicting Effects sheet (one per student)

TEACHER NOTE: Save Cause and Effect graphic organizers for Lesson 10.

Suggested Teacher Preparation:

- Review the Energy Pro & Con sheets.
- Create samples of the Cause and Effect Relationships graphic organizers to model for the students.
- Divide students into groups and choose a coal fact for each group to use. (See step 6.)

Standards:
Science: 4-ESS3-1 (Explicit)

Social Studies: SS5.4.1(Practiced/Encountered)

ELA: 4.RI.5 (Explicit)

Vocabulary:

- **Con** - the unfavorable factors or reasons; disadvantages
- **Pro** - the favorable factors or reasons; advantages

Instructional Procedure/Steps:

1. Ask students to review the six energy resources discussed in previous lessons by using a popcorn share in which the teacher names one of the six resources, and students quickly share facts, ah-has, or big ideas they gleaned from previous lessons. As each share out is completed, ask students to tell whether that resource is a renewable or a nonrenewable.

2. Say: **"Today, we will be examining cause and effect relationships connected to Wyoming's various energy resources. Turn to a partner and give a quick explanation of what a cause is and what an effect is."** Have several group members share out to ensure everyone has an understanding of both cause and effect.

3. Pass out the Cause and Effect Relationships graphic organizers. Model completing graphic organizers with a fact about coal. Say: **"I'm going use this fact: In 2017, Wyoming remains the nation's largest producer of coal. We will start with the graphic organizer that has one cause and multiple effects. First, write that fact in the cause box. This shows that I want to think of several things that are an effect of our state producing a lot of coal."** Continue to think aloud for

In this task, students will be engaged in the higher order thinking skill of synthesis by inferring causes and effects. They engage in analysis through work with different types of cause and effect relationships.

students as you write the three effects. See example below:

Cause: In 2017, Wyoming remains the leading coal producer in the country. (Source 1)

Possible Effects:

1. ***Coal mining provides jobs.***
2. ***Coal provides income for the state.***
3. ***We are using up a nonrenewable resource.***

4. Guide students in a brief discussion about what would happen if the fact in the cause box was to change. Say: **"If Wyoming was no longer the leading coal producer, what new effects might that have?"**

5. When finished discussing, have students help you complete each of the alternate graphic organizers using the same fact to ensure that they understand all three types of cause and effect relationships: one cause = multiple effects; multiple causes = one effect, and a cause and effect chain.

Example for multiple causes = one effect:

Effect: Wyoming remains one of the leading coal producers in the country. (Source 1)

Possible Causes:

1. ***Wyoming has large coal reserves.***
2. ***People want Wyoming coal because it is low sulfur, so it is more environmentally friendly.***
3. ***Wyoming coal is surface mined, so it's easier to access.***

Example for cause and effect chain:

Box 1: Wyoming remains one of the leading coal producers in the country. (Source 1)

TEACHER NOTE: If students struggle to identify cause and effect relationships, provide more support before moving on to step 7. Teachers may choose to add stems to the boxes for students who need that support. (Ex - Fact: One effect is... Another effect is...) Students may be given two examples and asked to tell which one is the cause and which one is the effect. All scaffolds should ensure that students are still working toward the intent of the science standard.

Box 2: Coal provides income for the state.

Box 3: Every Wyoming county has benefited from industry funds.

Box 4: Highways, community colleges, and public schools have been improved because of the funds.

6. Divide students into groups. Assign each group one of the following facts about coal:
    - Coal contributes 69% of CO_2, more than any other source (Source 2).
    - After coal is mined, they put back the dirt and rocks, and plant trees and grass. This is called reclamation (Source 3).
    - Coal can be accessed through underground mining or surface mining (Source 4).
    - Wyoming coal is low-sulfur (Source 3).

    Groups work together to complete a graphic organizer for their given fact. Once they finish one type of cause and effect relationship, they should try to complete one of the alternate graphic organizers. If they don't naturally do so, prompt students to identify the effect of the resource's use on the environment as that is the idea specifically addressed in the science standard.

7. After about 10 minutes, pull the groups back together, and have each one take turns sharing with the whole class the cause and effect relationships that they identified. Be sure to choose examples from each of the different types of cause and effect graphic organizers. After all groups have shared, ask:
    - **"What would happen if one part of their relationship changed?"**
    - **"How would that affect the other parts of the system?"**

In this task, students will be engaged in the higher order thinking skill of synthesis.

- **"How does predicting changes to the system help you better understand the complexities of energy production?"**

8. Next, have students independently show their understanding of cause and effect relationships by using another energy resource. Pass back students' Energy Pro and Con sheets from the previous lesson. Students will choose facts from the Energy Pro and Con sheets. Assign the following parameters, say:
    - **"First, select any of the other five resources to use."**
    - **"Choose a fact from that resource and complete a cause and effect relationship that shows how the resource's use impacts the environment."**
    - **"After completing the first graphic organizer, use the other cause and effect graphic organizers to show different types of relationships."**

9. When students have completed their graphic organizers, pass out the Predicting Effects sheets. Students complete the sheet based on one of their graphic organizers.

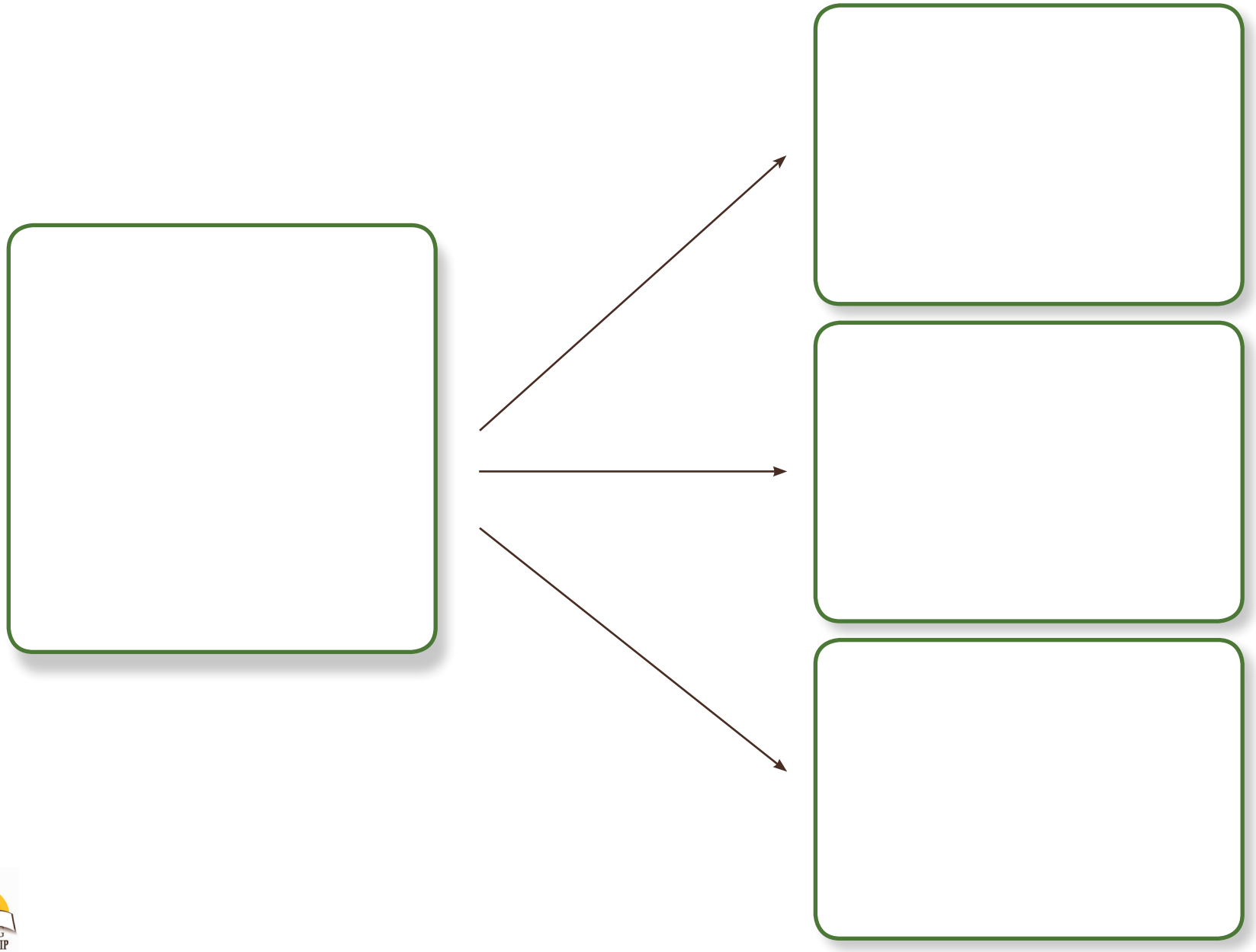
In this task, students will be engaged in the higher order thinking skill of synthesis.

Assessment: Collect completed graphic organizers and Predicting Effects sheets. Check students' work for are general accuracy and understanding of cause and effect relationships.

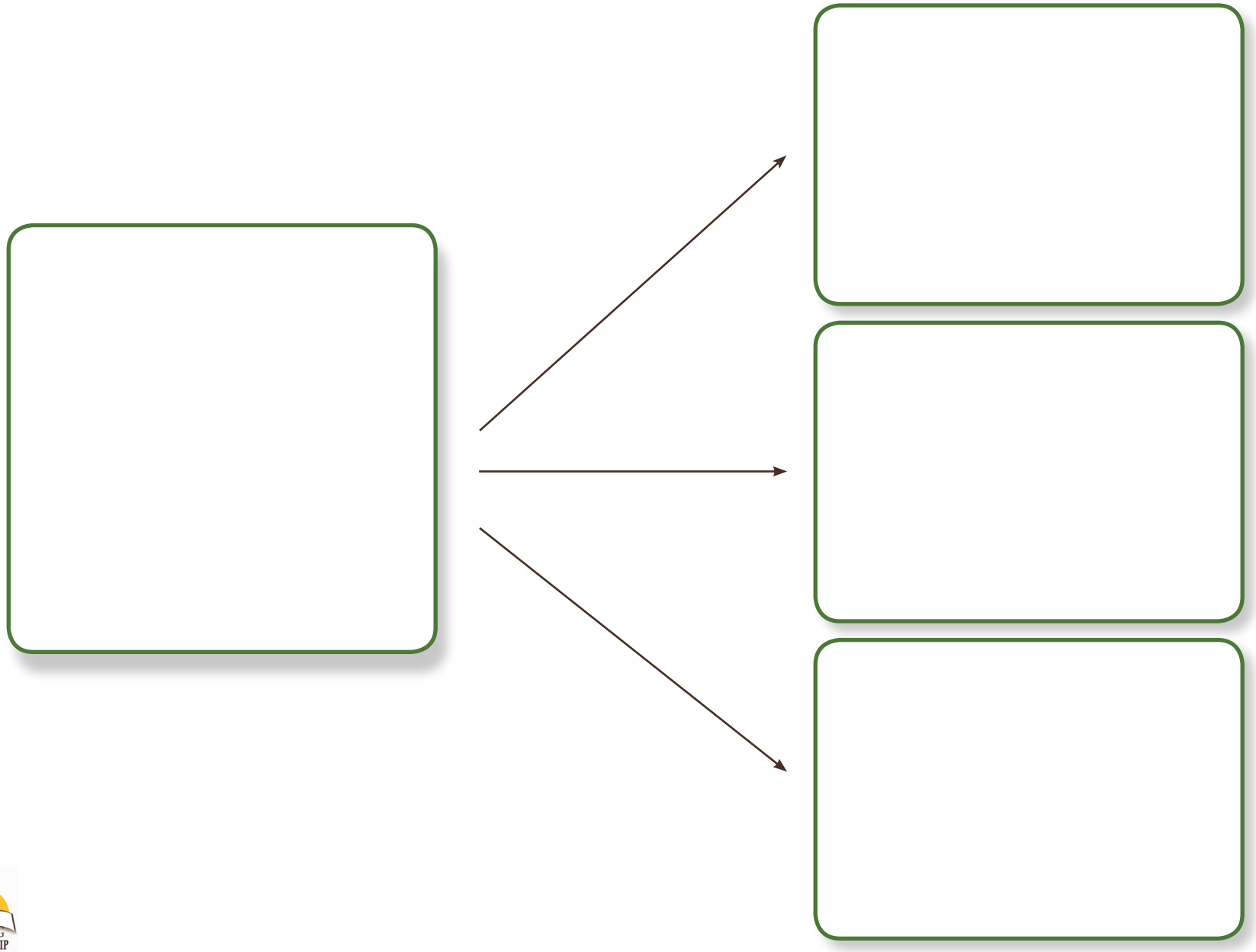
Credits/Sources:

1. U.S. Energy Information Administration - EIA. (2015). *Rankings Coal Production, 2015.* Retrieved July 9, 2017, from https://www.eia.gov/state/rankings/#/series/48
2. U.S. Energy Information Administration - EIA. (2018, June 8). *FAQs: How much of U.S. carbon dioxide emissions are associated with electricity generation?* Retrieved October 6, 2018, from https://www.eia.gov/tools/faqs/faq.php?id=77&t=11
3. Wyoming Mining Association. (n.d.). *Coal.* Retrieved June 26, 2017, from https://www.wyomingmining.org/minerals/coal/
4. The NEED Project. (2019-2020). *Elementary Energy InfoBook: Coal* (Publication). Retrieved October 14, 2020, from https://www.need.org/wp-content/uploads/2019/10/Elementary-Energy-Infobook.pdf

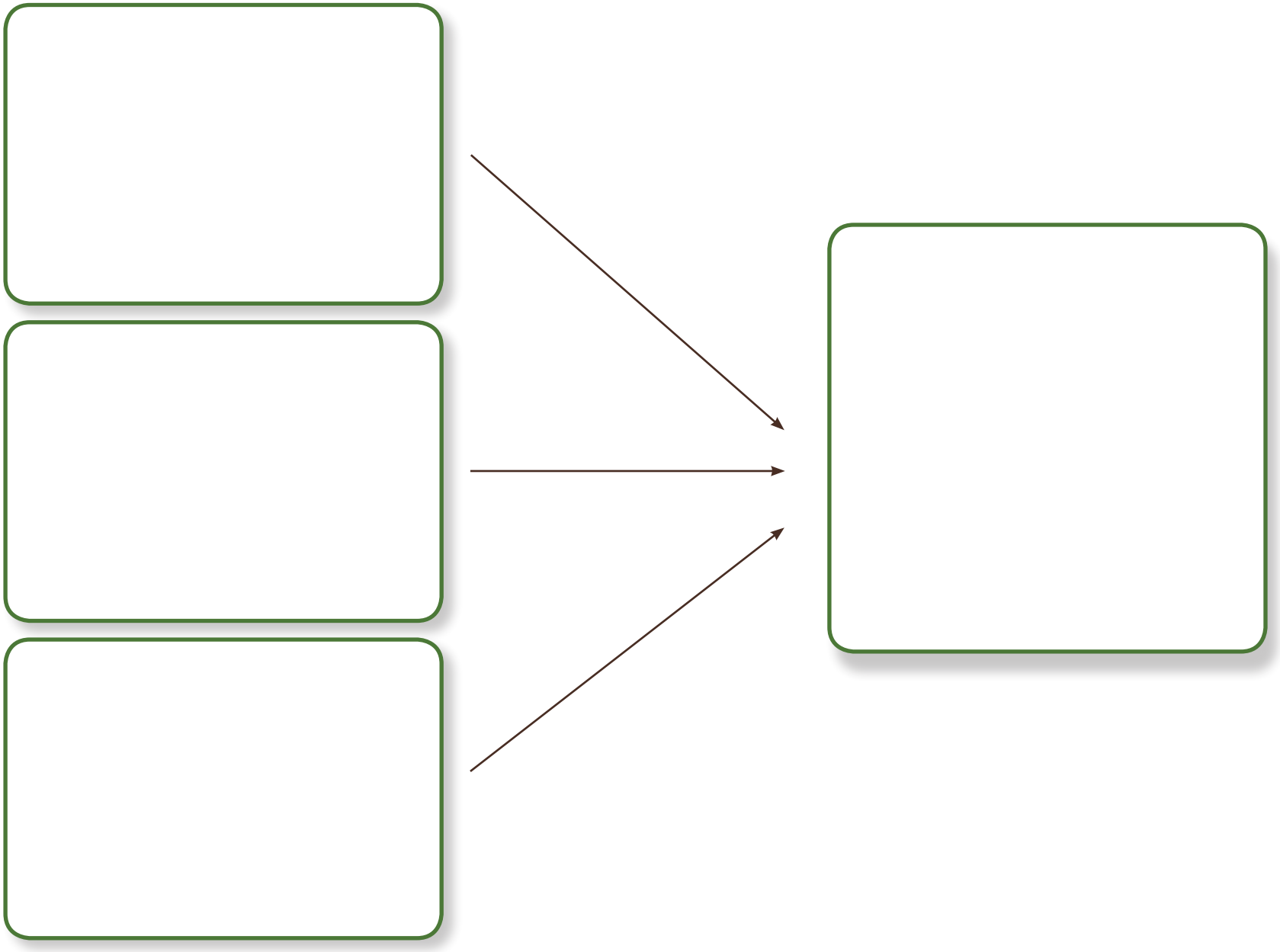
Cause and Effect Relationships



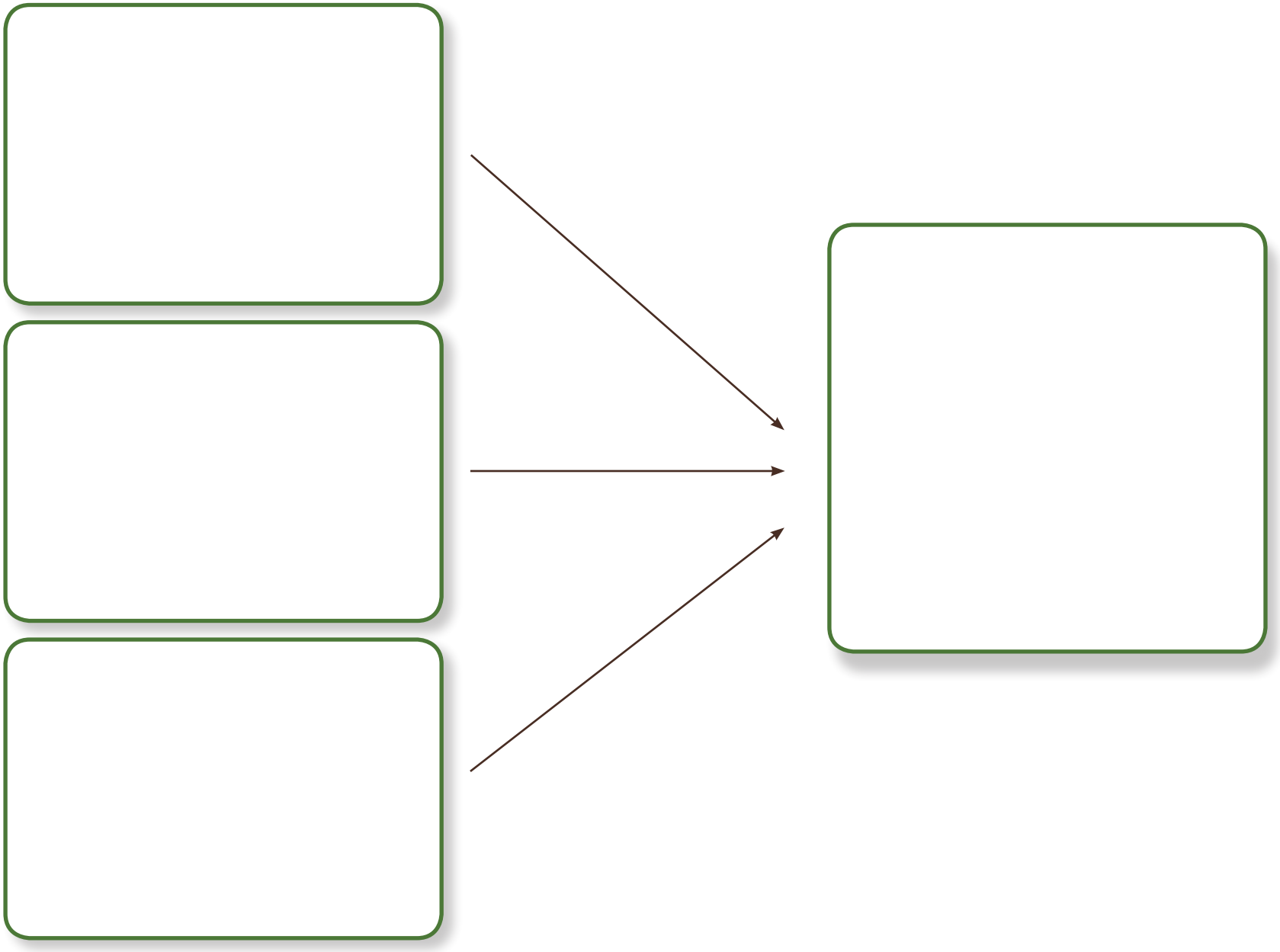
Cause and Effect Relationships



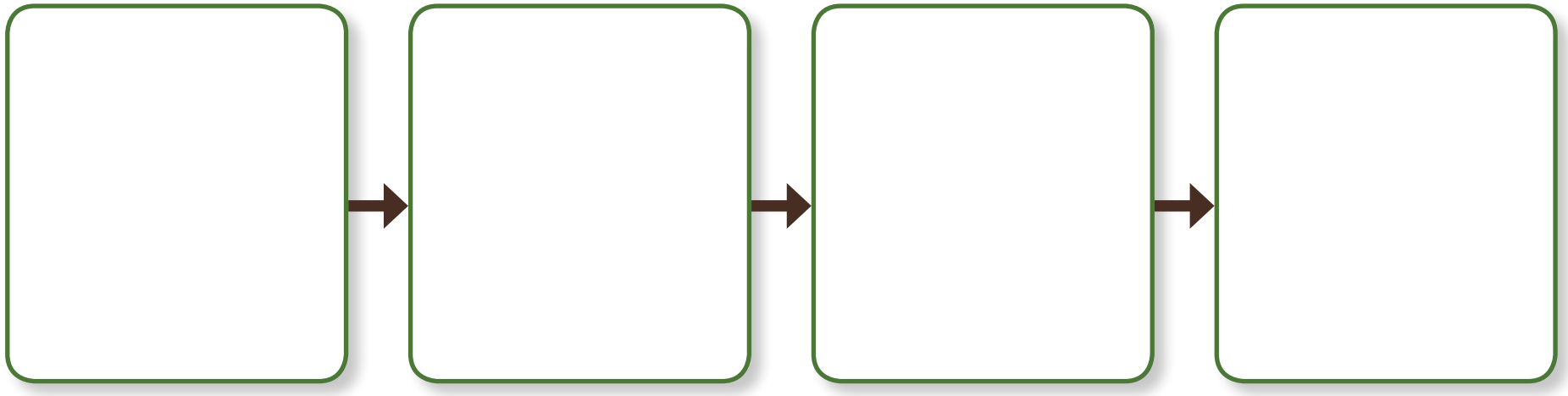
Cause and Effect Relationships



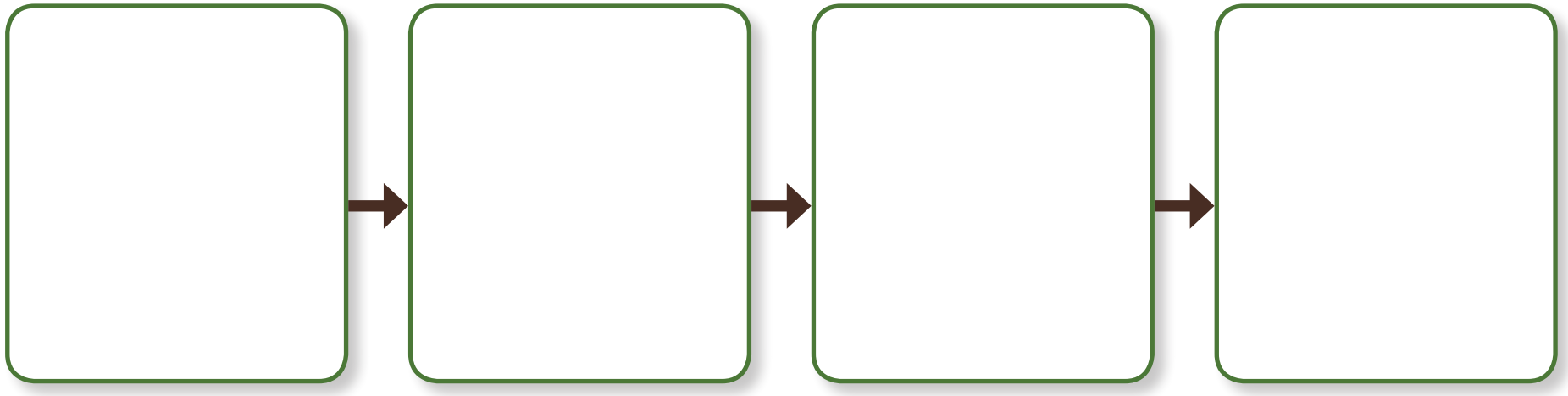
Cause and Effect Relationships



Cause and Effect Relationships



Cause and Effect Relationships



Energy Cause & Effect Relationships

Predicting Effects

Name: _____

Choose one of the graphic organizers that you completed showing cause and effect relationships. Imagine that one of the parts of the system changed. Write about your predictions for how that would change other aspects of the system.

What change I am considering: _____

_____

_____

My predictions for how that would affect the other parts of the system: _____

_____

_____

_____

_____

_____

_____

_____

Please staple your graphic organizer to this page.

Lesson Nine: Good to the Last Drop

Grade Level: 4th Grade

Time: Two 60-minute class periods

Essential Question: How can we be stewards of Wyoming's minerals and energy to benefit current and future generations?

Objective: Students will complete the engineering design process (refining a model for extracting oil from a rock formation) to understand the potential for technology to improve our ability to steward Wyoming's resources.

Purpose: Students learn that scientists and engineers go through a design process to improve upon existing technology or create new innovative solutions to problems that can improve our ability to steward Wyoming's resources.

Required Materials/Resources:

- Video: https://www.youtube.com/watch?v=kxBqKY36h7M *The Phases of Oil Recovery – So Far* (Source 4) Video Length: 2 minutes 40 seconds
- Video: https://www.youtube.com/watch?v=fiWsM8TPzI0 *The Environmental Partnership: Who We Are* (Source 1) *Video Length: 2 minutes 12 seconds*
- Oil Production text (one per student) (Sources 2, 3)
- Oil Recovery Design Challenge student worksheet (one per student)
- Supplies for Oil Recovery Model
    - Instruction sheet or video: https://youtu.be/V337sOZLt_4 *How to: Build an Oil Recovery Model* (Source 5) Video Length: 2 minutes 28 seconds

TEACHER NOTE: Instructions have been included to build your own oil reservoirs. If you would like to have one provided, please contact Wyoming Agriculture in the Classroom, and we will provide pre-built oil reservoir models for your classroom.

- Small disposable plastic containers (1-2 cup) with tight-fitting lid
- Plastic water bottles for injection reservoir and oil collection (one for the "extracted" oil, and one for water. Additional bottles may be needed for alternate design methods)
- Rocks or gravel (gravel that has been sifted or had the sand removed would work best)
- Vegetable Oil
- ¼ inch plastic tubing (two 30 cm pieces)
- Material to make a watertight seal (ex: Goop, silicone caulk, hot glue)
- Food coloring for the inlet water *optional
- Bucket or container for disposal of liquids
- Seal-able container for disposal of oil
- Metric measuring cup or graduated cylinder for liquids
- Water
- Additional materials and liquids of your choice use for design challenge (See steps 7-10)

TEACHER NOTE: The purpose of the lesson is for students to use the design process to improve an existing technology. Because of that and a desire to not have students spending their time trying to create a functional model, the teacher is providing them with a basic design structure from which to start.

Suggested Teacher Preparation:

- Preview video resources
- Before the lesson, make an oil recovery model following the attached instruction sheet or by watching: https://youtu.be/V337sOZLt_4
- Review the Oil Recovery Design Challenge Student worksheets in order to model/explain them for your students.
- Think about which supplies you can have available for your students to use in their design challenge.
- Gather appropriate supplies.

Standards:

Science: 4-PS3-4, 3-5-ETS1-1,3-5-ETS1-3 (Explicit)
3-5-ETS1-2 (Practiced/Encountered)

Social Studies: SS5.1.1, SS5.3.3,
SS5.4.2 (Practiced/Encountered)

CVE: CV5.3.1, CV5.3.2 (Explicit)
CV5.2.3 (Practiced/Encountered)

Vocabulary:

- **Constraint** - a limitation or restriction
- **Engineer** - a person who designs, builds, or maintains engines, machines, or public works
- **Extraction -** the action of taking out something, especially using effort or force
- **Oil field -** an area of land or seabed underlain by strata yielding petroleum, especially in amounts that justify commercial exploitation
- **Oil industry** - the global processes of exploration, extraction, refining, transporting (often by oil tankers and pipelines) and marketing of the products
- **Reservoir -** a natural or artificial place where water (or oil) is collected and stored for use
- **Residual oil -** oil found in low concentrations naturally or in oil fields following primary production

Instructional Procedure/Steps:

Part One:

1. Say**: "In past lessons, we talked about being a good steward of Wyoming mineral and energy resources. We have also learned about oil, an energy used throughout the world, and how it is found, extracted, transported, and refined within the state of Wyoming. Imagine what it means to Wyoming for the oil industry to be a good steward. Today, we are going to learn more about how the oil industry extracts this valuable resource from the ground, and one way they are good stewards, by using multiple techniques to recover as much oil as possible from a well."**

2. Play the video: *The Phases of Oil Recovery – So Far*. (Source 4)

3. Discuss with students how oil companies have used the engineering process. Why might it be a good idea for companies to try and continue using an older well instead of just digging new ones?
    - Possible answers could include: maximizing the production of the well, minimizing the number of wells needed as each well has an impact on the surface, more cost efficient.

TEACHER NOTE: Students may not independently come up with the idea of using CO_2. If they do not, the teacher might prompt their thinking by asking them to think back to the video about extraction and the tertiary method that was described.

Students may also need scaffolding to help think about how they might be able to put CO_2 into the system. The teacher can draw on their background knowledge of carbonated beverages. Some students may also be familiar with the bubbles produced from reactions such as effervescent tablets dissolving or Mentos and soda.

4. Pass out and read the Oil Production text. Say: **"Remember every energy resource has its benefits and its challenges. Discuss with a partner the challenges that the oil industry faces."** Have students identify the challenges with a partner. After a few minutes, have students share out. Say: **"When we get to the planning process, we will factor in these challenges to improve your oil extraction design."**

5. Show students the oil recovery model you created before the lesson. Fill the reservoir with just enough oil to cover the rocks. (Mark on the outside of the container the level of the oil so that it can be "reset" for future experiments.) Explain how this represents the oil trapped in a rock formation in the ground. Remind students that the layers of rock and soil covering the oil reservoir places the oil under pressure. To simulate the pressure oil is under in real life, our oil recovery model must be a sealed system to keep the oil under pressure. Discuss with students how the scaled model relates to a full-scale oil field.

6. Ask students to recall what they learned in the video about oil extraction. Tell them that this represents a well that has already gone through pumping/primary recovery. Say: "**There is still oil in the rock formation. What might be the next method of extraction?"** Students should bring up the secondary recovery method of water flooding. Demonstrate for the class the water flooding process. Pass out the Oil Recovery Design Challenge worksheets and have students complete the first portion with a brief description of the water flooding process. Measure the oil that was extracted, and have students record the amount, along with other observations of the results. (They should be able to note that there is still oil visible in the rock formation.)

   Students should understand that the oil being extracted now is actually "leftover" or residual oil after the primary and secondary extraction processes. The analogy of a spatula and a cake mix might help students understand that the additional residue can be removed using another tool or process.

7. Say: **"Now we are going to be think about some additional oil recovery methods to help us complete an engineering design challenge. The purpose of this engineering challenge will be to recover as much oil as possible from our model, so our success criteria will be that we are able to recover more oil. Like the engineers in the oil industry, we will have a specific goal, but we will also have constraints."** If students are unfamiliar with the word "constraints" go over the definition together. Read the list of constraints and discuss why each one is in place.

8. Give students a few minutes to brainstorm ways that they might use the oil recovery model to extract more oil from the well. After they have had some time to work say: **"Let's see what kinds of ideas you generated."** As students share out ideas, record them on a document camera, chart paper, or smart board so they are visible to everyone. Student responses might include trying a different liquid, a larger amount of water, soapy water, carbonated water or soda, hot water, etc.

9. Say: "**Once engineers have generated some ideas, their next step is to compare multiple possible solutions and think about how well each is likely to meet the criteria and constraints of the problem. Let's look at our list. Are there any ideas that don't meet the constraints of the problem?**" Guide students in eliminating from the list any ideas that would require a whole new "well" to be built, that would require materials that are cost/time prohibitive or that you as the teacher are not able to acquire before part 2 of this lesson. Say: "**Now let's think about which possible solutions might be most likely to meet our success criteria, which is extracting as much of the oil as possible.**"

10. As a class, select 2 "enhanced methods" to try. Tell students that they will be running experiments with these methods in part 2.

TEACHER NOTE: Depending on which ideas students generate and select to test, the "control" method of water flooding may still need to be done. Some extraction process ideas might be done in place of the initial water flooding method (ex: flooding with hot water), and some might be done after the water flooding (ex: CO_2).

Part Two:
Be sure to gather any additional materials necessary based upon student ideas selected at the end of part 1. You will also need to "reset" the oil recovery model. As much as possible, reuse the same oil and water from the original setup. Since students will not each have their own systems to test, the teacher can encourage engagement by having a different student help with each part of the processes (measuring liquids, holding the bottles, etc.).

1. Say: **"Yesterday, we tested our oil recovery models. We noticed that there was still oil left to be extracted, so we came up with some additional ideas. We decided that today we would test** _____ (name ideas selected in part 1). **"**

2. Decide which method will be tested first, and have students record that on their Oil Recovery Design Challenge worksheets. Say "**In order for us to determine whether or not the ideas we are testing today are really more effective, we need to make sure that the only thing that is changing is the specific method of oil recovery that we are testing. Everything else should be the same. Yesterday I marked the oil level, and I've 'reset' the well to have the same starting amount. Can you think of anything else that needs to stay the same?**" The aspect of the system students are changing for this experiment will change, but all other variables should stay the same, including the rocks used, size of containers, tubing (length and type), amount of liquid used, etc.

3. Conduct a trial with the oil recovery method. Students should record a brief description, results, and other observations on their Oil Recovery Design Challenge worksheets. After completing the trial, discuss whether or not the method was effective. Be sure that students are drawing upon evidence when determining whether or not the model was successful.

In this task, students will be engaged in the higher order thinking skill of application by designing, testing, and experimenting through the use of problem-solving techniques.

TEACHER NOTE: If students pick a method that would "contaminate" the model (ex- soapy water), that should be the last method tested, as it would be very difficult to reset the model after using a contaminant. That may be a discussion opportunity about the precautions taken when putting chemicals into the ground.

4. Repeat the process to conduct a trial with an additional oil recovery method. Again, point out that the well will need to be" reset" so that it is a fair test. Students should again record a brief description, results, and other observations on their worksheets. After completing the trial, use the results to discuss whether or not the method was effective.

5. If using CO_2 was not one of the methods selected by the class, at this point the teacher should decide if that model should be done as an additional trial. It is an engaging demonstration, and it is a process that resembles actual enhanced oil recovery methods. Some teachers may opt not to do it, as it is developmentally more complex, and students may not have schema for CO_2, pressurized systems, etc. Additionally, the focus of the lesson is not on that method per say, but on the engineering design process and the idea that engineers have used the process to help the oil industry be better stewards by enhancing their oil recovery methods. Students can meet that goal without conducting a trial using CO_2.

6. Students can now compare which of the methods was most successful. As they discuss the different methods, be sure that they are evaluating them based on the success criteria and constraints. If any of the methods didn't work, students can discuss why they think that method might have been unsuccessful, and if there are changes they could make that would improve the method.

7. Discuss the activity. Allow students to respond before moving to the next question. Ask:
   - **"What were our results?"**
   - **"What did you find engaging?"**
   - **"What challenges did we experience?"**
   - **"What were some of our successes?"**
   - **"If you had more time and/or unlimited resources, what might you like to try?"**

TEACHER NOTE: When disposing of the liquids from the lesson, be sure to dispose of the oil properly. It can be poured back into its original bottle or into another sealed container like a milk jug. Make sure it is sealed before disposing of the container.

In this task, students will be engaged in the higher order thinking skill of evaluation.

8. Say: **"Energy and fuels are derived from renewable and nonrenewable resources and their uses affect the environment. Oil industries have a responsibility to be good stewards of our land and natural resources. They play an important role in stewardship decisions affecting Wyoming's land. The awareness of being good stewards is evident. Let's watch this quick video about The Environmental Partnership."** https://www.youtube.com/watch?v=fiWsM8TPzI0

9. Say: "**As you saw in the video, the U.S. Natural Gas and Oil Industries look for ways to improve production processes just like you did in the oil extraction activity**." Discuss how scientists/industry experts might have different/additional approaches when trying to improve our use and production of energy. Possible discussion points are:
    - *innovating existing devices*
    - *developing new ideas for how to use energy sources*
    - *developing ways to minimize the negative impacts of some energy resources*
    - *finding new sources of energy, etc.*

10. Say: "**After completing the experiments and watching the video, what are some ways the oil and gas industries are being good stewards?"** Students may recognize the older wells are being enhanced rather than abandoned (the life of the older wells is extended), the drilling sites and paths of pipelines have been reclaimed putting the landscape back to its previous state, safety procedures are in place to protect the environment, and preventative measures are taken with the pipelines, storage tanks and refineries to protect areas from damage.

11. Say **"Remember, you are our future, and just like scientists in the oil field, you are empowered to solve problems, and create positive change in our world!"**

Assessment: Use the completed student worksheets and discussions at the end of part 2 of the lesson to assess student understanding that scientists use the engineering process to improve upon existing designs or create new solutions to existing problems.

Credits/Sources:

1. The American Petroleum Institute. (2019, March 26). *The Environmental Partnership: Who We Are*. Retrieved June 11, 2020 from https://www.youtube.com/watch?v=fiWsM8TPzI0
2. U.S. Department of Energy (2013, April) Fossil Energy Study Guide: Oil. Retrieved June 6, 2019 from https://www.energy.gov/sites/prod/files/2013/04/f0/HS_Oil_Studyguide_draft2.pdf
3. U.S. Department of Energy (n.d.) *Enhanced Oil Recovery.* Retrieved June 6, 2019 from https://www.energy.gov/fe/science-innovation/oil-gas-research/enhanced-oil-recovery
4. Energy & Environmental Research Center. (2014, April 3). *The Phases of Oil Recovery – So Far*. Retrieved June 4, 2019 from https://www.youtube.com/watch?v=kxBqKY36h7M
5. Wyoming Agriculture in the Classroom. (2019, June 6). *How to: Build an Oil Recovery Model*. Retrieved June 6, 2019 from https://youtu.be/V337sOZLt_4

Oil Production

Oil is used for:

If you have ridden in a car today, you have used several oil based products. Gasoline, the fuel for most of our cars and trucks, is made from oil, and so are the tires. In addition to gasoline, oil and other hydrocarbons are used to make about 75% of the products we use each day. Just a few of these products include: heating oil, diesel fuel, jet fuel, propane, synthetic rubber, and plastics. It is also used to make many common household products, including crayons, dish washing liquids, deodorant, and eyeglasses.

What is an oil reservoir?:

If you could look down an oil well you wouldn't see a big underground lake. Oil doesn't exist in deep, black pools. In fact, an underground oil formation - an "oil reservoir" - looks very much like any other rock formation. Oil exists in this underground formation as tiny droplets trapped inside the open spaces inside rocks. The droplets cling to the rock, like drops of water cling to a window pane.

The first step to drilling for oil is knowing where to drill. Because it is expensive to drill an oil well, oil producers need to know a lot about an oil reservoir before they start drilling. Scientists learn as much as they can about an oil reservoir before they every drill a well.

Oil recovery can be done in multiple steps:

Crude oil development and production in U.S. oil reservoirs can include up to three distinct phases: primary, secondary, and enhanced recovery.

Primary recovery:

The natural pressure created by the rock layers over an oil reservoir drives oil into the well. Inside the well, pumps bring the oil to the surface where it can be collected and used. Only about 10 percent of a reservoir's original oil is typically produced during primary recovery.

Secondary recovery:

Secondary recovery techniques extend a field's productive life. Secondary recovery is typically done by injecting water or gas to push oil away from the rock holding it and driving it to an oil well. This results in the recovery of 20 to 40 percent of the original oil.

Enhanced Recovery:

Three major categories of enhanced recovery have been found to be commercially successful depending on characteristics of an oil reservoir:

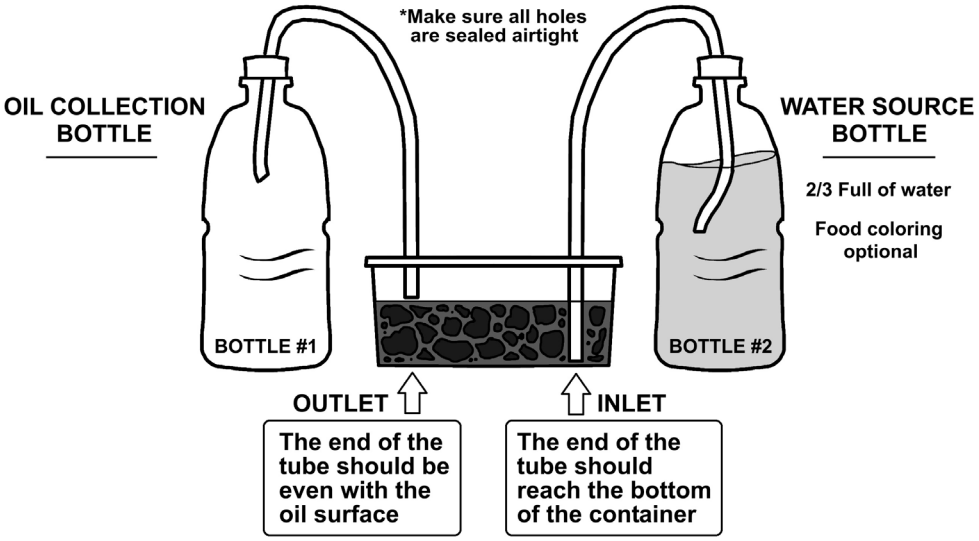
Thermal recovery adds heat in the form of steam to an oil well. This helps the oil flow through the rock formation more easily.
Gas injection uses gases such as natural gas, nitrogen, or carbon dioxide (CO_2) to push additional oil to an oil well.
Chemical injection is used the least often, and uses special chemicals to help oil move more easily to an oil well.

Oil Recovery Instruction Sheet

Required materials:

1. (1) Small disposable plastic container (1-2 cup) with tight-fitting lid
2. (2) Plastic water bottles for injection reservoir and oil collection (one for the "extracted" oil, and one for water. Additional bottles may be needed for alternate design methods.)
3. Rocks or gravel
4. Vegetable Oil
5. ¼ inch plastic tubing (two 30 cm pieces)
6. Material to make a watertight seal (ex: Goop, silicone caulk, hot glue)
7. Food coloring for the inlet water *optional
8. Bucket or container for disposal of liquids
9. Seal-able container for disposal of oil
10. Metric measuring cup or graduated cylinder for liquids
11. Water
12. Additional materials and liquids of your choice use for design challenge

Building the Model:

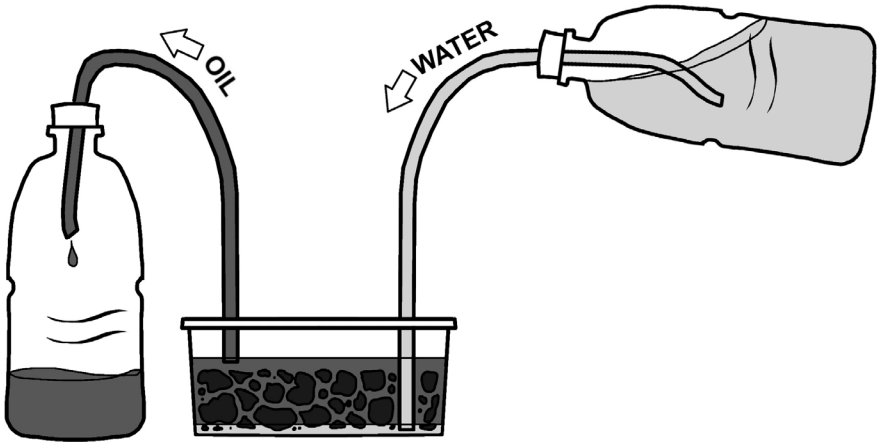


1. Make two holes in the plastic container lid, spacing them equally apart. They should be the same size as your tubing.
2. Slide one piece of tubing into each hole. Make sure that the first tube (outlet)protrudes at least 1-2 cm from the bottom of the lid. The second tube (inlet) should protrude about 4-5 cm in order to reach the bottom of the oil reservoir.
3. Seal the tubing hole with a type of watertight sealant.
4. Make a hole in the cap of each plastic water bottle. Slide the tubing so 5 cm extends below the lid. Make a watertight seal between the tubing and the lid. Repeat with the second lid.

Oil Recovery Instruction Sheet

5. Fill the plastic container $^{2}/_{3}$ full of rock or gravel to represent bedrock. Place the inlet tubing so it reaches the bottom of the container (manipulate the rocks and tubing accordingly).
6. Pour vegetable oil into the reservoir, enough to cover the rocks in the container.
7. When placing the sealed lid onto the container, the outlet (1-2 cm) tubing should rest at the surface of the oil. (trim it accordingly). Fit the lid onto the first water bottle to serve as the oil collection vessel. This will hold the oil as it is removed from the rocks in the oil reservoir.

Demonstrating Water Flooding



1. Fill the second bottle $^{2}/_{3}$ full of water. You might want to add food coloring to help observe water as it moves through the process to differentiate the water and oil.
2. Place the cap on the water bottle (inlet) tightening the lid.
3. Manipulate the water bottle so the water flows into the oil reservoir. This should cause the oil to flow out of the reservoir into the oil collection bottle.

Oil Recovery Design Challenge

Name:_____

Initial method: Water flooding

Procedure:

Results: _____ mL of oil were extracted.

Other Observations:

Success Criteria:

- We are able to extract more oil

Constraints:

- We can't build a whole new system (the well is already established).
- We can only use materials that we have access to.

Brainstorm modifications that we might make to the oil extraction process in order to increase the amount of oil that we can extract.

Oil Recovery Design Challenge

Method #2:

Procedure:

Results: _____ mL of oil were extracted.

Other Observations:

Method #3:

Procedure:

Results: _____ mL of oil were extracted.

Other Observations:

Lesson Ten: I Pledge to be a Steward

Grade Level: 4th Grade

Time: 45-60 minutes

Essential Question: How can we be stewards of Wyoming's minerals and energy to benefit current and future generations?

Objective: Students will:

- Complete a pledge to be stewards for Wyoming's mineral and energy resources.
- Write a persuasive writing piece/public service announcement using provided criteria.

Purpose: Students learn different ways they can serve as stewards of Wyoming's minerals and energy.

Required Materials/Resources:

- A piece of poster paper for each of the following terms:
    - preservation/conservation
    - advocacy
    - education
    - innovation
- Speed Gallery Walk Take-Away worksheet (one per student)
- Graphic Organizer for Writing worksheet (one per student) (Source 3)
- Stewardship Pledge Scroll (one per student)
- Energy Pro & Con sheets from Lesson 7

- Cause and Effect Relationships graphic organizers from Lesson 8
- Sticky notes
- Timer
- Video: http://www.theteachertoolkit.com/index.php/tool/whip-around *Whip Around* (Source 2) *Video length: 2 minutes*

Suggested Teacher Preparation:

- Prepare posters for gallery walk. Write each of the following terms on its own piece of poster paper: preservation/conservation, advocacy, education, and innovation. Once made, post around the room.
- Read steps/watch video for Whip Around strategy if you are not familiar with it.

TEACHER NOTE: If you are unfamiliar with a gallery walk, learn about it at https://www.facinghistory.org/resource-library/teaching-strategies/gallery-walk. (Source 1)

Standards:

Social Studies: SS5.1.1 (Practiced/Encountered)

ELA: 4.W.4 (Explicit), 4.L.6, 4.W.1.a, 4.W.1.b, 4.W.1.d (Practiced/Encountered)

Vocabulary:

- **Advocacy -** the act or process of supporting a cause or proposal
- **Conservation -** the careful utilization of a resource in order to prevent waste and leave some for future generations
- **Innovation -** a new method, idea, product
- **Preservation -** the act of maintaining or protecting

Instructional Procedure/Steps:

1. Remind students of the definition of stewardship and the guiding question for this unit. Say: **"As Wyoming citizens, we are stewards entrusted with the responsible development, care, and use of our resources to benefit current and future generations. Because of this, we ask ourselves, how can we be stewards of Wyoming's mineral and energy resources?"**

2. Draw students' attention to the posters hanging around the room. Provide students definitions or brief explanations for the vocabulary words. Say: **"There are many different ways to engage in stewardship. We are going to discuss those today."**

3. Pass back students Energy Pro & Con sheets and Cause and Effect Relationships graphic organizers from previous lessons. Say: **"Please reread the facts from your sheets. Pay special attention to the facts you felt were cons for each resource. Also, think about other issues associated with each resource. These are some of the areas where we might direct our stewardship efforts."**

4. Give each student a set of sticky notes. Say: **"Now, think about how we can practice stewardship of Wyoming's mineral and energy resources. You will write a stewardship idea on each of your sticky notes. When time is up, place each of your sticky notes on the poster it applies to: conservation, advocacy, education, and innovation. For example, if you want to teach a younger sibling about renewable energies, you would place that on the education poster. An idea could be something that you personally could do, like teaching your sibling, or an idea could be something that would take efforts from a bigger group/community, like passing a law to help increase safety standards. Record one idea per sticky note. Are there any questions?"** Take questions at this time about the activity not ideas for the sticky notes. Give students enough time, so they are working productively and that every student has created at least one sticky note. When you feel it is time to move on, have students place their sticky notes on the appropriate posters.

TEACHER NOTE: Students may not generate ideas for all categories. The teacher can prepare some Post-it notes with ideas for each category. The class could also work together to add ideas to any posters that are empty prior to the gallery walk.

5. Now, have students complete a speed gallery walk. Pass out the Speed Gallery Walk Take-Away worksheets. Say: **"You will have three minutes to study each poster. Read all of the sticky notes on the poster. After reading, choose an idea to record in each section of**

your worksheet. Questions?" Place students at each poster, so there are not too many students at a poster. Start the timer for the first three-minute period. When time is up, have students rotate to the next poster and repeat the process. Continue rotating until all students have spent time with every poster.

6. Next, students will create a persuasive writing piece/public service announcement explaining how to be stewards of Wyoming's mineral and energy resources. Pass out the Graphic Organizer for Writing worksheets. The topic sentence has been provided, but students will create their key ideas, supporting details, and conclusion. Give students a few minutes to use the ideas from their gallery walk notes to complete their graphic organizers. Once students have their ideas mapped out, have students create their writing pieces.

7. After students have finished their stewardship writing pieces, pass out the Stewardship Pledge Scrolls. Have students complete the pledge with one thing that they will commit to doing to be a steward of Wyoming's mineral and energy resources. Once all Pledge Scrolls are completed, have students make a circle. Have students share their pledge using the Whip Around strategy. Display Pledge Scrolls, so they are visible during the Mineral and Energy Fair that will occur during the final assessment.

In this task, students will be engaged in the higher order thinking skills of evaluation by making a claim about stewardship and defending their thinking with supporting ideas.

TEACHER NOTE: Students need to create clear and coherent writing in order to demonstrate their understanding of stewardship. However, students should not be completing the full writing process. That is not the focus of the lesson.

Assessment: Evaluate students' writing pieces based on their understanding of stewardship and using writing rubrics specific to your school or district.

Possible extension activity: Have someone from the energy industry or local conservation district come in to talk about ongoing efforts/projects in your local area. If possible, have students participate in a stewardship project.

Credits/Sources:

1. Facing History And Ourselves. (2018). *Teaching Strategy:*

Gallery Walk. Retrieved October 7, 2018 from https://www.facinghistory.org/resource-library/teaching-strategies/gallery-walk

2. The Teacher Toolkit. (n.d.). *Whip Around.* Retrieved July 6, 2017, from http://www.theteachertoolkit.com/index.php/tool/whip-around
3. EnchantedLearning.com. (1996 – 2018). *Generate Your Own Worksheets.* Retrieved October 7, 2018 from, https://enchantedlearning.com/generatepages/

Speed Gallery Walk Take Aways

Type of Stewardship	Something I Could Do	Something the Community Could Do
Conservation		
Advocacy		
Education		
Innovation		

Graphic Organizer for Writing

TITLE: _____

Topic

We can be stewards of Wyoming's mineral and energy resources.

Supporting Reason 1

Proof-Evidence (facts/examples)

Supporting Reason 2

Proof-Evidence (facts/examples)

Supporting Reason 3

Proof-Evidence (facts/examples)

Conclusion

Stewardship Scroll

I pledge to be a steward of Wyoming's mineral and energy resources by...

_____

_____

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_____

Signed by:_____

Date:_____

Lesson 11: Wyoming Mineral & Energy Fair

Grade Level: 4th Grade

Time: Teacher should provide enough work sessions so students can complete their projects. A final session needs to be set aside for the fair itself.

Essential Question: How can we be stewards of Wyoming's minerals and energy to benefit current and future generations?

Objective: Students will create and present a project about Wyoming's mineral and energy resources describing how they are developed, used and cared for, pros and cons of each, and how we can be stewards of them.

Purpose: Students demonstrate their knowledge about being a steward of Wyoming's mineral and energy resources by sharing their learning with a larger community.

Required Materials/Resources:

- Wyoming Mineral & Energy Fair Success Criteria sheet (one per student)
- Project Checklist (one per student)
- Peer/Self Evaluation (one per student)
- Supplies for project method teacher decides his/her class should do
- Anchor charts, worksheets, graphic organizers, resources from all previous lessons in the unit
- Invitations, if class is inviting parents, community members, other classes, administrators, etc. to visit their fair

Suggested Teacher Preparation:

- Decide on time and location space for your Mineral and Energy Fair where students will present their projects.
- Decide what method of project your students will present: poster, PowerPoint, Prezi, etc.
- Gather all appropriate materials necessary for creating projects.
- Decide on time you are allowing for creating projects, feedback/revision, and the fair itself.
- Post anchor charts and provide worksheets, graphic organizers, etc. from all previous lessons.
- Assign students to six small groups. Assign each small group one of the following Wyoming resources: Coal, Oil, Natural Gas, Wind, Hydropower, and Uranium.
- Assign group roles if teacher feels students need them to work productively and use time efficiently. Group roles are per teacher discretion depending on project method assigned.

Standards:

Science: 4-ESS3-1 (Practiced/Encountered)

Social Studies: SS5.1.1, SS5.6.1 (Practiced/Encountered)

ELA: 4.SL.4 (Practiced/Encountered)

CVE: CV5.2.2 (Practiced/Encountered)

In this task, students will be engaged in the higher order thinking skill of synthesis by combining the unit's concepts and ideas into a culminating project.

Vocabulary: No new vocabulary is introduced in this lesson.

Instructional Procedure/Steps:

1. Say: **"In our last lesson, you will start creating a final project about one of Wyoming's mineral and energy resources: Coal, Oil, Natural Gas, Wind, Hydropower, and Uranium. You will also present your projects at a Wyoming Mineral and Energy Fair."** If other individuals/groups from outside of the classroom will attend the fair, share that information with students at this time.

2. Divide students into six groups. Assign each group their Wyoming mineral and energy resource and explain specific project details pertaining to the project method that the teacher has decided upon. Pass out Wyoming Mineral & Energy Fair Success Criteria sheets and Project Checklists. Say: **"After groups have been working on their projects and feel it is complete, your group will present your project to me. I will give you feedback on areas your group needs to improve in your project and note which areas your project has exceeded my expectations."** Review both the sheet and checklist with students and answer any questions students might have about them. Share any additional grading criteria you might have. Tell students how many days/how much time you have decided that groups will have to complete their projects. Be sure to specify how much time is before your feedback session and how much time groups will have for project revisions after the feedback session.

3. Display/pass out previous lessons' resources that students may refer to if needed. Allow groups to begin working.

4. After work sessions are completed, have groups present projects to you, and provide feedback about their projects. Allow time for groups to revise their projects. Below are some examples of possible feedback/notes you might give to groups:
    - *A way to improve the **Knowledge of the Resource** section: "Your project does not state if your resource is renewable or nonrenewable. Please add that."*
    - *Exceeds comment for the **Pros and Cons** section: "Your project clearly and specifically describes three pros and three cons for this resource."*
    - *Try and not include "judgment" statements in your comments such as "I liked that your project …" or "I do not like how your project …"*

5. After all projects have been revised, have students present their completed projects at the Wyoming Mineral and Energy Fair.

Assessment: Grade projects according to provided Success Criteria and other criteria decided upon at the start of the unit. Have students complete the Peer/Self Evaluation either before or after presenting at the fair, per teacher discretion.

Credits/Sources: Not applicable

Wyoming Mineral & Energy Fair

Success Criteria

Group Topic: _____

Group Members' Names: _____

	Specific comments that offer ways to improve project in each area	Success Criteria	Specific comments on how the project exceeds expectations	Final Scoring of Success Criteria. (Circle choice that applies.)
Stewardship		Students include a call to action. They provide specific examples of what people can do to help be stewards of this resource.		Project met this criteria: Yes No Partially
Knowledge of the Resource		Students provide information telling about what the resource is; whether it is renewable or nonrenewable; and how it is developed, used, and cared for.		Project met this criteria: Yes No Partially
Pros and Cons		Students describe pros and cons associated with the resource.		Project met this criteria: Yes No Partially

Wyoming Mineral & Energy Fair

Success Criteria

Role in Wyoming's Culture & Economy		Students describe how the resource affects Wyoming's culture and economy, and why it is important to our state.		Project met this criteria: Yes No Partially
Speaking and Listening		Students use appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly and at an understandable pace.		Project met this criteria: Yes No Partially
				Project met this criteria: Yes No Partially

Wyoming Mineral & Energy Fair

Project Checklist

As you are working on your project, make sure it answers the following questions:

- ☐ Is the resource renewable or nonrenewable?
- ☐ How is the resource developed, used, and cared for?
- ☐ Who is involved with the development, use, and care of this resource?
- ☐ How is the resource used?
- ☐ What are pros and cons of this resource?
- ☐ How does the resource relate to Wyoming's culture and economy?
- ☐ What are ways we can be stewards of this resource to benefit current and future generations?

Wyoming Mineral & Energy Fair

Peer/Self Evaluation

My Name: _____

My Group Members' Names: _____

Self Evaluation	Peer Evaluation
I would rank my effort on this project 1 2 3 4 No effort Exceeds	I would rank my group members' effort on this project 1 2 3 4 No effort Exceeds
The parts of this project that I was responsible for were:	The parts of this project that other group members were responsible for were:
If I could change anything about my project, I would...	Other Notes:

Glossary

Advocacy	the act or process of supporting a cause or proposal
Benefit	an advantage or profit gained from something
Bentonite	a kind of absorbent clay formed by the breakdown of volcanic ash
Coal	A black/dark brown rock made from old plant matter found mainly underground; mined and used as fuel
Con	the unfavorable factors or reasons; disadvantages
Conservation	the careful utilization of a resource in order to prevent waste and leave some for future generations
Constraint	a limitation or reservation
Crude oil	unrefined petroleum
Culture	a way of thinking, behaving, or working that exists in a place or organization
Economy	financial system of interaction and exchange
Energy	power derived from the utilization of natural resources, especially to provide light and heat or to power machines, useable power
Engineer	a person who designs, builds, or maintains engines, machines, or public works
Entrust	to give somebody the responsibility of doing something or of caring for someone or something
Extraction	the action of taking out something, especially using effort or force

Generation	a group of individuals, most of whom are the same approximate age
Hydropower	electricity produced from machines that are run by moving water
Impact	have a strong effect on someone or something
Industry	a group of businesses that provides a particular product or service
Infrastructure	the basic physical and organizational structures and facilities (e.g., buildings, roads, pipelines, and transmission lines) needed for the operation of a society or enterprise
Innovation	a new method, idea, or product
Mineral	a substance (such as quartz, coal, petroleum, salt, etc.) that is naturally formed under the ground
Natural gas	odorless gas that is taken from under the ground and used as fuel and used to make materials
Natural resources	sources of life, materials, or energy that we are able to get naturally from the earth
Nonrenewable resources	resources that cannot be replenished (made again) in a short period of time
Oil field	an area of land or seabed underlain by strata yielding petroleum, especially in amounts that justify commercial exploitation
Oil industry	the global processes of exploration, extraction, refining, transporting (often by oil tankers and pipelines) and marketing the products
Preservation	the act of maintaining or protecting
Pro	the favorable factors or reasons; advantages
Renewable resources	resources that are capable of being replenished
Resource	a place or thing that provides something useful
Reservoir	a natural or artificial place where water (or oil) is collected and stored for use
Residual oil	oil found in low concentrations naturally or in oil fields following primary production
Revenue	money that is made by or paid to a business or an organization
Steward	an individual who manages areas or resources

Stewardship	As Wyoming citizens, we are stewards entrusted with the responsible development, care, and use of our resources to benefit current and future generations.
Trona	a gray mineral that occurs as an evaporate in salt deposits and consists of a hydrated carbonate and bicarbonate of sodium
Uranium	a gray, dense radioactive metal used as a fuel in nuclear reactors