UNIT 1: ENERGY IN CONTEXT

Understanding personal place in the energy conversation

CONTENTS

OVERVIEW

The goal of this introductory unit is to make the energy discussion more meaningful by setting it in the context of personal energy consumption and moving outward. As students uncover their own energy usage in the form of electricity, they will also begin to look at trends in energy consumption at the state, national, and global scales. Students will understand that electricity is a primary method of electricity consumption and the various sources of energy that are used to create electricity. Students will complete a lab in which they build a simple electric generator to help demonstrate how primary energy sources - coal, natural gas, wind, etc. - are used to generate electricity.

Additionally, students will compare energy consumption by sector as they examine the energy profiles of countries around the world in relation to each other, to the United States, and to the state of Wyoming. Students will look at changing trends in energy consumption over time and discuss potential future changes to the local and global energy portfolios. Students will also be introduced to Wyoming's energy portfolio and discover how valuable the future of energy production really is, not only to the state but also nationally and globally.

ESSENTIAL QUESTION

- How do I use energy? Why does it matter?

ESSENTIAL UNDERSTANDING

- Students will understand their position in the energy puzzle at multiple scales.

DURATION

Seven or eight 45 minute lessons

STANDARDS

Next Generation Science Standards

- **Disciplinary Core Ideas**
  - Physical Science
  - Engineering
  - Earth & Space Science
- **Crosscutting Concepts**
  - Patterns
  - Energy & matter
  - Scale, proportion & quantity
  - Systems & systems models
  - Stability & change
- **Science and Engineering Practices**
  - Analyzing & interpreting data
  - Using mathematical & computational thinking
  - Constructing explanations & designing solutions
  - Obtaining, evaluating & communicating information
  - Engaging in arguments from evidence

- **Connection to Nature of Science**
- **Connection to Engineering, Technology, and Applications**

Wyoming Science Standards
- SC11.1.13
- SC11.2
- SC11.2.2
- SC11.2.3
- SC11.2.5
- SC11.3
- SC11.3.1
- SC11.3.2

Wyoming Social Studies Standards
- SS12.3.1
- SS12.3.3
- SS12.3.5
- SS12.4.1
- SS12.4.2
- SS12.5.1
- SS12.6.1

Common Core Math Standards
- CCSS.MATH.Content.HSF.LE.A.3
- CCSS.MATH.Content.HSF.IF.B.4
- CCSS.MATH.Content.HSS.IC.B
- CCSS.MATH.Content.HSF.LE.A.1.B

Common Core Literacy and Writing Standards
- CCSS.ELA- Literacy.SL.11-12.1
- CCSS.ELA- Literacy.RI.11-12.7
- CCSS.ELA- Literacy.W.11-12.1
- CCSS.ELA- Literacy.RST.11-12.2
- CCSS.ELA-Literacy.RST.11-12.3

OBJECTIVES

Science and Energy Literacy
- Students will recognize electricity production as only one part of energy consumption.
- Students will understand how electricity is produced from primary energy sources.
- Students will be able to identify a variety of energy sources and their uses common today.
- Students will know how energy consumption has changed over time in the US.

Stewardship and Community
- Students will assess their own use of energy in the form of an electricity inventory to better

understand their role in the energy discussion.
- Students will identify how energy is used by different sectors (transportation, residential, commercial, and industrial) of the economy at state, national, and global scales.

STEM Careers and Leadership Development
- Students will be aware of different energy sources, how each serves to produce electricity, and the niches they fill in the energy economy.

Place
- Students will be able to identify similarities and differences in local, national, and international energy consumption.
- Students will recognize Wyoming's capacity for energy production based on its wealth of energy producing resources.

Applied Problem Solving & 21st Century Skills
- Students will be able to scale energy use to determine it at a larger scale.
- Students will discuss proportions in terms of their own energy use in a larger system.
- Students will be able to interpret charts, graphs, and maps to determine energy production potential in Wyoming compared to the rest of the United States.

ASSESSMENT EVIDENCE

Diagnostic:
At the beginning of the unit, students will demonstrate understanding by:
1. Writing a comprehensive list identifying the different ways they use energy.
2. Creating a concept map to uncover their prior understanding of sources of energy, energy consumption, and energy production methods.
3. Drawing a representation of how they perceive energy consumption by sector in the US.

Formative:
During lessons, students will demonstrate understanding by:
1. Adding to their concept map as they develop new understandings of energy sources, production, and consumption.
2. Exploring, discussing, and evaluating online resources from the Energy Information Administration that display data on energy consumption trends by source and by sector in the United States.

Summative:
By of the unit, students will demonstrate understanding by:
1. Creating a simple electric generator and being able to explain how it relates to electricity production on a larger scale.
2. Presenting on America's future potential energy portfolio based on trends in energy production and consumption over time.
3. Comparing and contrasting energy consumption by sector at state, national, and global scales to explain trends that exist.

DIAGNOSTIC & FORMATIVE ASSESSMENT: CONCEPT MAPPING

***To be completed at the beginning of the unit**

Standards:

Next Generation Science Standards	Common Core Standards	WY Science Standards
DCI - Physical Science; Earth & Space Science **CCC -** Patterns **SEP -** Developing & using models; Obtaining, evaluating & communicating information	ELA-Literacy.RST.11-12.2 MATH.Content.HSS.IC.B	SC11.1.13 **WY Social Studies Standards** SS12.6.1

Materials:

Student notebooks with on-going concept map, example concept map, pens of different colors

Instructions:

Ask each student to create a concept map for their current understanding of energy. During the first round of concept mapping, ask the students to write down what they know in black ink. The concept should be in a spot that the student can refer back to because they will be asked to add to it in other lessons. In each subsequent round of concept mapping, have the students use ink of a different color to show progression of understanding over time. The goal is to keep an evolving concept map of energy throughout this unit.

A concept map uses phrases describing relationships that connect key ideas or themes. Provide students with an example so they understand how to connect concepts using prepositions and phrases. An example using Harry Potter can be found here: http://www.scy-lab.eu/content/en/mission1/LAS_Reporting_expert/Assignments/A_Expert_cmap_3.html

LESSON 1: PERSONAL ELECTRICITY INVENTORY

Standards:

Next Generation Science Standards	Common Core Standards	WY Science Standards
DCI - Physical Science **CCC -** Scale, proportion & quantity **SEP -** Analyzing & interpreting data; Using mathematical & computational thinking	ELA-Literacy.RST.11-12.2 MATH.Content.HSS.IC.B	SC11.3 **WY Social Studies Standards** SS12.3.5

Lesson Overview:

In this lesson, students will begin to understand energy consumption by way of understanding electricity usage and their own electricity consumption patterns. Students will make a list of all of the things in their lives that use energy, especially electricity. For homework, they will be asked to take inventory of all the things in their home that use electricity. The outcome of creating this inventory is that students will recognize how important electricity, and therefore energy, are in our day-to-day lives, making these lessons relevant and meaningful.

Guiding question:

How much electricity do I use and how does it compare to the average American?

Duration:

45 minutes

Materials:

Assorted appliances, computer with internet access and projector or printed resources, personal electricity inventory worksheet, calculator, Kill-A-Watt Electricity Usage Meter

Engage: What uses energy?

Have students collaborate to create a comprehensive list of all of the things they use in their day-to-day lives that require energy.

Explore: Electrical appliances

Set up stations around the room and have students look at different appliances for electricity ratings and use a Kill-A-Watt Electricity Usage Meter to see how many watts the appliance uses and how that corresponds with the energy rating. Students can fill out a worksheet with the appropriate appliance name and corresponding rating. Then ask the students to respond to the following questions: What do the numbers and units on a rating signify? What does a rating tell us? Which appliance uses the most/least electricity?

Note: To use a Kill-A-Watt Electricity Usage Meter, plug the meter into a wall socket, and then plug an appliance into the meter to measure its voltage, current, and watts. Keep the appliance plugged in for a whole class period to measure its kilowatt hour usage.

Explain: Measuring electricity

For the students who don't drive cars, probably the largest number of things that use energy will be appliances that require electricity. Electricity usage is measured in terms of kilowatt hours (kWh), or the equivalent of a consumption rate of 1,000 watts of energy per one hour. A watt is a standard unit of electrical potential in a circuit. The typical US house uses approximately 903 kWh per month or approximately 347 kWh per person per month.

Elaborate: Electricity consumption

The U.S. Energy Information Administration describes how electricity is used in a typical US home: http://www.eia.gov/tools/faqs/faq.cfm?id=96&t=3 It is also detailed in print in the attached **Lesson 1 Resources**. Give students the opportunity to explore the information on this website (digitally or printed). What accounts for the most electricity consumption? What accounts for the least? Why do the students think this is?

Evaluate: Interpreting electricity consumption data

This website shows averages only. The downfall of using averages is that they compile everything and often cannot show trends. How do students think these percentages compare to their own electricity usage? How might the percentages change depending on where people choose to live in the US?

Extend: Electricity inventory

As homework have students complete their own energy inventories. Students should fill out a worksheet (See **Lesson 1 Resources**) answering what appliances they use and how much electricity (in Watts) each appliance uses. The worksheet should also have space to help the students convert watts into electricity use per day.

LESSON 1 RESOURCES

Estimated U.S. Residential Electricity Consumption by End Use, 2012

End Use	Quadrillion Btu	Billion kilowatthours	Share of total
Space cooling	0.85	250	18%
Lighting	0.64	186	14%
Water heating	0.45	130	9%
Refrigeration	0.38	111	8%
Televisions and related equipment [1]	0.33	98	7%
Space heating	0.29	84	6%
Clothes dryers	0.20	59	4%
Computers and related equipment	0.12	37	3%
Cooking	0.11	31	2%
Dishwashers	0.10	29	2%
Furnace fans and boiler circulation pumps	0.09	28	2%
Freezers	0.08	24	2%
Clothes washers	0.03	9	1%
Other uses	1.02	299	22%
Total consumption	4.69	1,375	

Source: Energy Information Administration http://www.eia.gov/tools/faqs/faq.cfm?id=96&t=3

Electricity Inventory Worksheet

Electricity Cost

Cost of electricity in my area is $ ____ per kWh

Electricity in my area is produced from (circle one) coal / natural gas / wind / hydro / nuclear.

Electricity Consumption

Appliance	**kWh rating** (kWh)	**Time used / day** (hrs)	**kWh used / day** (kWh * hrs)	**Cost / day** (kWh / day * cost / kWh)
	Total			

Discussion Questions

1. Estimate how much electricity you use on a daily basis.

2. Is the inventory conducted above an accurate estimate of your daily electricity consumption? Why or why not?

3. Which appliance uses the most electricity?

4. Make a suggestion for how to save money from electricity costs on a monthly basis.

5. The cost of electricity varies by state. Do some research to determine how much this inventory would cost in other states like Hawaii, New York, or California?

LESSON 2: SCALING UP PART 1: ELECTRICITY USE LOCALLY & NATIONALLY

Standards:

Next Generation Science Standards	Common Core Standards	WY Science Standards
DCI - Physical Science **CCC -** Scale, proportion & quantity; Energy & matter **SEP -** Analyzing & interpreting data; Using mathematical & computational thinking	ELA-Literacy.RST.11-12.2 MATH.Content.HSS.IC.B	SC11.1.13 SC11.3 SC11.3.2 **WY Social Studies Standards** SS12.3.5 SS12.3.1

Lesson Overview:

In this lesson, students will learn how electricity is measured and begin to understand electricity use at different scales. They will use math techniques to find ratios and proportions as they extrapolate their own electricity usage as part of the bigger picture. Using the same skills, they will be able to convert electricity usage from kilowatt hours of electricity into the amount of raw materials required to produce it. Students will understand that electricity is created using inputs from primary energy sources, and will also discuss the implications of what will happen to electricity production when the amount of primary energy sources declines.

Guiding question:

How much electricity do we use at various scales and where does it come from?

Duration:

45 minutes

Materials:

Personal electricity inventory worksheet from Lesson 1, student notebooks, computer with internet, projector, calculators

Engage: Personal electricity inventory

Review the personal electricity inventory worksheets from Lesson 1. Make sure students have completed worksheets by converting their results into kilowatt-hours (kWh). Divide students into small groups and have them share their results with others to make comparisons with other group members. Share back with the class to see if there are any common trends. Student can also revisit the U.S. Residential Electricity Consumption chart from Lesson 1 to make comparison.

Explore: Scale up!

Prompt students with the question: If everyone in Wyoming used as much electricity everyday as you did, how much would it be? What about in the country?

Discuss as a class how to solve these problems (by multiplying individual consumption by the number of individuals) and provide the correct population number for a multiplier. In 2013, population of Wyoming = 582,658; population of United States = 316,448,990. What does this number mean in terms of electricity, and ultimately energy consumption? How close to reality is this estimate?

Explain: Energy for electricity production

Understanding electricity consumption is a major part of understanding overall energy consumption. Because electricity can't be mined from the ground like coal or captured from moving air like wind, it is called a secondary source of energy, meaning that it is derived from primary sources. Electricity is created by converting the kinetic energy of a spinning turbine into something more useful using a device called a transformer. A variety of fuel sources are used to power the spinning of a turbine.

Follow a diagram to explain how raw materials (primary energy sources) are transformed into electricity (See diagram in **Lesson 2 Resources**). To make electricity, an energy source enters a power plant and is combusted; purified water is turned to steam by the heat. The pressure of the steam is then forced across a turbine causing it to spin. The turbine is connected to a generator that also spins and produces energy that is converted in a transformer to usable electricity. In the case of hydro and wind power, the process is similar but does not involve combustion of any fuel to cause a turbine to spin a generator.

Elaborate: How much energy for electricity?

Electricity is usually measured in kilowatt-hours (kWh). One kWh represents the amount of energy needed by a 1000-Watt device such as a clothes-iron or a microwave oven to operate for one hour. Leaving a 100-watt light bulb on for 10 hours consumes 1 kilowatt (kWh) of energy.

We know that electricity is created by consuming other raw materials of energy, but exactly how much of those other energy sources do we need to use to create the electricity we consume? If we know kilowatt hours consumed, we can use simple conversions to determine how much raw material was used to produce a specific amount of kilowatt hours of electricity.

Using each student's personal electricity inventory (including kWh consumed per day) have the students find how much coal, natural gas, and/or petroleum they consume each day to meet their needs. Conversion units can be found at: http://www.eia.gov/tools/faqs/faq.cfm?id=667&t=3 or below:

- Amount of fuel used to generate 1 kWh of electricity:
  - Coal = 1.09 pounds
  - Natural gas =1,000 cubic feet
  - Petroleum = 0.08 gallons

Note: To make this place-based, ask students to research where their electricity comes from. Almost all power plants in Wyoming are coal powered, so ask students to determine how much coal they consume each day to meet their electricity consumption needs. See **Lesson 2 Resources** and visit http://www.wsgs.wyo.gov/public-info/onlinepubs/Electrical-Generation.aspx for information on Wyoming's electricity production portfolio.

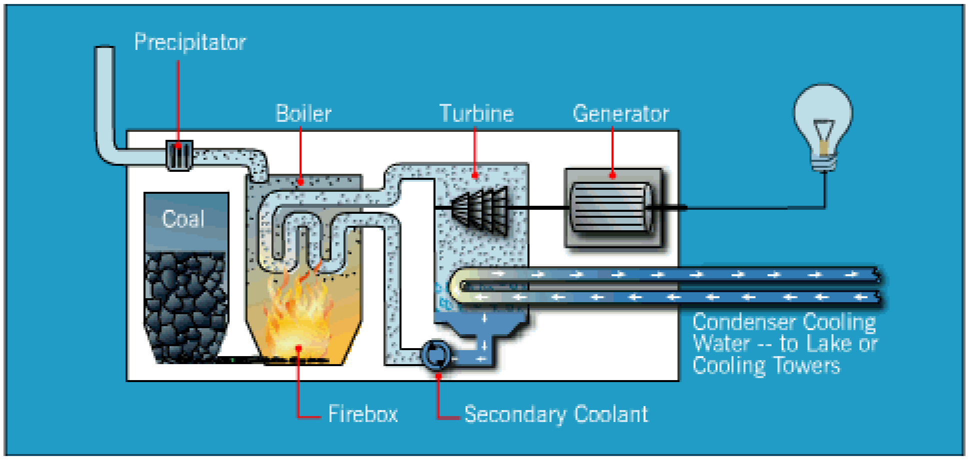
Evaluate: Electricity production in the future

In 2012, the U.S. residential sector (US households) consumed about 1,375 billion kWh of electricity. Experts predict a 26% increase in the demand for electricity in the United States by 2030. Increasing demand for electricity means an increasing demand for the sources of fuel that create electricity.

Conclude class with a discussion. Ask students to think, pair, share what will happen to different sources of energy for electricity production if demand for electricity rises 26% by 2030 as expected?

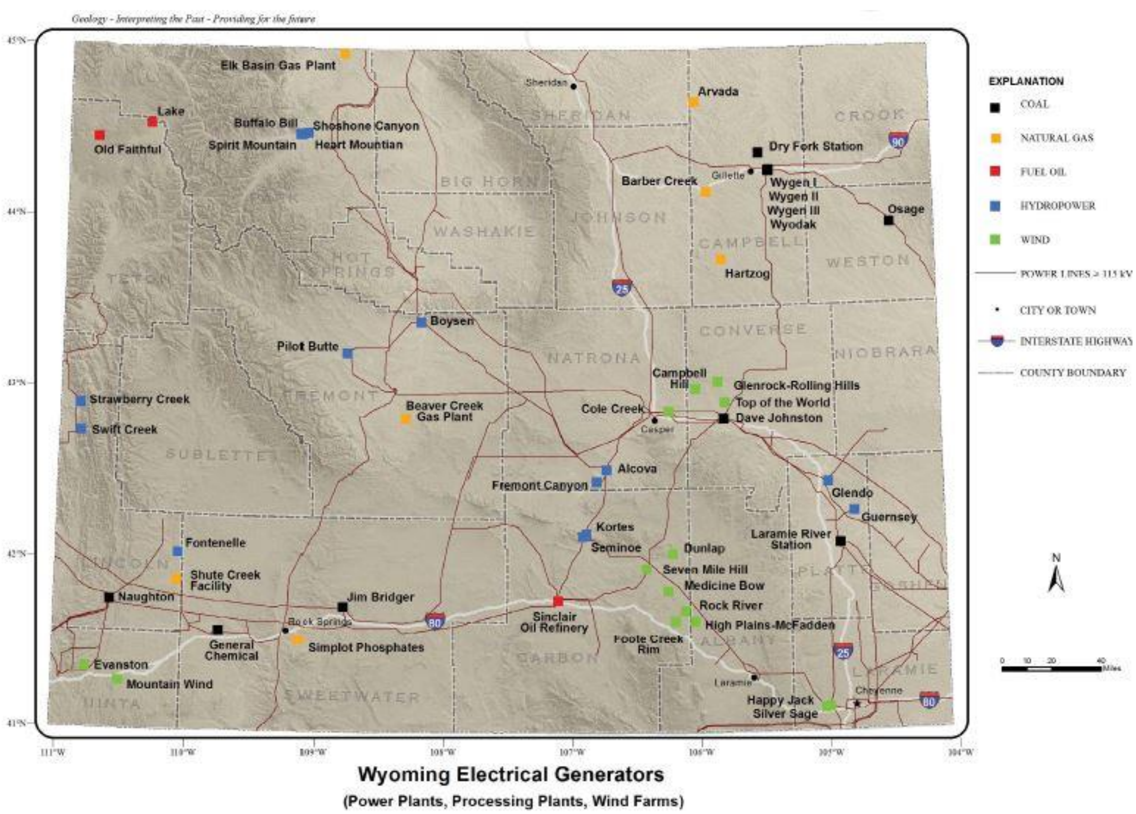
LESSON 2 RESOURCES

Electricity production from a power plant



Visit http://www.duke-energy.com/about-energy/generating-electricity/coal-fired-how.asp to see this image as an interactive simulation

Wyoming Power Plants



Source: http://www.wsgs.wyo.gov/public-info/onlinepubs/docs/ElectricalGenMap.pdf

LAB 1: BUILD AN ELECTRIC GENERATOR

Standards:

Next Generation Science Standards	Common Core Standards	WY Science Standards
DCI - Physical Science; Engineering **CCC -** Systems & systems models; Energy & matter **SEP -** Constructing explanations/ Designing solutions	ELA-Literacy.RST.11-12.3 MATH.Content.HSF.LE.A.1.B	SC11.2 SC11.2.2 SC11.2.3 SC11.2.5 **WY Social Studies Standards** SS12.4.2

Lesson Overview:

In this lesson students will develop a clearer understanding of electricity production by building a simple generator. By spinning magnets inside the generator, students will understand the role of a turbine in creating electricity. Manually spinning the magnets to generate electricity will demonstrate that electricity is a secondary energy output that requires inputs from primary energy sources.

Guiding Question:

How do we get electricity?

Duration:

45-90 minutes

Materials:

Cardboard, rectangular ceramic magnets, magnet wire (thinner is better), 16 penny nail, incandescent light bulb (Radio Shack 12V/25mA mini lamp), digital multimeters

Background Information:

According to the theory of electromagnetism changes in an electric fields induces changes in a magnetic fields, and vice versa, changes in a magnetic field induces changes in an electric field. In this experiment the spinning magnets induce a magnetic field that creates an electric field and in turn causes electricity to flow. The electricity made with the small electric generator is the exact same electricity that flows through the power lines in a city and into the electrical sockets of a house. The only difference is size. This generator fits in your hand but a city's power probably comes from enormous 400+ megawatt coal fired power plant located hundreds of miles away.

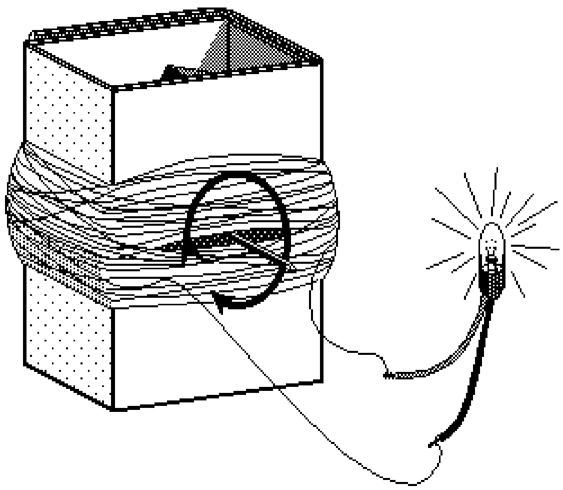
Engage: Types of electricity generators

Watch video clips or look at diagrams of turbines generating electricity from various types of electricity production strategies (see **Lab 1 Resources** for links to videos and diagrams). Break students into partners or small groups and have them become "experts" on a specific type of electricity generation. Ask students to draw a diagram of each type of production method and share back with the class. When finished, the class as a whole can compare and contrast the different methods. Have students reflect on the following questions: How do the methods compare and contrast? Which method seems to be the most efficient and why?

Explore: Build an electric generator

Students can complete this project individually or in groups of 2-3. Watch this video on Youtube for an explanation and to see you it's done (https://www.youtube.com/watch?v=k7Sz8oT8ou0)

Diagram of Electric Generator



Explain: Electricity generation

All methods of electricity generation (except for solar) have something in common - the spinning of a generator. A generator is built essentially the same way as this example - with powerful magnets and coils of wire. Wire, being made of metal, is ionic and contains free floating electrons. Typically, the electrons in the wire are stationary or move very little, but as the wire moves in and out of a powerful magnetic field, the electrons become excited begin to move, creating what is called an "induced current." This is what happens when we spin the nail in this simple generator with the magnets attached. Spinning the magnets causes the magnetic field to move in relation to the wire. The thinner the wire and the stronger the magnets, the faster the electrons will move. As the electrons move through the light bulb, they jump from one filament to the other, which is what we see as light. Faster moving electrons means more electrons jumping from filament to filament which in turn means more visible light.

In order to get a generator to spin, there needs to be some sort of energy input, which can be the result of burning of fuel to create steam that blows past a turbine, or the result of a naturally occurring form of energy like wind that spins blades or water falling over a generator. In order for the generator to spin enough to create usable electricity, it must be a very large generator and must move a lot more than we could do with just our hands.

Elaborate: Experiment with efficiency of electricity generation

Generating electricity takes a lot of inputs from other energy sources because it is not entirely efficient. It takes energy to make energy and efficiency of energy production is considered to be the amount of energy input that is lost during production and not converted to the end product, electricity.

Coal, nuclear, and natural gas power plants use steam to spin their turbines and turning water into steam requires a lot of energy. Additionally, a lot of energy that could be used as electricity is lost in the process as heat, which is generated by the friction of a spinning turbine.

Give students an opportunity to experiment with generator designs to see if they can improve efficiency. Manipulate the generator by trying different size magnets, increasing or decreasing the number of coils, using mini lamps with different amperage and voltage ratings, putting the nail through a straw to spin (decreasing friction), or using material other than cardboard. Use a digital multimeter to test outputs. Make sure students summarize or draw their design changes and then record the results. For a challenge, see if students can find a correlation between changes to design and outputs (e.g. number of coils of wire and electricity output)

Evaluate: Improving efficiency

Ask students to share the results of their experiments, and as a class brainstorm ways to make electricity generation more efficient.

Extend: Energy engineering

Many types of engineers work on improving energy production including materials, mechanical, civil, etc. For homework, assign the students to a group project where each group assumes the role of one type of engineer. Ask the students to draft a report on how to improve electricity generation. For this example,

- Materials engineers should recommend improved materials (cardboard, nail, ceramic vs. neodymium magnets etc.)
- Civil engineers should report on structural improvements (square shape vs. others, etc.)
- Mechanical engineers should recommend improved internal working of the generator, or how all the parts work together (type and number of wire coils, rotation of the nail, type of bulb, etc.)

Resources:

- Kid Wind's version of the generator lab has ideas for how to vary the activity http://learn.kidwind.org/sites/default/files/windwise/V2/Lesson-9.pdf

LAB 1 RESOURCES

Energy Production Resources

- Coal to electricity: http://teachcoal.org/energy-and-you/how-coal-is-converted-to-electricity/
  - http://2012books.lardbucket.org/books/principles-of-general-chemistry-v1.0/section_09/9c60f0031161edce4231dfbb04225a80.jpg
  - https://www.youtube.com/watch?v=GI7AhajfhWE
- Natural gas to electricity
  - http://holbert.faculty.asu.edu/eee463/combustion_turbine.gif
- Nuclear power plants
  - http://www.45nuclearplants.com/images/Nuclear_Plant.gif
  - https://www.youtube.com/watch?v=_UwexvaCMWA
- Hydropower
  - http://inwallspeakers1.com/wp-content/uploads/2014/03/hydroelectric-energy-diagram.jpg
- Wind power
  - http://www.south-ayrshire.gov.uk/images/wind_turbine_drawing.jpg

LESSON 3: SOURCES OF ENERGY: MORE THAN ELECTRICITY

Standards:

Next Generation Science Standards	Common Core Standards	WY Science Standards
DCI - Physical Science **CCC -** Patterns; Scale, proportion & quantity **SEP -** Obtaining, evaluating & communicating information; Analyzing & interpreting data	ELA-Literacy.RST.11-12.2	SC11.1.13 **WY Social Studies Standards** SS12.4.2

Lesson Overview:

In this lesson, students will expand their understanding of energy consumption as more than just electricity generation by exploring various online resources provided by the Energy Information Administration and National Academies of Sciences, including a comprehensive and interactive flow chart of energy use in the US. Students will create an on-going concept map to identify preconceptions of energy in general and track the evolution of their understanding of energy, energy consumption, and energy production.

Guiding Question:

What other purposes does energy production serve in addition to making electricity?

Duration:

45 minutes

Materials:

Student notebooks with on-going concept map, computer with internet, projector, and ideally computer access for small groups of students

Engage: Other types of energy

Explain that electricity production is a major consumer of all primary energy sources, but it is still only one way we can use energy. Ask students to revisit their energy concept maps and determine what other types of end products require energy inputs.

Explore: Energy sources

In the US, 40% of energy from all sources is used to generate electricity. As a class or in small groups, use prior knowledge to create a list of all energy sources. Ask students to guess what sources they think are the most common, what are the most useful, and what sources are used to generate the most electricity.

Explain: Electricity generation by sources

Percent shares of total electricity generation in 2013 were (From Energy Information Administration http://www.eia.gov/tools/faqs/faq.cfm?id=427&t=3):

- Coal 39%
- Natural Gas 27%
- Nuclear 19%
- Hydropower 7%
- Other Renewable 6%
  - Biomass 1.48%
  - Geothermal 0.41%
  - Solar 0.23%
  - Wind 4.13%
- Petroleum 1%
- Other Gases < 1%

Two-fifths of US energy from all sources is used to generate electricity with nearly 40% coming from coal and nearly 30% coming from natural gas. That means electricity production in the US uses about 90% of America's coal and nearly 30% of its natural gas. Resource: http://needtoknow.nas.edu/energy/energy-sources/

Elaborate: Energy systems

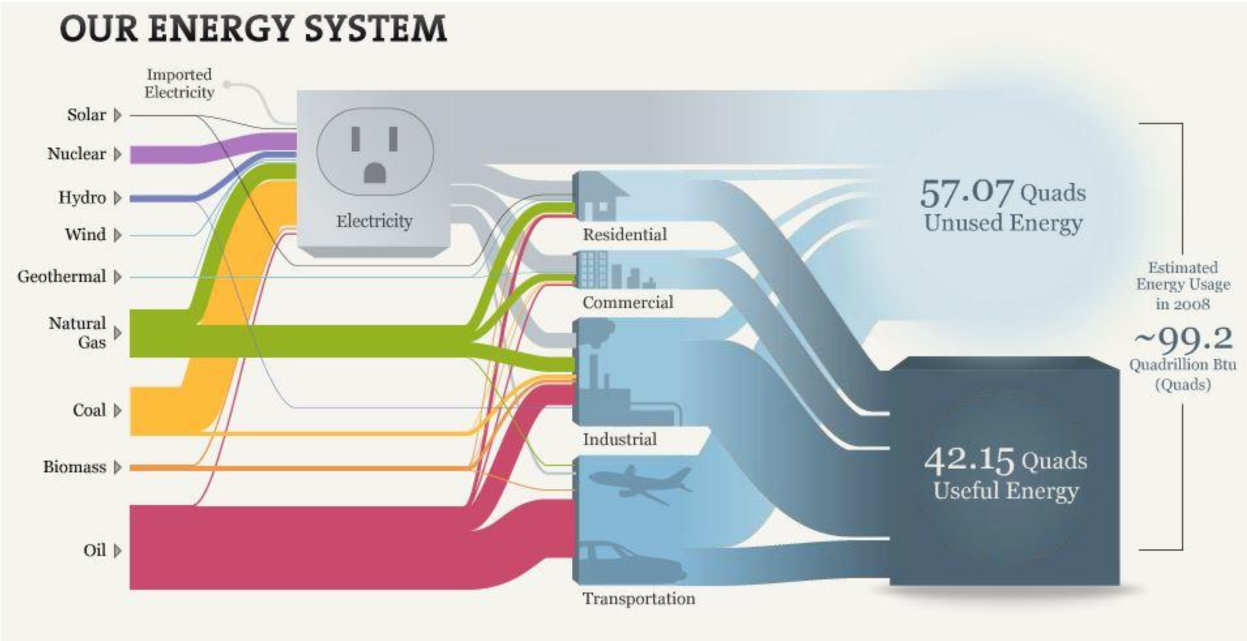
The National Academy of Science has created an interactive flowchart of energy use in the US based on data from the US Energy Information Administration.

Use their website or the image in the attached **Lesson 3 Resources** to determine what other energy uses there are in addition to electricity production: http://needtoknow.nas.edu/energy/interactive/our-energy-system/ Ask students to record and discuss any trends they see in the flow chart or anything they find surprising about energy sources and/or patterns of energy consumption.

Evaluate: Concept map

Ask students to revisit their energy concept maps and add to them with new information about energy sources and uses.

LESSON 3 RESOURCES



Source: National Academies of Sciences

http://needtoknow.nas.edu/energy/interactive/our-energy-system/

How to read this flow chart:

Each energy source on the left side corresponds with a line. The thickness of the line indicates the proportion of that energy source that goes to each of the different sectors of consumption. For example, follow natural gas. The width of the natural gas line is smaller than coal but bigger than hydropower indicating it accounts for energy sources somewhere in the middle of all energy sources. About one-third of natural gas goes to electricity production and the rest goes mostly to residential, commercial, and industrial sectors with a little partitioned for transportation. If you look at electricity, you can see that most of the output is in unused energy (often lost as heat in production). The rest is split between residential, commercial, and industrial with a little going to transportation. Looking at transportation, it is largely dependent on oil.

LESSON 4: SCALING UP PART 2: ENERGY USE GLOBALLY

Standards:

Next Generation Science Standards	Common Core Standards	WY Science Standards
DCI - Physical Science **CCC -** Patterns; Stability & change **SEP -** Analyzing & interpreting data; Constructing explanations/ designing solutions; Obtaining, evaluating & communicating information	ELA-Literacy.RST.11-12.2 MATH.Content.HSS.IC.B	SC.11.3.1 **WY Social Studies Standards** SS12.5.1

Lesson Overview:

In this lesson, students will explore global energy demands through an examination of diverse countries around the world. Students will evaluate a country's energy resources and usage, and then discuss some reasons that may explain the trends between developed and developing nations. The takeaway from this activity is to understand global energy demands, what causes them, how they might change in the future, and brainstorm solutions for meeting future global energy demands.

Guiding Question:

What is energy usage like globally?

Duration:

45 minutes

Materials:

Projector, computer with Internet, whiteboard

Engage: Earth at Night

Project the NASA video clip of the Earth at Night. This video provides a visual representation of electricity use across the world. It is important to encourage students to watch the video* or http://www.nasa.gov/mission_pages/NPP/news/earth-at-night.html and answer the following questions:

1. Do you notice any patterns in energy usage from the images of the world at night?
2. What does this tell you about access to energy and/or electricity worldwide?

*If the video is unavailable it may be accessed through You-Tube:

Explore: International energy profiles

Assign pairs of students to a country. Ask them to visit the CIA World Fact Book to gather information on their country's economy, population, energy consumption and production, as well as CO2 emissions using the Country Profile worksheet in the attached **Lesson 4 Resources**. If no computers are available, pick countries ahead of time and print off highlights from their world fact sheets for the students.

Explain: World energy outlook

In 2010, the World Energy Outlook reported that 20% of the global population (approximately 1.4 billion people) lacked access to electricity and 40% (approximately 2.7 billion) relied on wood or another form of biomass for cooking. While, the United States consumed 3.88 trillion kWh of electricity in 2010, second only to China. With 5% of the total world population, the U.S. consumes 20% of the electricity.

Elaborate: Global energy patterns

Ask students to share their country's information and keep notes on the board. After reviewing information for all the countries, ask students to respond to the following questions: What patterns do you notice in energy sector in relation to economy and vice versa. The goal is to compare developed and developing countries.

Show students the image of worldwide household electricity use in the **Lesson 4 Resources** and discuss why world electricity use is so much lower than the US.

Evaluate: Future world energy consumption

Explain to students that the consumption of energy worldwide is projected to rise by 50% between 2006 and 2030. Discuss: What does this indicate for future energy demands at the global level? What issues, if any, do they see potentially arising in relation to energy demands and production?

LESSON 4 RESOURCES

Country Profile Worksheet

Population: People and Society

Currently, your country ____________________ has a total population of ________________ people. The country's population is growing at a rate of __________%. The average life expectancy for men is_____________ years and for women ___________ years.

Economics

In __________ (year), your country's GDP (gross domestic purchasing power) was estimated at $_________________, which makes it the ___________ largest economy in the world. The economy was made up of _________% Agriculture, _________% Industry, and __________% Services.

Approximately _____________% of the population is below the poverty line. The nation exported $_____________in goods and imported $ _____________ in the same year.

Energy Sector: Energy

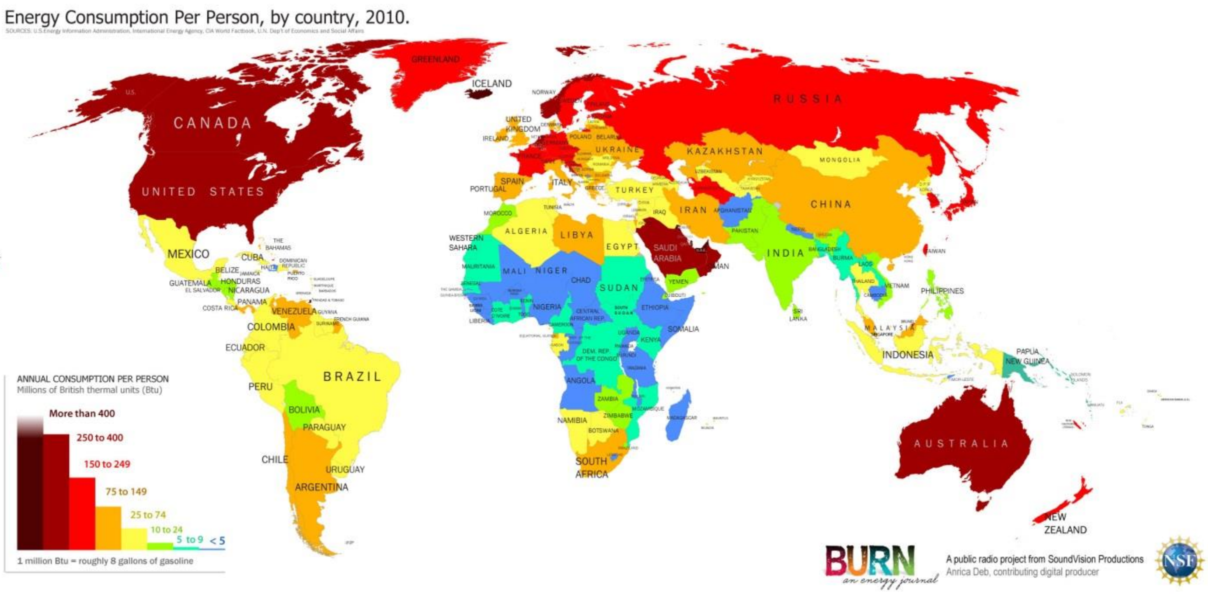
Your country used a total of ____________ kWh of electricity. Fossil fuels provided ___________% of your country's electricity. Nuclear power provided___________ %. Currently, renewables play a major / minor [circle one] role in your country's energy mix.

Your country is / is not [circle one] a major producer of primary energy. In __________ (year) the reserves for your country's crude oil was _______________ and reserves for natural gas was _______________.

Greenhouse Gas Emissions

Your country emitted ____________of CO2 in __________ (year).

World Energy Consumption Patterns



Source: Sound Vision and American Public Media

http://burnanenergyjournal.com/tag/world/

LESSON 5: ENERGY CONSUMPTION BY SECTOR

Standards:

Next Generation Science Standards	Common Core Standards	WY Science Standards
DCI - Physical Science **CCC -** Patterns; Scale, proportion & quantity **SEP -** Analyzing & interpreting data; Obtaining, evaluating & communication information	ELA-Literacy.RST.11-12.2 MATH.Content.HSS.IC.B MATH. Content.HSF.LE.A.3 MATH. Content.HSF.IF.B.4	SC11.3 **WY Social Studies Standards** SS12.3.3 SS12.4.1

Lesson Overview:

In this lesson, students will look at energy consumption trends across different sectors in the United States and discuss critical features of each sector that might indicate how or why it requires energy the way it does. Students will also compare energy consumption by sector at various scales including state, national, and global levels to find trends in consumption. Students should understand that consumption by sector varies at different scales depending on what sector of the economy is favored at that scale.

Guiding Question:

Where is energy consumption happening in the US? In the world? In Wyoming?

Duration:

45 minutes

Materials:

Student notebooks, Energy Consumption by Sector for the US, Wyoming, and globe (digital or printed)

Engage: Energy consumption by sector

Provide students with a list of labels corresponding to different parts of the economy (residential, commercial, industrial, transportation) and ask them to draw their own pie chart that divvies out what they assume to be an appropriate representation of energy use in the US. Ask them to identify and justify the sectors they think use the most and least energy.

Students can explore this website to understand more about energy use per sector: http://needtoknow.nas.edu/energy/energy-use/

Explore: Energy in the economy

Compare students' preconceptions with reality. Look at a breakdown of energy consumption by sector in the US in 2011 (See **Lesson 5 Resources**). Ask students to discuss the following questions in small groups: How do different sectors of the US economy differ in terms of their energy consumption? Why do you think that is? How does this compare with what you assumed?

Explain: Residential, commercial, transportation and industrial sectors

We divide our energy use among four economic sectors: residential, commercial, transportation, and industrial. Heating and cooling our homes, lighting office buildings, driving cars and moving freight, and manufacturing the products we rely on in our daily lives are all functions that require energy. If projections are correct, we're going to keep needing more energy. In the United States alone, energy consumption is expected to rise 13% by 2030. Global consumption is expected to increase by 44% over the same time period. See attached **Lesson 5 Resources** for chart showing changes in U.S. energy consumption by sector over time.

Elaborate: Energy consumption by sector at geographic scales

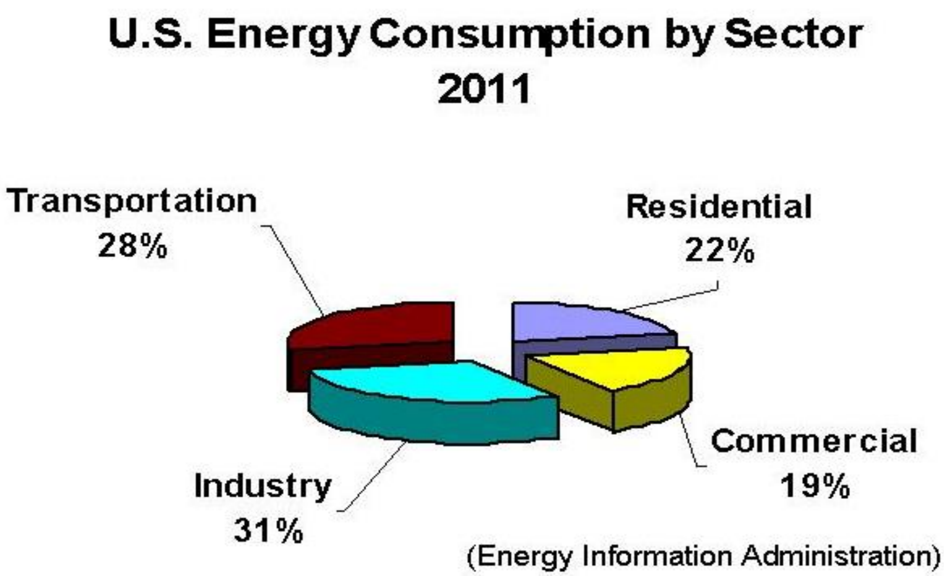
We discussed global energy use in the last lesson. Ask students to create another pie chart using the same labels that displays how energy breaks down by sector for the rest of the world and/or the state of Wyoming. Have students briefly write or discuss why they created the pie chart as they did. See the attached **Lesson 5 Resources** for the actual breakdowns in energy by sector for the world in 2012 as well as energy consumption by sector for Wyoming in 2011.

After revealing the actual breakdown for world energy consumption by sector and/or energy consumption by sector in Wyoming, ask students to compare and contrast energy consumption at state, national and global scales. What might account for trends in energy consumption? Discuss any surprising findings.

Evaluate: Energy concept mapping

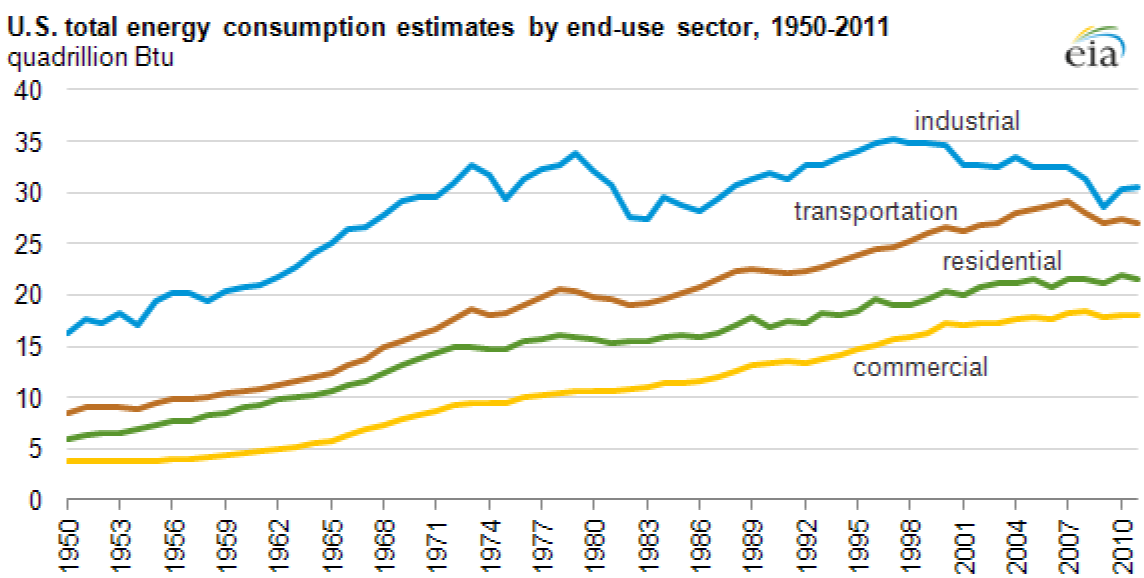
Students may add to their concept maps any new information about energy consumption by sector at various scales.

LESSON 5 RESOURCES

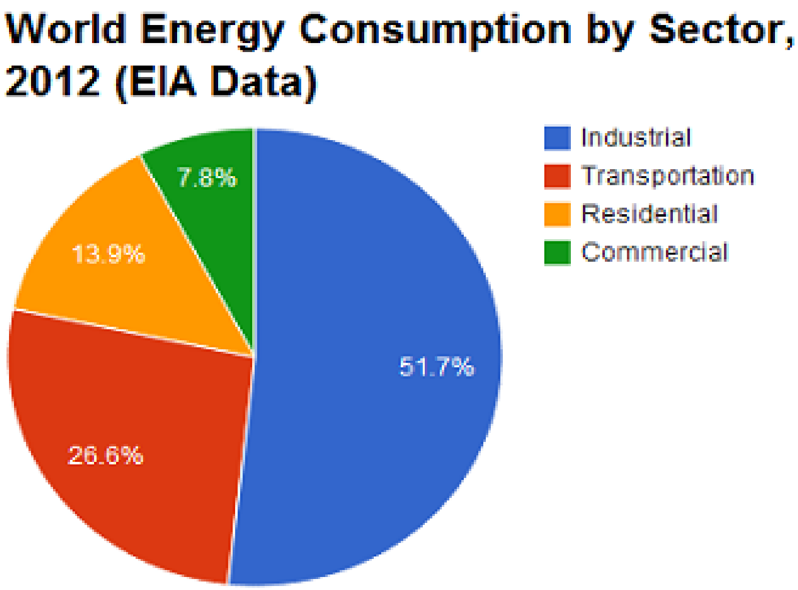


Source (Based on data provided by the Energy Information Administration): http://www.popularresistance.org/wp-content/uploads/2013/06/US-Energy-Consumption-by-Sector-2011.jpg

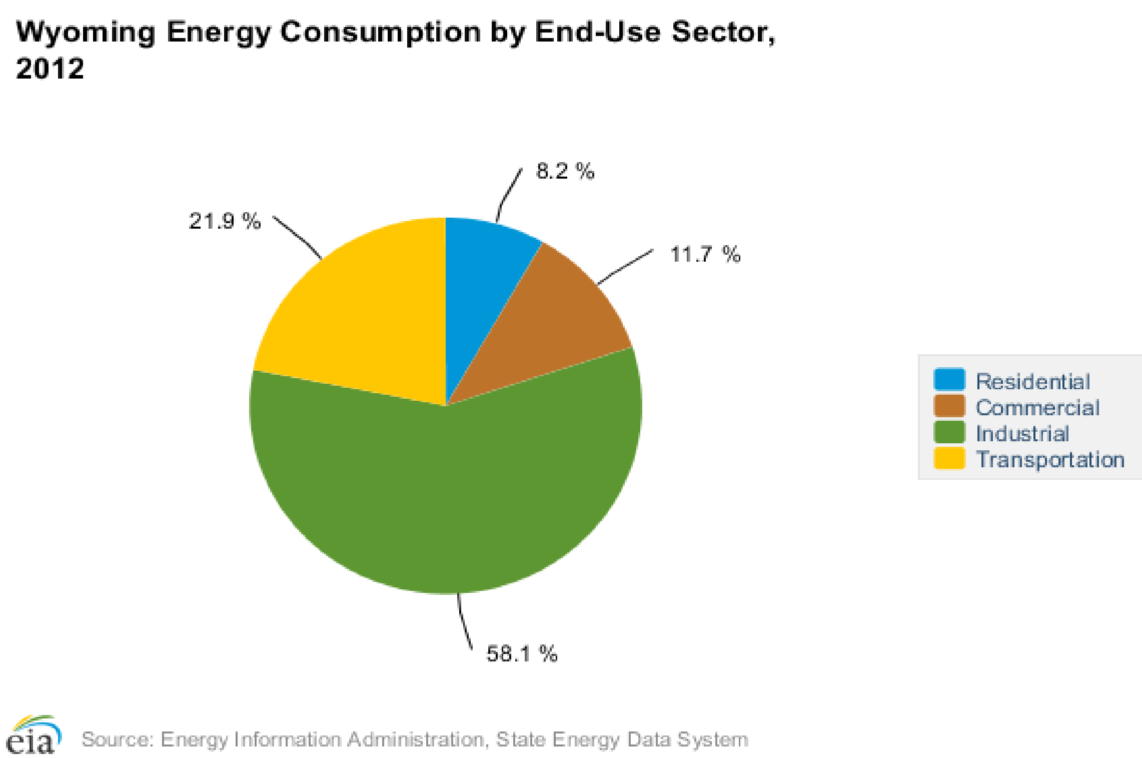
US Energy Consumption by Sector



Source: Energy Information Administration
http://www.eia.gov/todayinenergy/detail.cfm?id=9250



Source: Earthzine.org
Based on data provided by the Energy Information Administration



LESSON 6: ENERGY CONSUMPTION OVER TIME

Standards:

<u>Next Generation Science Standards</u>	<u>Common Core Standards</u>	<u>WY Science Standards</u>
DCI - Engineering **CCC -** Patterns; Stability & change **SEP -** Constructing explanations/ Designing solutions; Engaging in arguments from evidence	ELA-Literacy.RI.11-12.7 ELA-Literacy.W.11-12.1 MATH.Content.HSF.LE.A.3 MATH.Content.HSF.IF.B.4	SC11.3 **<u>WY Social Studies Standards</u>** SS12.4.1

Lesson Overview:

In this lesson, students will begin to understand that the development of America is due in large part to changes in the ability to harness and use energy. Students will understand the parts of an energy system - energy resources, carriers, converters, and services - and explore how changes to certain parts of this system led to energy transitions in United States history. Students will understand the potential impacts of energy transitions by discussing the associated impacts of specific technologies and discuss whether or not there is another energy transition in America's future. This lesson moves the focus from energy transformations, which are often the primary discussion in energy curriculum, by focusing on the bigger picture. Setting the historical context creates a base for students to dive deeper into the finer details of energy forms and transformations in later units.

Guiding Question:

Are we nearing another energy transition in the United States?

Duration:

45 minutes

Materials:

Internet for reading articles, or hard copies of supplied materials

Engage: Early energy consumption

Ask students to think back two hundred years and imagine life of the early American. Students can write or sketch responses to what life was like then and how is it different from your daily life now. At home? Traveling? Shopping? At school? Discuss responses as a class, making sure to, draw out key energy services that students mention: heating & cooling, lighting, electricity, transportation, etc.

Explore: Energy history in the U.S.

Shifts in available energy services result from changing access to energy resources and technological advances that aid in harnessing or converting the energy source into a usable end product. These significant changes, or energy transitions, have occurred throughout American history.

Read the energy history outlined in the attached **Lesson 6 Resources** to the students and ask them to chart what they think happened to energy consumption from different sources over time (time should be on the x-axis and energy sources on the y-axis).

After reading the story, reveal the actual graph of US energy consumption (See **Lesson 6 Resources**) over time and discuss peaks and valleys on the graph in relation to the history of energy transitions.

Explain: Energy systems and transitions

The energy system consists of relationships of energy resources, energy carriers, energy converters, and energy services. Each are briefly defined below:

- **Energy Resource:** a form of energy that can be extracted from the environment and placed into useful service in the economy. Fossil fuels, sunlight, wind currents, and uranium represent energy resources.
- **Energy Carrier:** A form of energy supplied to an energy converter. Example: natural gas (primary energy carrier) is transported to a power plant (a converter), turned into electricity (secondary energy carrier), and transported to a home, where it may be converted into light through a lightbulb (a converter).
- **Energy Converter:** A device that transforms one energy carrier into another, or into an energy service.
- **Energy Service:** The forms of energy demanded by consumers and industry. These generally include (but are not limited to) heating, cooling, lighting, mechanical power, and information.

Energy Resources (i.e. fossil fuels, renewable energies, etc.) are converted to Energy Carriers (i.e. electricity, gasoline, etc.), which are then supplied to Energy Converters (i.e. compact fluorescent light bulb, automobile, etc.) which provide Energy Services (i.e. lighting, transportation, etc.). Energy transitions will occur when there are major changes that affect any part of this energy system.

Energy transitions are marked by a significant set of changes to the patterns of energy use in society. Historically, energy transitions were driven by scarcity of resources and made possible by technological advances to support the appropriate infrastructure. Future energy transitions will be driven by demand, cost advantage, supply constraints, and policy decisions.

Elaborate: Are we nearing an energy transition?

Encourage students to brainstorm - what will be the next big transition? Let students explore and come up with ideas. Let their questions and suggestions guide the process. To prompt students, ask them to consider a possible scenario in which an energy transition is caused by a major change to an energy resource, an energy carrier, an energy converter, or an energy service. In small groups ask students to share what they think will be the next big transition and give evidence to back up their reasoning. After reviewing the history of energy consumption and characteristics of energy transitions in the US, ask the students to discuss/write a response to: Are we nearing another energy transition? Why or why not?

Evaluate: Energy concept mapping

Conclude by having students add to their concept maps any new information regarding energy consumption and transitions.

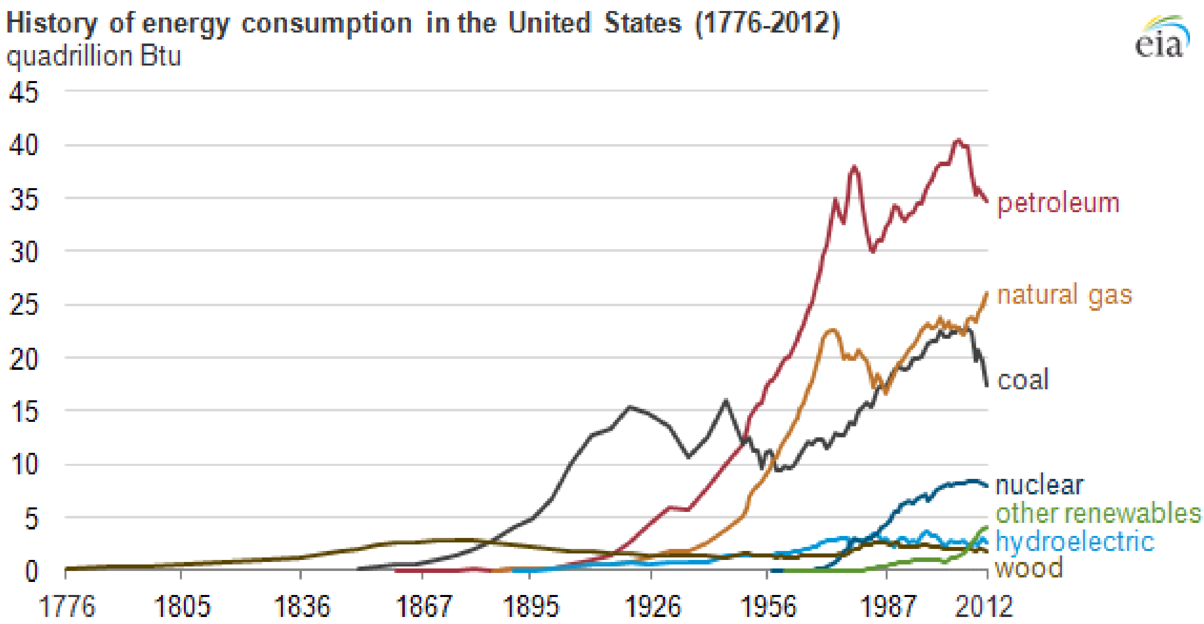
LESSON 6 RESOURCES

The History of Energy Transitions

Let's start in early American history - the 1700s to mid-1800s. Firewood was in abundance and individuals used wood as fuel for heating their homes, iron smelting and early steam engines. During this period, horses were utilized as the primary means of transportation. However, overuse of firewood led to deforestation, the price of wood increased, and a transition away from wood as a fuel source began.

By 1885, coal surpassed wood as the primary energy source utilized in the United States. The availability of coal, oil, and natural gas led to increased energy services. This time period was marked by an expanding manufacturing and industrial sector. The booming economy spurred the spread of public schools, transportation via steam engines, and added leisure time.

The discovery of abundant oil and gas reserves as well as improving technology to capture and use these resources caused another significant change in energy consumption. Around 1946, hydrocarbons (oil and natural gas) overtook coal as the primary energy source in the United States. Today, petroleum continues to lead in U.S. consumption and is utilized for diverse products from gasoline to plastic bags.



Source: Energy Information Administration
http://www.eia.gov/todayinenergy/detail.cfm?id=11951

SUMMATIVE ASSESSMENT: EVALUATING CONCEPT MAPS

***To be completed at the end of the unit**

Standards:

Next Generation Science Standards	Common Core Standards	WY Science Standards
DCI - Physical Science; Earth Systems Science **CCC -** Patterns; Systems & system models **SEP -** Developing & using models; Obtaining, evaluating & communicating information	ELA-Literacy.SL.11-12.1 ELA-Literacy.RST.11-12.2 MATH.Content.HSS.IC.B	SC11.1.13 **WY Social Studies Standards** SS12.6.1

Materials:

Student notebooks with on-going concept map, pens of different colors

Instructions:

Give students an opportunity to add anything else to their concept map. Using the final version of the concept map, ask students to assess their changing knowledge of energy by writing a three paragraph summary outlining what they knew at the beginning of the unit, how their understanding of energy and energy consumption changed throughout the lesson, and any new questions they have. Students should submit the three paragraph summary and concept map together.