UNIT 3: HUMAN HISTORY OF ENERGY IN WYOMING

Evolution of mining, drilling and production

CONTENTS
Overview ........................................................................................................................................ 3.2
Standards ........................................................................................................................................ 3.2
Objectives ....................................................................................................................................... 3.3
Assessment Evidence ..................................................................................................................... 3.4
Diagnostic & Formative Assessment: Energy Networks ................................................................ 3.5
Lesson 1: Wyoming’s Natural Resource Economy ......................................................................... 3.6
Lesson 1 Resources ......................................................................................................................... 3.8
Lesson 2: Boom and Bust Cycles ................................................................................................... 3.13
Lesson 2 Resources ........................................................................................................................ 3.15
Lesson 3: History of Coal Extraction .............................................................................................. 3.16
Lesson 3 Resources ........................................................................................................................ 3.18
Lesson 4: History of Oil & Natural Gas Extraction ......................................................................... 3.21
Lesson 4 Resources ........................................................................................................................ 3.23
Lesson 5: Advances in Wind Energy Production ........................................................................... 3.24
Lesson 5 Resources ........................................................................................................................ 3.26
Lesson 6: Energy transitions from new technology ......................................................................... 3.28
Lesson 6 Resources ........................................................................................................................ 3.30
Summative Assessment: Oral History Project ............................................................................... 3.34

DRAFT – August 2015
UNIT 3: HUMAN HISTORY OF ENERGY IN WYOMING

OVERVIEW

The goal of this unit is to dive into the human history of coal mining, oil and gas drilling, and more recently, wind power in Wyoming. The students begin by exploring the relationship between energy production that happens in Wyoming and the United States as a whole. Students will understand that Wyoming is dependent on its energy resource development to support its people and economy while at the same time the rest of the United States is dependent on Wyoming to supply the energy resources that are needed for daily life. However, economies like that of Wyoming are often subject to boom bust cycles and students will listen to an oral history project that exposes the effects of economic cycles in the communities near the Niobrara oil play. Students will also review current news articles and discuss whether or not Wyoming is approaching a boom or a bust.

The second part of the unit takes students through the changes over time in technology in coal mining, oil and gas drilling, and wind power generation. Students will create timelines and note important historical events including technological innovations and key moments in history, like when Wyoming became the number one coal producing state in the United States. Lastly, students will compare technological advances with energy transitions to recognize how enhancing the ability to harness and convert energy sources can have significant impacts on energy consumption.

ESSENTIAL QUESTIONS

● How did energy production begin in Wyoming?
● How has energy production changed throughout Wyoming’s history?

ESSENTIAL UNDERSTANDINGS

● Students will understand the history of oil, natural gas, and coal production in Wyoming.
● Students will understand the evolution of production technology over time.

DURATION

Six to eight 45 minute lessons

STANDARDS

Next Generation Science Standards

● Disciplinary Core Ideas
  ○ Physical Science
  ○ Engineering

● Crosscutting Concepts
  ○ Patterns
  ○ Energy & matter
  ○ Stability & change
  ○ Connection to technology and engineering applications
  ○ Scale, proportion & quantity
  ○ Systems & systems models

● Science and Engineering Practices
  ○ Analyzing and interpreting data
  ○ Obtaining, evaluating, and communicating information
UNIT 3: HUMAN HISTORY OF ENERGY IN WYOMING

- Engaging in arguments from evidence
- Asking questions/Defining problems

Wyoming Science Standards
- SC11.3
- SC11.3.1

Wyoming Social Studies Standards
- SS12.3.1
- SS12.3.3
- SS12.3.4
- SS12.4.1
- SS12.4.2
- SS12.4.5
- SS12.5.1
- SS12.5.2
- SS12.5.4
- SS12.6.1

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

Common Core Language Arts Standards
- CCSS.ELA-LITERACY.RI.11-12.1
- CCSS.ELA-LITERACY.RI.11-12.7
- CCSS.ELA-LITERACY.W.11-12.3
- CCSS.ELA-LITERACY.SL.11-12.1

OBJECTIVES

Science and Energy Literacy
- Students will be able to explain, in broad terms, the development of coal mining, oil and natural gas drilling, and wind power generation.
- Students will explain how innovations in extractive technology have allowed for increased production and consumption of coal, oil, natural gas, and wind power.

Stewardship and Community
- Students will understand how locally produced energy resources and national energy resource demand are related.
- Students will discuss the future development of Wyoming’s energy industry based on current and projected energy portfolios.

STEM Careers and Leadership Development
- Students will become familiar with current industry practices in coal mining and oil and natural gas drilling.
UNIT 3: HUMAN HISTORY OF ENERGY IN WYOMING

Place
- Students will listen to a local oral history project.
- Students will interview a local community member about his or her relationship with Wyoming’s energy industry.

Applied Problem Solving & 21st Century Skills
- Students will brainstorm potential innovations to extractive technology and energy conversion.
- Students will interpret scientific figures, using evidence to support placement of wind farms.

ASSESSMENT EVIDENCE

Diagnostic:
At the beginning of the unit, students will demonstrate understanding by:
1. Describing in their own words what energy portfolios and energy transitions are, as recalled from Unit 1.
2. Listing potential challenges and limitations facing the early coal mining industry.
3. Listing all of the products they can think of that use coal, crude oil, or natural gas.

Formative:
During the unit, students will demonstrate understanding by:
1. Creating posters explaining the applications of coal, oil, and natural gas in everyday life.
2. Creating timelines that describe the history of energy resource extraction technologies.

Summative:
By the end of the unit, students will demonstrate understanding by:
1. Comparing timelines to energy consumption over time and explaining how technological innovation corresponds with energy transitions.
2. Being able to hypothetically site wind turbines in Wyoming and justify their decisions with evidence.
**Diagnostic & Formative Assessment: Energy Networks**

*To be completed at the beginning of the unit*

**Standards:**

<table>
<thead>
<tr>
<th>Next Generation Science Standards</th>
<th>Common Core Standards</th>
<th>WY Social Studies Standards</th>
</tr>
</thead>
</table>
| SEP - Obtaining, evaluating & communicating information | ELA-Literacy.RST.11-12.2  
MATH.Content.HSS.IC.B | SS12.3.3  
SS12.5.1  
SS12.5.2 |

**Instructions:**

The objective of this activity is for each student, and the class as a whole, to make a network of people, places, and things that are connected to Wyoming’s energy industry to see demonstrate pervasive energy resources and the energy economy are. The end product may look like a concept map for energy with prepositions connecting ideas or just a chart. The list should include:

- People who students know that work in energy,
- Where those people work,
- Corporations involved,
- Where in Wyoming those businesses are located, etc.
LESSON 1: WYOMING’S NATURAL RESOURCE ECONOMY

Standards:

<table>
<thead>
<tr>
<th>Next Generation Science Standards</th>
<th>Common Core Standards</th>
<th>WY Science Standards</th>
<th>WY Social Studies Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCC - Energy &amp; matter</td>
<td>ELA-Literacy.RI.11-12.7</td>
<td>SC11.3</td>
<td></td>
</tr>
<tr>
<td>SEP - Analyzing &amp; interpreting data</td>
<td>MATH.Content.HSS.IC.B</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SS12.5.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SS12.3.4</td>
<td></td>
</tr>
</tbody>
</table>

Lesson Overview:

In this lesson, students will understand that energy resource production is a two-way street. While Americans require valuable energy resources that Wyoming can provide, Wyoming is also dependent on the continuing demand for its energy resources because their extraction helps support the economy. Students will walk away understanding the important role Wyoming and its natural resources played in the development of modern America and the ongoing role it has.

Guiding question:

Does Wyoming depend on US energy consumption or does US energy consumption depend on Wyoming energy resources?

Duration:

45 minute

Materials:

Resource end use cards, poster paper, markers, computer with internet, projector, historical and current maps revealing coal and oil development

Engage: What uses coal, oil, and natural gas?

This lesson uncovers just how much we use energy sources for our everyday lives. Begin by asking students to list all the things they can think of that are made from coal, crude oil, and natural gas. They will most likely be able to create a longer list for crude oil than any other resource. This list will help students see how many energy resources they use on a daily basis, beyond just electricity.

Explore: Everyday use of coal, oil, and natural gas

Break students up into groups and have each group explore a different resource: Coal, crude oil, natural gas. Give students resource cards as outlined below, or allow students to search on the Internet. Student groups should create a poster to present to the rest of the class that highlights the most significant uses of each natural resource. See Lesson 1 Resources for pre-made resource cards for coal, crude oil, and natural gas.

Explain: Wyoming’s natural resource economy

At the same time as people all over the country and world depend on products that are produced using Wyoming’s energy resources, Wyoming is dependent on energy resource extraction to support its people and economy. Refer to Quick Facts in Lesson 1 Resources to see how much money...
Wyoming receives from oil and gas production each year. Watch these videos and discuss the role played by energy industry in Wyoming.

- **Coal mining and the economy:** [https://www.youtube.com/watch?v=GJzux03y0Fg](https://www.youtube.com/watch?v=GJzux03y0Fg)
- **Oil mining and the economy:** from KCWY13 - [How New Oil & Gas Drilling Techniques Benefit Economy; Wyoming Oil Industry on the Up and Up](https://www.youtube.com/watch?v=GJzux03y0Fg)

**Elaborate: Historical importance of energy in Wyoming**

In Unit 1 we learned that the history of development in America has depended largely on the ability to extract and harness energy resources. Modern daily life in the US is dependent on natural resource use and consumption of energy resources. Wyoming has a long history of natural resource extraction and energy production and has therefore played a critical role in the development of life in America.

Compare maps of energy production sites in Wyoming (historical and current) to see how energy resources have remained an important part of Wyoming’s economy. See [Lesson 1 Resources](#) for full size historical and current maps of oil and coal development.

**Evaluate: Future of Wyoming’s energy economy**

Knowing the value of products and services provided by natural resources like those found in Wyoming, and the history of natural resource based industry in Wyoming, discuss the future of Wyoming’s energy economy. Ask the students to respond to the following question: Will energy continue to be important to Wyoming’s economy? Why or why not? Students should use maps and prior knowledge to help them make their case.

**Resources:**

Coal, Crude Oil, and Natural Gas resource cards

Coal:

The most significant uses of coal are in electricity generation, steel production, cement manufacturing and as a liquid fuel. Other important users of coal include aluminum refineries, paper manufacturers, and the chemical and pharmaceutical industries. Several chemical products can be produced from the by-products of coal. Refined coal tar is used in the manufacture of chemicals, such as creosote oil, naphthalene, phenol, and benzene. Ammonia gas recovered from coke ovens is used to manufacture ammonia salts, nitric acid and agricultural fertilizers. Thousands of different products have coal or coal by-products as components: soap, aspirins, solvents, dyes, plastics and fibers, such as rayon and nylon. Coal is also an essential ingredient in the production of specialist products:

- **Activated carbon** - used in filters for water and air purification and in kidney dialysis machines.
- **Carbon fiber** - an extremely strong but lightweight reinforcement material used in construction, mountain bikes and tennis rackets.
- **Silicon metal** - used to produce silicones and silanes, which are in turn used to make lubricants, water repellents, resins, cosmetics, hair shampoos and toothpastes.

**What Coal Did Today**

- Provided over 40% of the power for 300 billion e-mails. 75 million “tweets” and the activation of 350,000 Androids
- In just 24 hours
- Produced 23 TWh of electricity—more than gas, wind and hydro combined
- Generated power equivalent to 1,340 nuclear power plants
- Fueled about 60% of China’s industrial sector
- Enhanced energy security for dozens of nations across the globe
- Enabled the production of 2.4 million metric tons of steel
- Provided more than half the electricity for 3 billion people—10 times the population of the U.S


http://www.rmcmi.org/education#.VJMDkl4DQ
Crude Oil:

Also known as petroleum, crude oil is the most important natural resource of the industrialized nations. Crude oil products include transportation fuels, fuel oils for heating and electricity generation, asphalt and road oil. Petroleum is also an important feedstock for making chemicals, plastics, and synthetic materials found in nearly everything we use today. It can generate heat, drive machinery and fuel vehicles and airplanes. Its components are used to manufacture almost all chemical products, such as plastics, detergents, paints, and even medicines.

Thousands of consumer goods are produced using petroleum. Consider the crude oil within our materials: 40 percent of all textiles contain oil; for clothing like fleece this may be as much as 100 percent. Oil within our leisure activities: 40 billion liters of oil a year are used to make CDs and DVDs. Oil helps us relax: A single sofa contains 60 liters of oil. Modern life is inconceivable without crude oil. The world consumes almost 14 billion liters of oil each day. [http://www.wintershall.com/en/company/oil-and-gas/oil-can-do-more.html](http://www.wintershall.com/en/company/oil-and-gas/oil-can-do-more.html)

Here is a partial list of things made out of oil:

<table>
<thead>
<tr>
<th>Solvents</th>
<th>Diesel fuel</th>
<th>Motor Oil</th>
<th>Bearing Grease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ink</td>
<td>Floor Wax</td>
<td>Ballpoint Pens</td>
<td>Football Cleats</td>
</tr>
<tr>
<td>Upholstery</td>
<td>Sweaters</td>
<td>Boats</td>
<td>Insecticides</td>
</tr>
<tr>
<td>Bubble Gum</td>
<td>Sports Car Bodies</td>
<td>Nail Polish</td>
<td>Fishing lures</td>
</tr>
<tr>
<td>Dresses</td>
<td>Tires (auto/bicycle)</td>
<td>Golf Bags</td>
<td>Perfumes</td>
</tr>
<tr>
<td>Cassettes</td>
<td>Dishwasher parts</td>
<td>Tool Boxes</td>
<td>Shoe Polish</td>
</tr>
<tr>
<td>Motorcycle Helmet</td>
<td>Caulking</td>
<td>Petroleum Jelly</td>
<td>Transparent Tape</td>
</tr>
<tr>
<td>CD Player</td>
<td>Faucet Washers</td>
<td>Antiseptics</td>
<td>Clothesline</td>
</tr>
<tr>
<td>Curtains</td>
<td>Food Preservatives</td>
<td>Basketballs</td>
<td>Soap</td>
</tr>
<tr>
<td>Vitamin Capsules</td>
<td>Antihistamines</td>
<td>Purses</td>
<td>Shoes</td>
</tr>
<tr>
<td>Dashboards</td>
<td>Cortisone</td>
<td>Deodorant</td>
<td>Footballs</td>
</tr>
<tr>
<td>Putty</td>
<td>Dyes</td>
<td>Panty Hose</td>
<td>Refrigerant</td>
</tr>
<tr>
<td>Percolators</td>
<td>Life Jackets</td>
<td>Rubbing Alcohol</td>
<td>Linings</td>
</tr>
<tr>
<td>Skis</td>
<td>TV Cabinets</td>
<td>Shag Rugs</td>
<td>Electrician's Tape</td>
</tr>
<tr>
<td>Tool Racks</td>
<td>Car Battery Cases</td>
<td>Epoxy</td>
<td>Paint</td>
</tr>
<tr>
<td>Mops</td>
<td>Slacks</td>
<td>Insect Repellent</td>
<td>Oil Filters</td>
</tr>
<tr>
<td>Umbrellas</td>
<td>Yarn</td>
<td>Fertilizers</td>
<td>Hair Coloring</td>
</tr>
<tr>
<td>Roofing</td>
<td>Toilet Seats</td>
<td>Fishing Rods</td>
<td>Lipstick</td>
</tr>
</tbody>
</table>

Natural Gas:

Natural gas burns very well. Therefore, it is mostly used for generating electric or thermal energy. When people think about applications for natural gas in the US some of the most iconic images are kitchen stove burners and large power plants. However, natural gas liquids are widely used in manufacturing thousands of everyday products like paint, as well as fertilizers and other applications that people may not be as familiar with.

Wyoming Energy Quick Facts

In 2013 Wyoming’s petroleum industry directly employed approximately 25,000 people with an annual payroll of over $1.4 billion. (http://www.pawyo.org/facts-figuers.pdf). In fiscal year 2013 oil and gas production contributed the following to Wyoming state and local governments:

- Property Taxes..................551.8 million
- Severance Taxes..................522.0 million
- Federal Royalties.................466.1 million
- Federal Lease Revenues..........53.4 million
- State Royalties..................142.3 million
- Sales and Use Taxes.............148.0 million
- Conservation Mill Levy...........4.3 million

TOTAL FOR STATE ..................$ 1.9 Billion

Historical and current maps showing coal and oil development

Early map of oil fields in Wyoming

http://aoghs.org/stocks/lincoln-idaho-oil-company/

Current shale plays (large, beige patches) and oil wells (dark brown spots)

http://wyobio.org/application/
1951 USGS map of coal fields

http://www.wsgs.wyo.gov/research/energy/coal/Geology.aspx

Current coal deposits (light grey patches) and surface coal mines (black triangles)

http://wyobio.org/application/
LESSON 2: BOOM AND BUST CYCLES

Standards:

<table>
<thead>
<tr>
<th>Next Generation Science Standards</th>
<th>Common Core Standards</th>
<th>WY Science Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCC - Stability &amp; change</td>
<td>ELA-Literacy.RI.11-12.1</td>
<td>SC11.3</td>
</tr>
<tr>
<td>SEP - Obtaining, evaluating &amp; communicating information</td>
<td>MATH.Content.HSF.IF.B.4</td>
<td>WY Social Studies Standards</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SS12.3.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SS12.4.1</td>
</tr>
</tbody>
</table>

Lesson Overview:
In this lesson, students will explore the variability in economies characterized by boom bust cycles and will understand the economic fluctuations between periods of rapid growth and recession. Students will hear about booms and busts in Wyoming’s oil industry through an oral history project conducted by the Wyoming Heritage Center on the Niobrara Oil Play. Students will then examine the current state of Wyoming’s energy economy by reading local news articles and speculate on whether or not Wyoming is nearing a boom or a bust and why.

Guiding Question:
How have boom bust cycles presented themselves in the Wyoming energy industry and will they continue?

Duration:
45-90 minutes

Materials:
News articles on boom bust economy in Wyoming

Engage: Booms and busts in Ecology
Observe the relationship between snowshoe hare populations and lynx populations over time (See Lesson 2 Resources for an example diagram). What trends do the students notice? This segues into a conversation about booms and busts in the energy industry.

Explore: Oral histories of booms and busts
Despite the worldwide importance of the natural resources Wyoming has to offer, the energy industry in Wyoming is not immune to boom-bust cycles that happen in most economies. Listen to oral histories on boom and bust cycles collected by Ruckelshaus institute - WY Heritage Center Niobrara Oil Play (45 minutes) https://www.youtube.com/watch?v=uk0gJWJ5jdE

Explain: Booms and busts in economics
Booms and busts are characterized by rapid economic expansion (the boom) and contraction (the bust), and they happen in ecosystems as well as human systems. They have occurred in a variety of industries ever since the first settlers came to the West and usually involve the production and marketing of a single commodity.

Take, for example, the fur trade boom in the Rocky Mountains of Wyoming caused by increased demand for beaver felt to use in hats, the gold mining boom, the coal industry associated with the
railroad and its coal powered steam locomotives, the open range cattle industry of the northern plains and the uranium industry. All of these examples of economic booms were followed by busts caused by changes in fashion (beaver), more easily obtained gold (gold mining), the replacement of coal fired with diesel powered locomotives, overgrazing and severe winter weather, and fears of nuclear plant accidents. See Lesson 2 Resources for diagram of boom and bust cycles.

Elaborate: Booms and busts in the news
Break students up into groups and assign each student a different news article. Have the students read excerpts from different news articles pertaining to boom-bust cycles in Wyoming and then summarize for their groups the main point of the article. The summary should include main points and an interpretation on why this article is relevant to this discussion.

- Energy job losses may sap Wyoming resident boom;
- Wyoming Oil Jobs;
- WPR's Boom 2.0;
- Wyoming oil production trending upwards;
- Shale revolution may lessen boom busts;
- Are we in a boom or bust in Wyoming?;
- Industry talking another boom in Wyoming;

Evaluate: Where is Wyoming?
After reading the articles, discuss: Where is Wyoming in the boom-bust cycle? Are we nearing a boom or a bust?

Resource:
- http://www.uwyo.edu/ahc/energyboom/index.htm
Lesson 2 Resources

Booms and Busts in Ecology


Boom and bust cycles in the economy
LESSON 3: HISTORY OF COAL EXTRACTION

Standards:

<table>
<thead>
<tr>
<th>Next Generation Science Standards</th>
<th>Common Core Standards</th>
<th>WY Science Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCI - Engineering</td>
<td>ELA-Literacy.RI.11-12.7</td>
<td>SC11.3</td>
</tr>
<tr>
<td>CCC - Scale, proportion &amp; quantity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEP - Asking questions/Defining problems</td>
<td></td>
<td>WY Social Studies Standards</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SS12.3.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SS12.4.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SS12.4.2</td>
</tr>
</tbody>
</table>

Lesson Overview:
In this lesson, students will work through the history of coal mining in Wyoming by creating a timeline of the development and extraction technologies. Students will consider some of the challenges and limitations to early coal mining operations as well as the technological advances that have allowed Wyoming to become the top coal producing state in the nation.

Guiding Question:
What advances in coal mining caused it to become the number one coal producing state in the US?

Duration:
45 minutes

Materials:
Historical photos of coal mining operations, computer with Internet and projector

Engage: Mining photo diary
Compare and contrast coal mining in the past and present. Show students pictures of coal mining operations from the 1800s and ask them to record any words that come to mind. Ask students to identify challenges to early coal mining operations that would have either put people's lives at risk or limited the amount of coal that could be produced. See Lesson 3 Resources for full size images of historical coal mining operations.

Explore: Dangers of coal mining
After viewing historical photos and identifying potential challenges and limitations, ask the students to brainstorm potential solutions to the challenges.

Then show students a video describing and touring Black Thunder Mine in Gillette, WY. While watching the video, ask students to pay attention to the differences between modern mining strategies and historical mining strategies as well as if and how modern techniques have addressed any challenges and limitations. As a follow up, show students this video of Big Muskie, the largest walking dragline in the world housed at Black Thunder Mine.
**UNIT 3: HUMAN HISTORY OF ENERGY IN WYOMING**

**Explain: Changes in mining technology**

**Elaborate: Coal mining timeline**
Using resources from [Wyoming Historical Society](http://www.wyominghistory.org) and [Wyoming State Geological Survey](http://www.wsgs.wyo.gov), have students create a timeline and map for the history of coal development in Wyoming. Ask students to review the history and plot on a map any important discoveries or events related to coal in Wyoming.

See [Lesson 3 Resources](#) for a list of important historical dates

- **Timeline resources:**

**Evaluate: Major advances in mining technology**
Discuss what advances in technology have led to the biggest changes in coal mining over time.

**Resources:**
- Black Thunder Mine video [https://www.youtube.com/watch?v=2LQwxTm94Ps](https://www.youtube.com/watch?v=2LQwxTm94Ps)
- Big Muskie video [https://www.youtube.com/watch?v=jcmGKsHZXZ8](https://www.youtube.com/watch?v=jcmGKsHZXZ8)
- [How Do They Do It? Coal Mining](#) Video from the Science Channel
**LESSON 3 RESOURCES**

**Historical Coal Mining Photos**

Coal miners and horses at the mouth of the Monarch Mine north of Sheridan, about 1903. Sheridan County Museum.

[http://www.wyohistory.org/encyclopedia/sheridan-county-wyoming#sthash.eOLzlvFj.dpuf](http://www.wyohistory.org/encyclopedia/sheridan-county-wyoming#sthash.eOLzlvFj.dpuf)

The coal mine and tipple at Dietz, Wyo., north of Sheridan, 1909. Sheridan County Fulmer Public Library.

UNIT 3: HUMAN HISTORY OF ENERGY IN WYOMING

http://www.westernmininghistory.com/special/people/36865/

http://commons.wikimedia.org/wiki/File:Horse_Railway_in_Coal_Mine.jpg
Coal Mining: Important historical dates

- 1600s-1800s - Digging by hand, some explosives
- 1800s - developing more advanced mining equipment - drills, lifts and steam-powered pumps
- 1839 - steam shovel is invented and becomes instrumental in mechanizing surface coal removal
- 1843 - The Fremont Expedition discovers coal in Wyoming
- 1850s-1860s - Coal mines open near Carbon and Rock Springs, Wyoming after the arrival of rail
- 1866 - surface mining becomes more practical and popular; horse-drawn ploughs are used to remove layers above coal seams
- 1889 - Wyoming draws up the state constitution and includes provisions for safer coal mining
- 1913 - Walking draglines are invented
- 1937 - the shuttle car is invented
- 1961 - coal becomes the primary source for electricity production
- 1987 Wyoming became the largest coal producing state
- 1990 - US coal production tops 1 billion tons for the first time
LESSON 4: HISTORY OF OIL & NATURAL GAS EXTRACTION

Standards:

<table>
<thead>
<tr>
<th>Next Generation Science Standards</th>
<th>Common Core Standards</th>
<th>WY Science Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCI - Engineering</td>
<td>ELA-Literacy.RI.11-12.7</td>
<td>SC11.3</td>
</tr>
<tr>
<td>CCC - Scale, proportion &amp; quantity; Patterns</td>
<td></td>
<td>WY Social Studies Standards</td>
</tr>
<tr>
<td>SEP - Obtaining, evaluating &amp; communicating information</td>
<td></td>
<td>SS12.3.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SS12.4.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SS12.4.2</td>
</tr>
</tbody>
</table>

Lesson Overview:
In this lesson, students will explore the history of development and advances in technology in the oil and gas industry.

Guiding Question:
How have drilling techniques changed over time?

Duration:
45 minutes

Materials:
Construction paper and markers for timeline, computer with internet access

Engage: Guided imagery
Tell students to close their eyes. Now imagine you are in your same town here in Wyoming, but the year is 1832. You are a fur trapper tracking and trapping everything from jackrabbits to wolves. You wake up before sunrise one morning and start your tracking in the crisp morning air. You see sign of black bear and decide to follow in its path. As you are tracking, what you think might be the largest black bear ever, you notice something odd off to your left, so you go investigate. No, you think, it can’t be. I have heard of tales of this stuff but I never thought anyone had ever seen it! I just found liquid gold!!! This liquid gold is what we know as oil. Now, imagine yourself traveling through space and time to today. Open your eyes.

Make a list with the students about how oil influenced human life from the 1800’s to today and how oil and gas development may have changed over the years.

See Lesson 4 Resources for associated image of late 1800s oil well photograph.

Explore: Drilling timelines
Have students work in two groups to create two different timelines. One timeline of the history of oil and natural gas development in Wyoming, the second group will create a timeline on the technology used for extraction. See Lesson 4 Resources for examples of completed timelines. Have students use the information from the following websites to construct their time lines:

- History and development:
UNIT 3: HUMAN HISTORY OF ENERGY IN WYOMING

  - History of technologies used for extraction:
    - Extraction techniques: http://www.naturalgas.org/naturalgas/extraction_onshore.asp
    - History of extraction: http://thesciencebeneaththesurface.wordpress.com/2010/08/30/a-brief-introduction-to-the-history-of-natural-gas-extraction/

Explain: History of oil and gas development
Watch ‘A history of natural gas’ (12 min): http://www.youtube.com/watch?v=BXi14Dr0Cj4

Elaborate/Evaluate: Themes in oil and gas development
Ask the students what main themes they noticed throughout the history of natural gas development and have all of the students write what they thought the themes were on the board. The theme that you want to concentrate on is changes in technology.

- In what ways has oil and gas technology changed?
- What are some reasons why oil and gas technology changed?
- How do the changes in oil and gas technology affect our economy?

Resources
Lesson 4 Resources

In 1883, tales of a “tar spring” inspired Pennsylvanian Mike Murphy to drill the first Wyoming oil well.

http://aoghs.org/newsletter/first-wyoming-oil-well/

Example Timelines

Oil and Gas History in Wyoming
- 1832 - Capt. B.L.E. Bonneville found oil springs southeast of Lander area
- 1842 - Oil springs discovered near Fort Bridger
- 1862 - first recorded oil sale in Wyoming along the Oregon Trail near Casper
- 1866 - John C. Fiere from Fort Bridger reported oil nearby
- 1883 - First oil well in Wyoming
- 1895 - Oil refinery built in Casper
- 1920s - “Heyday” of oil production and refining in Wyoming
- 1970s and 1980s - most of Wyoming’s refineries are closed
- 1990s and 2000s - Booming natural gas production in Jonah Field and Pinedale Anticline of Sublette County

Extraction Technology
- Early 1800s - Vertical Percussion Drilling
- 1830 - Vertical Rotary Drilling
- 1929-1980s - Directional/Slant Drilling
- 1970s - Horizontal Drilling
- 1947 - Hydraulic Fracturing - became more active during 1990s.
LESSON 5: ADVANCES IN WIND ENERGY PRODUCTION

Standards:

<table>
<thead>
<tr>
<th>Next Generation Science Standards</th>
<th>Common Core Standards</th>
<th>WY Science Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCI - Engineering</td>
<td>ELA-Literacy.RI.11-12.7</td>
<td>SC11.3</td>
</tr>
<tr>
<td>CCC - Engaging in argument from evidence</td>
<td>ELA-Literacy.W.11-12.3</td>
<td></td>
</tr>
<tr>
<td>SEP - Analyzing &amp; interpreting data; Structure &amp; function</td>
<td>MATH.Content.HSS.IC.B</td>
<td>WY Social Studies Standards</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SS12.3.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SS12.4.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SS12.4.2</td>
</tr>
</tbody>
</table>

Lesson Overview:

In this lesson, students will explore Wyoming’s wind energy potential. Students will create a timeline of development in wind turbine technology and compare sizes of wind turbines over the last 20 years for their electricity production capacity. Students will hypothetically site wind turbines to maximize electricity production and use maps of Wyoming wind speeds to justify their decision. This lesson concludes with students discussing Wyoming’s energy portfolio and potential addition of renewable portfolio standards that would encourage development of wind energy production in the state.

Guiding Question:

With improving turbine technology, what is Wyoming’s wind energy production potential?

Duration:

45-90 minutes

Materials:

Wind power maps of Wyoming, computer with internet, projector, printed timeline resources or computer access for students

Engage: Wind creation story

Quick-write: Write a creation story for why Wyoming is so windy. Examples of creation stories can be found here: The Moon and Morning Star; The Legend of How Bear Lost Its Tail

Explore: Wind power timeline

Wind can create a lot of force and has been harnessed for centuries by people all over the world to draw water, grind flour, power saw mills, and generate electricity. Use the resources below to make a timeline showing where and how wind has been used throughout history. See Lesson 5 Resources for Advances in Wind Power Technology timeline.

- US: http://energy.gov/eere/wind/history-wind-energy
- UK: http://www.theguardian.com/environment/2008/oct/17/wind-power-renewable-energy
- Canada: http://www.centreforenergy.com/AboutEnergy/Wind/History.asp
- Canada: http://www.cbc.ca/doczone/features/timeline1
Explain: Wind turbines over time

The windiness of Wyoming may lend itself to development of alternative energy sources in the near future, and as technology for harnessing wind energy improves, it may become a dominant energy resource. See Lesson 5 Resources for an image that shows the evolution of wind turbines over the last 30 years and their increasing potential to supply power to the electric grid.

While Wyoming ranks 1st in the US in coal mining, its high ranking in available winds makes the "mining" of wind increasingly cost effective. The state's wind resource is ranked 7th among the contiguous states. Approximately 42,875 mi$^2$ of available windy land has a potential wind energy yield of 747 billion kWh per year with a wind energy potential of 85,200 MW. This is equivalent to the potential of supplying approximately 66 million homes with energy annually. (http://www.wrds.uwyo.edu/sco/climateatlas/wind.html)

Per capita, Wyoming already ranks highest in its installed wind power capacity. The ability of Wyoming to meet the electricity needs of its population entirely by wind power may not be far away.

Elaborate: Wind speeds

Wyoming is windy and has the potential to tap into these natural renewable resources. Refer to a map of wind speed in Wyoming at 50 meters (Lesson 5 Resources), the average height of a wind turbine. Ask students to assess the map and determine where they would site wind turbines. Would your school grounds be a good location to site a wind turbine? Why or why not? Why is it relevant that the map measures wind speeds at 50 m and not 0 m or 100 m? (Answer: 50-80 m is approximately the height of modern wind turbines).

Evaluate: Energy portfolios revisited

Recall the definition of an energy portfolio and description of Wyoming’s energy portfolio from Unit 1. Energy portfolios are the comprehensive list of methods that places (cities, states, nations) use to produce energy, specifically electricity.

Renewable portfolio standards (RPS), also referred to as renewable electricity standards (RES), are policies designed to increase generation of electricity from renewable resources. Currently, Wyoming does not have a set of renewable portfolio standards. Considering the past, present and future of wind energy, do you think Wyoming should adopt standards?
Lesson 5 Resources

Wind power in Wyoming

Per Capita Wind Power Capacity


Advances in Wind Power Technology

- **Late 1800s**—Wind power in North America helps farmers and ranchers pump water for irrigation and windmills generate electricity for homes and businesses.
- **Late 1890s**—The invention of steel blades for windmills makes them more efficient and more than six million windmills are erected throughout the countryside of the West.
- **1890**—Larger windmills, called wind turbines, begin appearing on hills in Denmark.
- **1940s**—The largest wind turbine begins operating on a Vermont hilltop known as “Grandpa’s Knob.” It is rated at 1.25 megawatts (MW) in winds of about 30 mph and feeds electric power to the local utility network for several months during World War II.
- **1970s**—The price of oil skyrockets and so does interest and research in wind turbines.
- **1981**—National Aeronautics and Space Administration “The Viterma Method,” which still increases the efficiency of turbines today.
- **2007**—Wind produces enough energy to power roughly 2.5 million homes and makes up 5% of the renewable energy used in the United States.
- **2012**—The amount of wind energy produced in the United States reaches the point of being able to power 15 million homes and becomes the number-one source of renewable electricity.
Evolution of Wind Turbines over Last 20 Years

- **1995-2000**: 750 kW turbine can power 225 houses per year
- **2000-2005**: 1,500 kW (1.5 MW) turbine can power 450 houses per year
- **2005-2010**: 1,800 kW (1.8 MW) turbine can power 540 houses per year
- **2011**: 7,500 kW (7.5 MW) turbine can power 5350 houses per year

**Wyoming Wind Speed at 50 m**

![Wind Speed Map](http://commons.wikimedia.org/wiki/File:Wind_turbine_size_increase_1980-2010.png)
LESSON 6: ENERGY TRANSITIONS FROM NEW TECHNOLOGY

Standards:

<table>
<thead>
<tr>
<th>Next Generation Science Standards</th>
<th>Common Core Standards</th>
<th>WY Science Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCI - Physical Science; Earth &amp; Space Science</td>
<td>ELA-Literacy.RI.11-12.7</td>
<td>SC11.3</td>
</tr>
<tr>
<td>CCC - Energy &amp; matter</td>
<td>MATH.Content.HSS.IC.B</td>
<td></td>
</tr>
<tr>
<td>SEP - Analyzing &amp; interpreting data</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Lesson Overview:
In this lesson, students will uncover the effects of technological advances on energy transitions. Students will play a coal extraction game to simulate how improved techniques have allowed for significant increases in production of coal. Students will also watch a demonstration to help understand how horizontal drilling has improved oil and natural gas extraction. Students will compare a graph showing changes in energy consumption over time with the timelines created for changes in extractive technologies and energy production. Finally, students will brainstorm about future energy production in Wyoming and revisit the question of potential energy transitions.

Guiding Question:
Do changes in technology trigger energy transitions?

Duration:
45 minutes

Materials:
Hershey’s Kisses, pudding cup, flexible straw, coffee stirrer straw, scissors, coal, oil & gas, and wind development timelines

Engage: Coal Extraction Game
This is an interactive way for students to learn about changes in coal mining techniques over time and how they have improved coal recovery. See Lesson 6 Resources for Coal Extraction Game directions.

Explore: Oil & Gas Extraction Demonstration
This demonstration uses familiar materials to help students see how oil and gas extraction strategies have changed over time to improve resource recovery. See Lesson 6 Resources for Oil & Gas Extraction Demonstration directions.

Explain: Energy transitions from technology
As we saw in Unit 1, energy transitions have occurred throughout the history of America and have caused changes to America’s energy portfolio. For example, coal-fired electricity is at its lowest point since January 1973 while wind and other renewable energy sources are starting to make up a higher
percentage share of electricity generation (See Lesson 6 Resources for image comparing changes in shares of total energy resource production over time). Policy changes have accounted for some of the transition, but a more important factor is improvements in technology. Without better technology to harness and convert diverse energy sources, policy changes alone would not be practical.

**Elaborate: Transitions and technology through time**

Give students a graph of changes in energy consumption over time. Referring back to the timelines they created for advances in coal, oil, and natural gas extraction as well as in wind power, ask students to compare how advances in technology correspond with increases in consumption of specific energy resources. See Lesson 6 Resources for Energy Consumption Over Time graph and Technological Advances Timelines

**Evaluate: Future of energy transitions**

Not only have extractive technologies improved, but so has the efficiency in converting raw materials into usable end products and services. Ask students to brainstorm new solutions for improving energy extraction or conversion techniques. What does the future of energy production look like? How much coal, natural gas, oil and wind will continue to be produced in Wyoming? How will trends in production change in the next 5, 10, or 50 years?
Lesson 6 Resources

Coal Extraction Game Directions

Materials: Hershey’s Kisses, timer

Directions: Set up “coal seams” (piles of Hershey’s Kisses) all around the classroom. Make some seams longer, some shorter, and bury some seams under textbooks. Prompt the students by telling them they are coal miners and they must try and extract as much coal as possible. Students must “process” coal by removing candy wrappers before it becomes viable. The students will play in two rounds of 3-5 minutes each. The rules in each round correspond to different extraction techniques utilized in different time periods. The end result should be that students are able to extract more coal (acquire more Hershey’s Kisses) in the second round after the rules change, indicating more advanced and improved extraction techniques.

Round 1) The year is 1888! The rules of the coal extraction game are:

- Students may only take one Kiss at a time
- After picking up a Kiss, students must take 5 steps away from the source before removing the candy wrapper
- Students may not pick up another Kiss until after they have processed (removed the wrapper) from the previous Kiss
- No lifting up textbooks to uncover buried coal seams.
- If a textbook collapses because of too much coal mining, those resources are lost and the Kisses may not be mined further

Round 2) The year is 2015! The rules of the coal extraction game are:

- Students may take up to three Kisses at a time
- Students must take two steps away from the source before removing the candy wrapper
- Students may not pick up another Kiss until after they have processed (removed the wrapper) from the previous Kiss
- Students may lift up textbooks to uncover buried coal seams.
- If a textbook collapses because of too much coal mining, those resources are lost and the Kisses may not be mined further

After round two, be sure to debrief the game with students. Ask them how their ability to recover Kisses in the second round compared to the first round. Then explain to them how this game was an analogy for changes in coal extraction technology.

Oil & Gas Extraction Technology Demonstration

Materials: Pudding cup, coffee stirrer straw, toothpick, scissors, flexible soft drink straws

Directions: Set the pudding cup on its side. Explain that the pudding is like an oil reserve and the hard plastic around the pudding cup represents layers of bedrock on top of the oil that lock it into a hard to penetrate crust, like the illustration here. Use the coffee stirrer straw as an analogy for early oil drilling technology and try to drill through the plastic side of the container. It is quite hard to do. However, as
technology improved, it became easier to drill through tough layers of bedrock to access reserves. Use a toothpick to poke and enlarge a hole in the hard plastic simulating advances in drilling technology in the early 1900s.

Explain that over the last half a century, drilling technology has advanced tremendously allowing industry to access reserves that were previously nearly inaccessible. Take a flexible soft drink straw and cut the mouthpiece at a 45 degree angle, drawing the analogy to improved technology that is able to bore through tough layers of rock. Bend the straw at a 45 degree angle and explain that horizontal drilling has been an important breakthrough in oil and gas extraction technology. This allows drilling technicians to bore into the ground miles away from the oil reserve and tap horizontally through the ground at the level of the reserve until they reach it. Simulate this by holding the straw perpendicular to the pudding cup and using the bent, cut the mouthpiece of the straw to penetrate the lid of the pudding cup, which should be on its side.

http://www.eia.gov/todayinenergy/detail.cfm?id=6550
Energy Transitions: Consumption vs. Technology

Technological Advances Timelines

**Advances in Coal Mining Technology**
- 1600s - 1800s: Digging by hand, some explosives
- 1800s: Developing more advanced mining equipment, such as drills, lifts and steam-powered pumps
- 1839: Steam shovel is invented and becomes instrumental in mechanizing surface coal removal
- 1866: Surface mining becomes more practical and popular; horse-drawn ploughs are used to remove layers above coal seams
- 1937: The shuttle car is invented
- 1961: Coal becomes the primary source for electricity production
- 1990: US coal production tops 1 billion tons for the first time

**Advances in Oil and Gas Mining Technology**
- Early 1800s: Vertical Percussion Drilling
- 1830: Vertical Rotary Drilling
- 1929-1980s: Directional/Slant Drilling
- 1947: Experimental hydraulic fracturing is developed
- 1970s: Horizontal Drilling
- 1990s: Hydraulic fracturing activity increases
Advances in Wind Power Technology

- Late 1800s–Wind power in North America helps farmers and ranchers pump water for irrigation and windmills generate electricity for homes and businesses.
- Late 1890s–The invention of steel blades for windmills makes them more efficient and more than six million windmills are erected throughout the countryside of the West.
- 1890–Larger windmills, called wind turbines, begin appearing on hills in Denmark.
- 1940s–The largest wind turbine, known as “Grandpa’s Knob,” begins operating in Vermont. It is rated at 1.25 megawatts in winds of 30 mph and feeds electric power to the local utility network for several months during World War II.
- 1970s–The price of oil skyrockets and so does interest and research in wind turbines.
- 2007–Wind produces enough energy to power roughly 2.5 million homes and makes up 5% of the renewable energy used in the United States.
- 2012–The amount of wind energy produced in the United States reaches the point of being able to power 15 million homes and becomes the number-one source of renewable electricity.
SUMMATIVE ASSESSMENT: ORAL HISTORY PROJECT

*To be completed at the end of the unit

Standards:

<table>
<thead>
<tr>
<th>Next Generation Science Standards</th>
<th>Common Core Standards</th>
<th>WY Social Studies Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEP - Obtaining, evaluating &amp; communicating information</td>
<td>ELA-Literacy.SL.11-12.1</td>
<td>SS12.4.2</td>
</tr>
<tr>
<td></td>
<td>ELA-Literacy.W.11-12.3</td>
<td>SS12.4.5</td>
</tr>
<tr>
<td></td>
<td>ELA-Literacy.RI.11-12.7</td>
<td>SS12.5.4</td>
</tr>
<tr>
<td></td>
<td>MATH.Content.HSS.IC.B</td>
<td>SS12.6.1</td>
</tr>
</tbody>
</table>

Instructions:

Students should conduct their own oral history project by interviewing a family or community member about their interaction with the energy industry and present their findings to the class. The report should include:

- Where the person works and in what type of energy resource field?
- What that person's role is?
- How long he/she has been working in the industry?
- How he/she first became involved in the industry?
- What he/she thinks about their job; Do they like it or dislike it and why?
- Why does he/she think their job is important? What need does it fill?
- What changes, if any, has he/she seen in their industry over their life?
- What does he/she think is the future of energy in Wyoming?