UNIT 6: WYOMING’S OIL & NATURAL GAS

Extraction and reclamation in the Pinedale anticline

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OVERVIEW

In this unit students will re-engage with prior understandings of natural gas and oil including geologic formation, history of oil and gas production, and the importance of oil and gas on a global scale. Students will demonstrate an understanding of the chemical structure of hydrocarbons that are the basis for oil and natural gas compounds. They will complete a distillation lab to demonstrate the process of turning crude oil into usable end products and will discuss the difference in processing methods for oil compared to natural gas. Students will also discuss some of the successes of oil and gas development like the innovation of directional drilling, hydraulic fracturing, and mega-well pads, as well as the surge in the natural gas market in the 2010’s. Students will then turn to some of the challenges faced by the industry, especially the landscape scale implications on wildlife and habitat fragmentation. The culmination of this unit is a case study and class mediation related to the oil and gas development in the Pinedale Anticline Project Area in Sublette County, Wyoming.

ESSENTIAL QUESTIONS

- What is happening with natural gas production in Wyoming?
- How is crude oil and natural gas removed from the ground and made useable?
- Why do people sometimes call petroleum, “black gold?”

ENDURING UNDERSTANDINGS

- Students will understand that not all oil is equal and each grade of oil has a different purpose.
- Students will know the similarities and differences between oil and natural gas extraction.
- Students will identify some landscape scale impacts of natural gas production.
- Students will be familiar with different views on a case study of natural gas production in the Pinedale Anticline Project Area.

DURATION

Seven to eight 45 minute lessons

STANDARDS

Next Generation Science Standards

- **Disciplinary Core Ideas:**
  - Life Science
  - Physical Science
  - Earth & Space Science

- **Crosscutting Concepts**
  - Patterns
  - Cause & effect
  - Stability & change
  - Energy & matter
  - Scale, proportion & quantity
  - Structure & function
  - Nature of Science
  - Connection to technology and engineering applications

- **Science and Engineering Practices**
  - Asking questions & defining problems

DRAFT – August 2015
● Planning & carrying out investigations
● Analyzing & interpreting data
● Using mathematics & computational thinking
● Constructing explanations
● Engaging in arguments from evidence
● Obtaining, evaluating & communicating information

Wyoming Science Standards
● SC11.1
● SC11.1.7
● SC11.1.12
● SC11.1.13
● SC11.1.6
● SC11.2
● SC11.2.2
● SC11.2.3
● SC11.2.5
● SC11.3
● SC11.3.2

Wyoming Social Studies Standards
● SS12.4.2
● SS12.4.3
● SS12.4.4
● SS12.5.3
● SS12.5.4
● SS12.6.1
● SS12.6.2
● SS12.6.3
● SS12.6.4

Common Core Math Standards
● MATH.CONTENT.HSS.IC.B
● MATH.CONTENT.HSF.IF.B.4

Common Core Language Arts Standards
● CCSS.ELA-LITERACY.W.11-12.1
● CCSS.ELA-LITERACY.W.11-12.2
● CCSS.ELA-LITERACY.W.11-12.4
● CCSS.ELA-LITERACY.W.11-12.8
● CCSS.ELA-LITERACY.W.11-12.9
● CCSS.ELA-LITERACY.SL.11-12.1
● CCSS.ELA-LITERACY.SL.11-12.2
● CCSS.ELA-LITERACY.SL.11-12.6
● CCSS.ELA-LITERACY.RST.11-12.3
● CCSS.ELA-LITERACY.RI.11-12.1
● CCSS.ELA-LITERACY.RI.11-12.2
● CCSS.ELA-LITERACY.RI.11-12.7
OBJECTIVES

Science and Energy Literacy
● Students will re-engage the biological and geological processes that form oil and natural gas.
● Students will investigate the properties of crude oil through a distillation lab.
● Students will identify the pathways taken by oil and natural gas after they leave the ground.
● Students will develop skills of the scientific process.

Stewardship, Community, and Place
● Students will explore the economic benefits and environmental challenges of oil and natural gas development in Wyoming.
● Students will identify the parties involved in local oil and natural gas development discussions.

STEM Careers and Leadership Development
● Students will identify professionals and stakeholders in various fields associated with oil and gas development: energy executives, wildlife biologists, local business owners, ranchers, etc.
● Students will understand that Wyoming is a leader in natural gas development.

Applied Problem Solving & 21st Century Skills
● Students will evaluate and make recommendations on distillation techniques for deriving products from crude oil.
● Students will discuss the interconnectedness of the economic, social, and environmental challenges and opportunities within Wyoming’s current oil and gas production situation
● Students will develop argumentation and discussion skills by participating in mediation.
● Students will apply science and engineering practices in a lab.

ASSESSMENT EVIDENCE

Diagnostic:
At the beginning of the unit, students will demonstrate understanding by:
● Assessing their prior knowledge of oil and natural gas development.
● Modeling atoms that are relevant to hydrocarbon generation.
● Completing a fact match activity using information about Wyoming natural gas development.

Formative:
During the unit, students will demonstrate understanding by:
● Modeling hydrocarbon combustion and explaining its relevance.
● Comparing and contrasting the processing of oil and natural gas into useful end products.
● Completing a distillation lab to explore how different types of crude oil are refined.
● Discussing the successes and challenges faced by oil and gas industry in Wyoming.

Summative/Presentations and products:
By the end of the unit, students will demonstrate understanding by:
● Making recommendations for how to improve the distillation process.
● Participating in mediation on development in the Pinedale Anticline Project Area.
DIAGNOSTIC ASSESSMENT: RE-ENGAGING WITH OIL AND GAS

*To be completed at the beginning of the unit

Standards:

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<td>SEP - Obtaining, evaluating &amp; communicating information</td>
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WY Social Studies Standards

SS12.6.1

Instructions:

Have students draw a line down a middle of a piece of paper. On one side, students should write all they know and have learned about oil. On the other side, students should write everything they know or have learned about natural gas. After doing so, prompt the students to note similarities and differences as well as any comparisons with coal or other forms of energy producing natural resources.
LESSON 1: RESOURCE BASICS

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Lesson Overview:
Making sense of how people are able to harness energy from natural resources involves an understanding of a few chemistry concepts. In this lesson, students will use a modeling activity to explore molecular shapes and the combustion process to demonstrate how the chemical structure of the hydrocarbon molecule makes it so valuable to people.

Guiding Question:
What is a hydrocarbon and how is it useful?

Duration:
45-90 minutes

Materials:
4-2” Spheres (oxygen), 4-1” Spheres (hydrogen), 1-1 ½” Spheres (carbon), 16 Round toothpicks, Modeling Combustion worksheet, Lesson 1 Resources

Engage: Modeling a hydrocarbon
Hydrocarbons are the important chemical compound in oil and natural gas processes. They contain carbon and hydrogen atoms. Review the basic chemistry of carbon and oxygen atoms with students and have them make the simple hydrocarbon, methane (CH₄).

Introduce the basic chemistry of carbon with students by reviewing the following questions:
- How many electrons does a carbon atom have? (It has six.)
- Of those six electrons, how many are valence electrons? (Four are valence electrons.)
- How many more electrons does carbon need to complete its valence shell? (Four more.)
- How many bonds can it make with other atoms? (It can make up to four bonds.)

Review the basic chemistry of hydrogen with students. The following questions may be asked:
- How many electrons does hydrogen have? (It has one.)
- How many more electrons does hydrogen need to complete its valence shell? (One more.)
- How many bonds does hydrogen make with other atoms? (It makes one bond.)

Explore: Methane combustion
Turning hydrocarbons into usable energy involves combustion, and combustion requires oxygen. Review the basic chemistry of oxygen with students. The following questions may be asked:
- How many electrons does oxygen have? (It has eight.)
• How many more electrons does oxygen need to complete its valence shell? (It needs two more.)
• How many bonds does oxygen make with other atoms? (It makes two bonds.)

Give the students the Modeling Combustion worksheet found in Lesson 1 Resources. Let students work in pairs through modeling hydrogen, oxygen, methane, and the products of combustion.

**Explain: Hydrocarbons Defined**

Hydrocarbons are organic compounds containing only carbon and hydrogen atoms. We burn hydrocarbons to release stored energy. Combustion requires a fuel source (methane), oxygen, and heat. Petroleum, natural gas, and coal are among the world's most important energy resources and all are made of hydrocarbons. Hydrocarbons are used for fuels, electrical generation, heating, and raw materials. The average person in the US consumes about 3 gallons of crude oil daily. Wyoming oil produces 10% of all energy consumed in US. Approximately 45-50 million barrels are produced in Wyoming per year, which is enough oil for up to 1.5 million people annually. That's the population of Wyoming and Montana combined.

Methane (CH₄) is the simplest hydrocarbon molecule, made of four hydrogen atoms and one carbon atom. Methane is the principal component of natural gas, a mixture containing about 75% CH₄, 15% ethane (C₂H₆), and 5% other hydrocarbons, such as propane (C₃H₈) and butane (C₄H₁₀). The energy released by the combustion of methane, in the form of natural gas, is used directly to heat homes and commercial buildings. It is also used for electricity generation.

**Elaborate: Petroleum Stations**

Hydrocarbons from crude oil are in almost everything we do or make. Set-up the following petroleum stations and allot 20 minutes (4 minutes per station) for students to rotate through the stations and complete the defined tasks. See Lesson 1 Resources for how to set up the petroleum stations.

**Evaluate: Create a definition**

Have students write a brief explanation of what a hydrocarbon is in their own words and why it is important.

**Resources:**

- Chemistry of Petroleum 1: What are Hydrocarbons
- Chemistry of Petroleum 2: What happens to Hydrocarbons when they Burn
Lesson 1 Resources

Modeling Combustion Worksheet

Procedure

1. Use the spheres to build a model of methane (CH₄). Draw the model below:

2. Build two oxygen (O₂) molecules. Draw the model below:

3. In combustion, thermal energy (heat) + oxygen + hydrocarbons releases energy we can use. It also releases other by-products. Use your models to help you balance the equation for combustion:

   \[ \text{CH}_4 + 2\text{O}_2 \rightarrow \]

Draw the products of combustion below:
Petroleum stations

- **Station 1:** Core sample of Berea sandstone and oil-impregnated Berea sandstone (available from the University of Wyoming). Ask students to make observations of the core samples and to answer the following question: Why do scientists use Berea sandstone to study how fluids flow through rock?
- **Station 2:** Sample of crude oil and kerosene. Tell students that kerosene is a product of crude oil. Ask students to identify the process that crude oil undergoes to yield different products (i.e. gasoline, diesel, kerosene, etc.).
- **Station 3:** Plastic bag, crayons, bike tire, scotch tape, shoes, glue, hand cream (any assortment of products). Ask students to identify the commonality of these products.
- **Station 4:** Map of oil development in Wyoming (source Wyoming Oil and Gas Commission). Ask students to identify determine the percentage of Wyoming counties that produce oil.

Debrief of petroleum stations

- **Station 1:** After listening to some of the students observations, identify the samples as Berea sandstone - with (impregnated) and without oil. (http://www.bereasandstonecores.com/). Sandstone is porous and can become saturated with oil (point out the sample that is saturated with oil). Similar core samples are commonly utilized in sub-surface flow research at the University of Wyoming’s Hess Digital Rock Lab.
- **Station 2:** Crude oil, also known as petroleum, is the natural form of oil when it is extracted from geologic formations. Refining is a process used to separate the different properties of the crude oil and remove impurities. Use the following site to help you explain the refining process. http://science.howstuffworks.com/environmental/energy/oil-refining2.htm
- **Station 3:** Each sample is a product made from crude oil. Ask students to rank the top 10 petroleum-based products from the following list: http://www-tpc.pbs.org/independentlens/classroom/wwo/petroleum.pdf
- **Station 4:** There are 23 counties in Wyoming, 22 of those counties produce oil and gas. Teton County is the only county that does not have oil and gas development. Why do you think there is not any development in Teton County?
LESSON 2: EXTRACTION AND CONVERSION

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Lesson Overview:
In this lesson, students will explore how oil and natural gas are extracted from tight reservoirs within sedimentary rock. They will learn how operators drill wells, see a virtual drilling demonstration, and compare the life cycles of the two resources.

Guiding Question:
How are oil and gas removed from the ground and turned into useful products?

Duration:
45 minutes

Materials:
Computer with internet, projector, printouts of resources

Engage: Oil and Gas Reservoirs
Re-engage students’ knowledge of the geologic processes that form oil and natural gas reservoirs. Have them draw on paper or model these processes as they remember them from Unit 2. Then watch this animation and have them compare what they recalled with the process. How much did students remember?

● https://www.youtube.com/watch?v=_PDOD_FEnNk

Explore: Hydraulic fracturing
Here, we will go into a little more detail about how directional hydraulic fracturing has made natural gas extraction much more efficient. Hydraulic fracturing (also called hydrofracturing, hydrofracking, fracking or fraccing), is a well-stimulation technique in which rock is fractured by a hydraulically pressurized liquid made of water, sand, and chemicals.

As a class, walk through the steps of hydraulic fracturing by watching one of the following animations. Have students make note of the steps and hypothesize how this method has revolutionized oil and gas production. Here is an example of an oil drilling rig in Pinedale, WY

● https://www.youtube.com/watch?v=VY34PQUiWQO
● http://geology.com/articles/horizontal-drilling/
Explain: Processing crude oil vs. natural gas

Hydraulic fracturing is a technique used to extract both oil and natural gas from below the Earth’s surface, but after that, the two raw materials head on different paths through processing to turn them into usable end products.

Natural gas processing consists of separating all of the various hydrocarbons and fluids from the pure natural gas, to produce what is known as ‘pipeline quality’ dry natural gas because transportation pipelines usually impose restrictions on the make-up of the natural gas allowed in the pipeline. Removed hydrocarbons are known as ‘natural gas liquids’ (NGLs) and can be valuable by-products of processing. NGLs include ethane, propane, butane, iso-butane, and natural gasoline, and have a variety of different uses including enhancing oil recovery in oil wells, providing raw materials for oil refineries or petrochemical plants, and as sources of energy (Source: http://naturalgas.org/naturalgas/processing-ng/)

A crude oil refinery is a group of industrial facilities that turns crude oil and other inputs into finished petroleum products. Crude oil is made up of a mixture of hydrocarbons, and the distillation process aims to separate this crude oil into broad categories of its component hydrocarbons, or “fractions.” See Lab 1 Resources for a diagram of the distillation process (Source: http://www.eia.gov/todayinenergy/detail.cfm?id=6970)

Elaborate: Oil and Natural Gas Refineries

Take a virtual tour of natural gas processing plant: http://www.cbi.com/natgas-station/ and of an oil refinery http://www.cbi.com/virtual-refinery. In the oil refinery, pay special attention to the Crude Distillation Unit and notice how large it is compared to other parts of the facility. Encourage students to do some research to determine what the primary end products are that come out of each processing facility or refer to resources from the introductory units.

Evaluate: Life Cycle Comparison

Compare and contrast the two life cycles following extraction from the ground. Use a Venn diagram to help discuss the different techniques and overall life cycles.

Extend: Field Trip or Guest Speaker

This lesson is designed to support a field trip to an oil or natural gas field in Wyoming or a guest speaker from the industry.

Resources:

- Niobrara Shale resource video https://www.youtube.com/watch?v=CCc_HqIG_4A
LAB 1: DISTILLING AND REFINING CRUDE OIL

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Lesson Overview:

In this lab students will develop an understanding of the distillation process involved in refining crude oil. A simple distillation is performed using a soda can and aluminum foil to distill a colorless liquid from a common, colored solution. The goal is to maximize the amount of colorless solution produced from the setup to be able to address potential inefficiencies in the distillation process.

Guiding Question:

What is the role of distillation in creating useable products from crude oil?

Duration:

45 minutes

Materials:

Per Two Students: 1 empty soda can, 4 oz to 8 oz. Clear glass jar with narrow opening at top, 4 oz to 8 oz. Clear glass jar, which will fit under the narrow opening jar, 4” x 12” piece of aluminum foil; Bunsen burner’ Ring stand; Iron Ring wire screen; Table salt; 6 ozs or 150 milliliters of crushed ice solution, cranberry, apple juice, coke, orange soda or colored aqueous solution (avoid using inorganic chemical solutions such as KMnO4, K2Cr2O7, or CuSO4 because they will react with the aluminum in the cans); Masking tape

Engage: Not All Oil is Equal

Whether it is oil or natural gas, both products must be processed to make them useable. Extracting and processing crude oil is not an easy job and requires a complex process of distillation. The amount of time it takes to produce an end product from crude oil determines its value. Explain to the students that they will now have the opportunity to experience how difficult it is to process fluids using fractional distillation.

Explore: Distillation Competition

Give each pair of students a laboratory sheet entitled, Crude Extraction (See Lab 1 Resources). The goal is to set up a distillation apparatus in such a way to maximize the production of water from one of the following fluids: cranberry juice, orange juice, apple juice, or coke. Allow the students 10-15 minutes to setup the apparatus. Then instruct the students to turn on the Bunsen burners and run the
distillation process for no more than 10 minutes to ensure all students distill the same amount of time. At the end of the 10 minute period, students should bring their flask of water to the teacher to be weighed.

Ask the students to compare the color of the starting material with that of the distillate. How are the colors different? (Students may respond that it is a more dilute version of the original or that it is completely clear unlike the original.) Emphasize the processes that allow distillation to be used as an effective purification tool like evaporation and condensation. Be sure to compare the color of the starting material with that of the distillate.

**Explain: Fractional Distillation**

When crude oil reaches the refinery it is a thick, black, smelly liquid that is not of much use. Crude oil contains mixture of hydrocarbons. At the refinery these are separated into fractions which are more useful. This is done by a process called fractional distillation. This process separates compounds by using the difference in boiling points. Fractional distillation is the separation of a mixture into its component parts, or fractions, such as in separating chemical compounds by their boiling point by heating them to a temperature at which one or more fractions of the compound will vaporize.

Lighter products, such as butane and other liquid petroleum gases (LPG), gasoline blending components, and naphtha, are recovered at the lowest temperatures. Mid-range products include jet fuel, kerosene, and distillates (such as home heating oil and diesel fuel). The heaviest products such as residual fuel oil are recovered at temperatures sometimes over 1,000 degrees Fahrenheit. The simplest refineries stop at this point. Most refineries in the United States reprocess the heavier fractions into lighter products to maximize the output of the most desirable products using more sophisticated refining equipment.

**Elaborate: Processing Crude Oil**

Examine a diagram showing inputs and outcomes of fractional distillation like the one in Lab 1 Resources. What trends do the students notice? Can they make assumptions about higher and lower quality or lighter/heavier oil products based on this diagram? Have students use their own words to explain the process of fractional distillation and how it improves the use of crude oil.

**Evaluate: Improving efficiency**

Knowing that crude oil is not used to its capacity unless it is processed by fractional distillation, a good understanding of chemistry and efficient equipment becomes even more crucial.

- Ask the students what modifications were helpful in extracting more water from their respective solutions.
- Ask the students to relate their experimental setup to the distillation process for crude oil. Are there any similarities? Differences?

**Tip:** For better sealing of the condenser tube, 1) The aluminum foil at the mouth of the can may be sealed with masking tape, or 2) The condenser tube can be fitted carefully into corks or stoppers at the mouth of the can and the collection bottle; however, the system should not be completely sealed.

**Resources:**

- Lesson adapted from: [http://www.pbs.org/wnet/ extremeoil/teachers/lp2.html](http://www.pbs.org/wnet/extremeoil/teachers/lp2.html)
- [http://science.howstuffworks.com/environmental/energy/oil-refining.htm](http://science.howstuffworks.com/environmental/energy/oil-refining.htm)
Crude Extraction worksheet

Distillation of Water From An Aqueous Solution

Name ________________________________

Equipment
- Empty soda can
- 4 to 8 - oz. Clear glass jar with narrow opening at top
- 4 to 8 - oz. Clear glass jar that will hold the glass jar above
- 4" x 12" piece of aluminum foil
- Bunsen burner or alcohol burner
- Ring stand
- Iron rings wire screen
- Masking tape

Procedure

1. Rinse the soda can clean.

2. Add the solution to be distilled until the can is 1/3 full (or 150 milliliters).

3. Mount the soda can above the burner on a wire screen supported by iron ring (attached to the ring stand). Mount the second iron ring around the top ⅓ of the can to prevent it from tipping over.

4. Insert the smaller glass jar into the larger one and surround liberally with an Ice-rich slush bath.

5. Prepare an air-cooled condenser made of aluminum foil. This is best done by wrapping the foil lengthwise around a dowel rod or broom handle, taking care to seal the seam that runs the length of the foil tube by making several folds of foil neatly pressed back on itself. (Failure to this will result in poor efficiency during distillation.)

6. Fit one end of the condenser into the opening at the top of the soda can. Gently bend the other end down and insert it into the smaller glass jar, which serves as a receiver flask for the distillation.
Example distillation set up

7. Wait for the teacher to indicate when to begin heating. Heat the soda can and its contents with a steady flame. As the solution boils, some vapor can be seen escaping from around the mouth of the can. Still, enough vapors make its way through the air-cooled condenser so that condensation (the condensed fluid is referred to as the distillate) soon occurs in the chilled receiver flask.

8. After the teacher indicates to stop heating, bring your flask or glass jar up to the front. All glass jars containing the distillate will be measured to see which pair of students set up the most effective distillation apparatus to produce the maximum amount of water.

9. Disposal: After pouring the original liquid down the drain, the entire distillation apparatus may be disposed of with the solid waste. If desired, the jars may be saved for re-use. The aluminum cans should be recycled.

Questions

1. What tips seemed to work more effectively for your team?

2. How much distillate did you produce from the process?

3. Do you think you could have improved your setup? How would you change the setup for future experiments like this?

4. Did the solution you choose make a difference in the amount of water collected?

5. How does this process relate to the fractional distillation process that occurs in a crude oil refinery?

Fractional Distillation Setup with Fractioning Column

End Products of Fractional Crude Oil Distillation Process

http://www.science-resources.co.uk/KS3/Chemistry/Chemical_Reactions/Hydrocarbons/Distillation.htm#sthash.bcSfOpUo.xryJiHiA.dpuf
LESSON 3: SUCCESSES - SUPER WELL-PADS & GROWING MARKETS

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Lesson Overview:
In this lesson students learn how oil and gas drilling have transformed from traditional well pads to mega-well pads, not only improving oil and gas production, but leaving a smaller imprint on the natural landscape around them.

Guiding Question:
What is a super well pad and how is it a success for oil and gas industries?

Duration:
45 minutes

Materials:
Computer with internet, projector, printouts of resources, Lesson 3 Resources

Engage: Wells in Wyoming?
As of 2012, 37,301 wells in Wyoming produced oil and/or natural gas. During 2013, 1,086 wells were drilled and completed. Of that number, 381, or 35% found oil, 599 or 55.2% found gas, and 106 or 9.76% were dry. See Lesson 3 Resources for a map showing all of the wells, current and inactive, in Wyoming.

Explore: One Spot, One Pad, One Well
Traditionally, there was just one well per pad. Every new area that was slated to be developed needed a new well which meant there had to be a new well pad which took up a lot of space with construction. That meant any area with high potential for oil/gas production could have hundreds of well pads taking up a lot of space. Ask students to consider, what are potential consequences of that? Show students an aerial photo of a well pad (See Lesson 3 Resources) and ask them to notice how much or how little space it takes up in its surrounding landscape.

Explain: Super well pads
The rapid advancement in drilling technology has also influenced development plans for many of these large projects. Directional and horizontal drilling allows for the siting of multiple wells on a single well pad. Such technological advances minimize the adverse impacts on the land from energy development while also extracting more resources from difficult to access reservoirs. Now some well pads can contain 5-50 wells per pad.
Elaborate: Increasing natural gas market

The natural gas industry has been doing quite well in the late 2000s and 2010s (See Lesson 3 Resources for gas consumption trends over time). As of the mid-2010s, there are 17 oil and gas projects throughout Wyoming in the permitting or early development phase, with many in the Greater Green River and Wind River basins. If approved, these projects are expected to begin development between 2014 and 2018, with the drilling of more than 23,000 wells. What will this mean in terms of landscape footprint with traditional well pads and super well pads?


Evaluate: Energy future

Knowing what we know now about oil and natural gas and also boom-bust cycles in the economy, make a prediction about the future of the industry in Wyoming and the United States. Why or why not is the industry about to boom, bust, or stay level?
Drilling activity (active and inactive) in Wyoming: Green is Coalbed Methane, Red is Natural Gas, Black is Oil; From www.wyobio.org

Lesson 4: Challenges - Landscape Changes

Lesson Overview:
In this lesson students will learn about the different aspects of a landscape and how oil and gas development has struggled to increase development while still meeting environmental restrictions and promoting good landscape health.

Guiding Question:
What is a landscape and what impacts do oil and gas development have on it?

Duration:
45 minutes

Materials:
Computer with internet, projector, printouts of resources, Lesson 4 Resources

Engage: What is a Landscape?
Quick-draw: Engage students by asking them to quickly sketch the first landscape that comes to their mind. Have them label the features and separate them into categories that are living, non-living, or made by humans.

All landscapes are made up of the abiotic, biotic, and cultural, or human-made, components within them. Ask students to define and give examples of things that are abiotic, biotic, and cultural. What happens to other parts of the system when the components change?

Explore: Landscape Changes
A challenge that faces oil and gas development is the dispersed but large impact it can have on its surrounding environment. Each well pad takes up 3-4 acres on the ground. Multiply that by 30,000 to get the estimated land coverage by well pads in Wyoming if they used traditional single-well-per-pad drilling technology. Soon that turns into a landscape very speckled with development and lots of denuded terrain. See Lesson 4 Resources for an example of this type of landscape impact.

Additionally, oil and gas must be transported from where it is extracted to where it can be refined and used. That requires long stretches of pipelines and pumping stations which take up even more land...
than just the wells themselves. Look at the image of Pipelines in Lesson 4 Resources to get an idea for how extensive oil and gas pipelines are in Wyoming.

**Explain: Increasing Landscape Change**

The number of natural gas wells alone has risen from less than 5,000 in 1999 to over 23,000 in 2013, which amounts to a large increase in land covered by wells and well pads. See Lesson 4 Resources for a graphic of how the number of gas wells in Wyoming has changed over time. Fortunately, the innovation of super well pads with many wells per pad has helped reduce the amount of impact on the landscape. Watch this time lapse video of the construction of well pads in West Texas: [http://blog.skytruth.org/2014/05/timelapse-west-texas-oil-boom.html?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+Skytruth+%28SkyTruth%29](http://blog.skytruth.org/2014/05/timelapse-west-texas-oil-boom.html?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+Skytruth+%28SkyTruth%29)

However, even though energy development companies are held to certain environmental regulations, there are still side effects of development on the environment including the biotic and abiotic components of the landscape.

**Elaborate: Air- and Water- scapes**

Many oil and gas developments have been in the news regarding new findings on potential air and water contamination. Some findings are quite controversial. Ask students to review some news articles about the impacts and practice media literacy skills to determine the main idea of the articles.

- Ozone pollution in Pinedale - [http://www.nytimes.com/2011/03/10/us/10smog.html?_r=0](http://www.nytimes.com/2011/03/10/us/10smog.html?_r=0)

Energy companies have been working with communities to improve these situations with better air quality controls and improved casements on fraccing well bores.

**Evaluate: Energy balancing act**

The balancing act with energy development is that everyone needs oil and natural gas. The average person consumes three gallons of crude oil daily in the US. But people near oil and gas development need to be sure that they are living in safe healthy environments. Given these situations, what measures can businesses and communities take to meet both objectives
UNIT 6: WYOMING’S OIL & NATURAL GAS

LESSON 4 RESOURCES

http://skytruth.org/timelapse-west-texas-oil-boom/

Oil/gas pipelines in Wyoming www.wyobio.org
Wyoming Natural Gas Number of Gas and Gas Condensate Wells

Source: U.S. Energy Information Administration

http://www.eia.gov/dnav/ng/hist/na1170_swy_8a.htm
Lesson Overview:
In this lesson, students will learn more about the life histories of mule deer and pronghorn, two iconic ungulate species, and understand the natural and human-induced barriers to their migration and critical habitats. During this lesson, students will start to think of some ways that humans can help mitigate their impact on migrations and crucial winter ranges of pronghorn and mule deer.

Guiding Question:
How is oil and gas development impacting wildlife migrations in Wyoming?

Duration:
45 minutes

Materials:
Computer with internet, projector, mammal field guides or information on mule deer and pronghorn antelope, printouts of resources, Lesson 5 Resources

Engage: Migration Introduction
Have students respond to this quick-write question: What is the purpose of migration? Then watch a brief National Geographic film on mule deer migration in Wyoming: http://video.nationalgeographic.com/video/short-film-showcase/mule-deer-migration

Explore: Mule Deer and Pronghorn Species Account
Break students into small groups that focus on mule deer or pronghorn antelope to create a poster to share that includes information on animal description, distribution and habitat, physical and behavioral adaptations (diet, migration, unique characteristics, etc.), natural history, conservation efforts, and human interactions. Students can use mammal field guides to create a poster to present to class about their research, and hang up with other parts to create a species account for each animal.

Explain: Wyoming Migratory Animals
Wyoming is home to two of the longest land migrations in the lower 48 states, one of which discovered just recently. Migration is an essential part of the natural history of many Wyoming
Elaborate:

Students should have a copy of a map of Wyoming that shows the Pinedale Anticline Project Area. Use the other maps provided to map the migration of pronghorn and mule deer using different colors. Use another color to mark their approximate winter ranges on the Pinedale map. See below for a list of map links.

Maps Links


Evaluate:

Ask students to describe why migration is important for some animals and what challenges they face during migration.
LESSON 5 RESOURCES


LESSON 6: CASE STUDY - PINEDALE ANTICLINE

Lesson Overview:
In this lesson, students will apply their background knowledge on oil and natural gas resources to a case study of energy development in Wyoming. Students will review the project overall through newspaper resources, federal documents from the Bureau of Land Management, and information from the project office. They will determine the stakeholders involved and each stakeholder’s opinion. Then students will participate in mediation, assuming the role of different parties, to try to reach a compromise on development.

Guiding Question:
What challenges and opportunities face a current natural gas project in Wyoming?

Duration:
45 minutes

Materials:
Computer with internet, projector, printouts of resources, Lesson 6 Resources

Background information:
- Information from Shell Oil https://www.shell.us/aboutshell/projects-locations/wyoming.html

Engage: Match the Stats
Become familiar with the Pinedale Anticline Project Area (PAPA) by matching the stats. Break students up into partners or small groups and provide each group with a list of facts provided in the Lesson 6 Resources. Groups should spend a few minutes trying to match statistics. Debrief the activity by asking students to share anything they found surprising.
Explore: Regional Geography
Use the resources in Lesson 6 Resources to determine: Where in the state is the PAPA? How much land does it take up? What else is in the area? Ask students to do background research on the history and demographics of Pinedale and Sublette County.

Explain: History of Development
Ask students to draw a timeline in their notebooks. Read to students about the history of development on the Jonah Field in the Pinedale Anticline area and have them take note of important dates. For an outline of the history: http://www.wyohistory.org/essays/jonah-field-and-pinedale-anticline-natural-gas-success-story
Review the history when finished and compare to the timeline presented in Lesson 6 Resources. Have students add to this history with prior knowledge of the project.

Elaborate: Meet the Stakeholders
There is a long history of development in the PAPA area. Ask students to identify a few potential conflicts that could arise here. Having discussed the history of the situation with oil and gas development in the Pinedale Anticline Project Area, ask students to identify a few of the stakeholders in this particular issue. Prompt students by asking them:

- What are the primary topics of concern? (Examples include: land use, wildlife management, economic value, social implications, technology, etc.)
- What people or which groups care about these topics?
- Why might they be concerned?

Evaluate: Mediation
Complete this unit with a class mediation in which students assume the roles of different stakeholders and present their positions. See Summative Assessment for information, directions, and resources on how to complete this mediation.

Resources:
## Lesson 6 Resources

### Fact-Match Activity

| 198,000 | Acres of land on Pinedale Anticline |
| 25,000,000,000,000 | Cubic feet of natural gas in Pinedale Anticline |
| 10,368 | Residents in Sublette County in 2012 |
| 50 | Wells directionally drilled on one super-pad |
| 2 | Wyoming’s national rank in natural gas production |
| 48 | % of Wyoming’s natural gas produced in Sublette County in 2012 |
| 60,000,000 | Dollars committed by gas companies for wildlife mitigation fund |
| 17,000,000,000 | Dollars for Wyoming from gas severance taxes |
| 380 | Well pads since 2008 |
| 12,000 | Feet of average drilling depth |

History of development on the Jonah Field from WyoHistory

- 1939 California Oil Company, later named Chevron, first drilled on the Pinedale Anticline using rotary tools, state-of-the-art drilling equipment at the time.
- Late 1940s and early 1950s, the company drilled a total of seven wells in the area, all producing limited gas, making the venture an economic failure.
- 1969 El Paso returned to the Pinedale Anticline to experiment with detonating nuclear devices to assist with natural gas extraction, known as Project Wagon Wheel.
- 1970 Clean Air Act passed (amended in 1977 and 1990) specified new strategies for cleaning up the air. Most of the nation’s electrical plants had been powered by coal, which emits high levels of ash, sulfur dioxide and mercury. The new strategies led companies to look for cleaner energy, including natural gas.
- 1991, McMurry Oil Company purchased three wells in the Jonah Field along with mineral leases on 25,000 acres of BLM land in the Jonah area.
- 1992 Major pipeline becomes operational from Jonah Field to Opal, Wyoming.
- 1992 McMurry Oil Company reported its first production of gas in the Jonah Field to the Wyoming Oil and Gas Commission.
- 1996, drilling expanded significantly when Snyder and Amoco Corporation moved into the Jonah Field with 3-D seismic survey equipment that helped delineate boundaries.
- 1996 and 1997 pipelines constructed increasing carrying and distribution capacity.
- 1999, the Jonah Gas Gathering Company, a Wyoming partnership operated and partially owned by McMurry Oil Company, opened a new 50.5-mile, twenty-inch pipeline.
- 1997 BLM reported 58 wells in place.
- 1999 more than 150 wells in both fields.
- 2001 well count reached 300.
- 1998 BLM allowed full-field development leading to rapid expansion.
- 2000 drilling in the Jonah Field and Pinedale Anticline continued, spurred by high natural gas prices. PAPA was one of the newest and most productive gas fields in the continental United States. Gas reserves are estimated at up to 40 trillion cubic feet - enough to serve the nation’s entire natural gas demand for 22 months.
- 2003 path of the pronghorn migration route discovered through the project area.
- 2003 Casper Star-Tribune reported that a total of 3,100 wells might ultimately be drilled in the Jonah Field — 1,300 more than had been requested in the March 2003 proposal.
- A 2005 study of Pinedale residents conducted by sociologists from the University of Wyoming found that the newcomers brought many new “social impacts.”
- 2008 Wyoming Department of Environmental Quality began issuing “Ozone Alerts” in Sublette County.
- 2010 longest mule deer migration found to pass through project area.
- 2010 BLM report shows a decline in 60 percent in deer populations from 2001 to 2009, based on annual estimates.
- Since 2010, additional natural gas fields in Wyoming and throughout the West have been located and development plans are underway.
- Today the Pinedale Anticline is among the top five largest natural gas fields in the U.S., and can supply 10 million homes for more than 30 years.
SUMMATIVE ASSESSMENT: MEDIATION

Standards:

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Assessment Overview:

Students will participate in a class mediation to discuss the oil and gas projects in the Pinedale Anticline area. This mediation seeks to answer the question: How can we manage the land to balance the needs of all stakeholders? The goal of the mediation will be to draft a land management plan that meets the needs of all stakeholders as best as possible.

Instructions:

After having identified a number of stakeholder groups, split students into different stakeholder groups (3-4 students in each group). Examples of stakeholder groups to include are:

- Local government: Sublette county commissioner, city planners, etc.
- Energy developers: representatives from natural gas companies
- Bureau of Land Management
- Wyoming Game and Fish Department
- Ranchers
- Citizens
- Wildlife Biologist
- Wildlife (or wildlife advocacy group)

Give a packet of resources relating to their stakeholder group including scientific papers, news articles and websites, facts and figures, and description of their stakeholder's viewpoint (see Summative Assessment Resources). Groups should spend 15 minutes looking through information and preparing a 1-minute opening statement about their viewpoint.

This is not a debate, but instead it is mediation in which different stakeholders understand the values of other groups in a facilitated forum. Groups will provide a one-minute opening argument stating their stakeholders’ perspective and needs, supported with information from their packets. At this time, no other students can make comments. Each group will then have an opportunity to ask two
questions to other groups. After question/answer session, each group will meet again to come up with three ideas for a land management plan.

Lastly, new groups will be created with one member of each stakeholder group. These groups will be given 10 minutes to share their ideas and come up with a consensus for a land management plan. Each group should present their ideas to the class.

Following the mediation, debrief the experience as a class. Could groups collaborate even if they had different opinions? What are some ways that you communicated well as a group? What would you change? In what ways did your viewpoints change from discussing the values of others in your group?
SUMMATIVE ASSESSMENT RESOURCES

Resources for each stakeholder group:

**Local government officials**

Sublette County Commissioner, city planners, etc. They represent the citizens of Sublette County and have information about how development affects the local economy and the citizens. Municipalities receive a lot of income directly and indirectly from oil and gas development so as a local government official, you are interested in development issues that would impact your town, but are also obligated to support your local citizens.


**Energy industry representatives**

As an industry representative from the natural gas companies, you can share what efforts you have been engaging in to mitigate wildlife. This includes the wildlife monitoring and mitigation plan and the reclamation plan for the PAPA. You also believe that development is important to the local economy, and that there should not be any decrease in activity due to wildlife. You believe that companies should continue to develop responsibly.

- From Shell: [https://www.shell.us/aboutshell/projects-locations/wyoming.html](https://www.shell.us/aboutshell/projects-locations/wyoming.html)
- Oil and Gas Summaries: [http://www.wsgs.uwyo.edu/Public-Info/OnlinePubs/docs/Oil-and-Gas-Summary.pdf](http://www.wsgs.uwyo.edu/Public-Info/OnlinePubs/docs/Oil-and-Gas-Summary.pdf)
BLM/PAPO

The Bureau of Land Management (BLM) is the lead agency in managing the Pinedale Anticline Project Office (PAPO), an interagency group. The mission of the BLM is to manage the multiple uses of the public land. BLM currently owns about 80% of the Pinedale Anticline.

- Oil and Gas Summaries: [http://www.wsgs.uwyo.edu/Public-Info/OnlinePubs/docs/Oil-and-Gas-Summary.pdf](http://www.wsgs.uwyo.edu/Public-Info/OnlinePubs/docs/Oil-and-Gas-Summary.pdf)

Ranchers

Less than 20% of the Pinedale Anticline is private land. However, ranchers can hold leases on BLM land to graze their cattle. Some argue that grazing cattle is detrimental to reclamation efforts and compete with wildlife, but it is also an important part of Wyoming’s economy and culture. The BLM has a responsibility to manage its land for multiple uses, including grazing. You prefer a plan in which multiple use is respected and you have equal access to public land for grazing cattle.

Citizens

The citizens of Pinedale have many different views on oil and gas development nearby. Some work for the industry, but others do not and are concerned about potential health impacts on the children in their community. Consider the views of many citizens and argue one position. Ideas include: Energy employee, Parent of child with asthma, or Local hotel owner or business person


Wildlife Biologist

As a wildlife biologist, you have been studying the populations of mule deer and pronghorn behavior, migration, and populations for over a decade. You have found that mule deer populations have declined by about 50% in recent years, and that a majority of animals avoid areas of high development. Your job is mainly to provide information about the wildlife, to share with stakeholders and give policy makers best available scientific information as they make decisions.

● Wyoming Migration Initiative: http://migrationinitiative.org/

Wildlife Advocacy Group

As a representative for a wildlife advocacy group, you speak to your personal experience watching hundreds of animals move through during migration and how that has changed with the increase in development.

● Fracking away the Wildlife: http://www.psmag.com/environment/fracking-away-the-wildlife-44012/