UNIT 8: WHAT'S NEXT?

The future of energy in Wyoming

CONTENTS

OVERVIEW

In 2013, Wyoming Governor Matt Mead released *Leading the Charge: Wyoming's Action Plan for Energy, Environment, and Economy*. Governor Mead's energy strategy outlines a plan of action for "achieving excellence in energy development, production, and stewardship of Wyoming's natural resources -- for the highest benefit of all citizens." In this summary unit, students will take into consideration all that they have learned about the economic, environmental, and cultural impacts of energy development and natural resource production in Wyoming to try to answer the question "What's next for energy in Wyoming?" Students will begin by writing or drawing a prediction of the future and then will learn about some innovative technologies that are being developed in response to many of the challenges discussed in the case studies from previous units. The summative evaluation for this unit has students revisit their concept map from Unit 1 to add any final thoughts and write a final reflective piece describing what they learned and what surprised them.

ESSENTIAL QUESTIONS

- What's next for energy in Wyoming?
- Where do we go from here?

ENDURING UNDERSTANDINGS

- Students will be familiar with innovative energy production and conversion technologies.

DURATION

Two to three 45 minute lessons

STANDARDS

Next Generation Science Standards

- **Disciplinary Core Ideas**
  - Physical Science
  - Earth & Space Science
  - Engineering
- **Crosscutting Concepts**
  - Patterns
  - Systems & system models
  - Energy & matter
  - Structure & function
  - Scale, proportion & quantity
- **Science and Engineering Practices**
  - Developing & using models
  - Obtaining, evaluating & communicating information
  - Constructing explanations and designing solutions
  - Connection to engineering, technology, and application

Wyoming Science Standards

- SC11.1.7
- SC11.1.12
- SC11.1.13
- SC11.3

Wyoming Social Studies Standards

- SS12.3.1
- SS12.3.3
- SS12.4.1
- SS12.4.2
- SS12.4.3
- SS12.5.4
- SS12.6.1

Common Core Math Standards

- CCSS.MATH.CONTENT.HSS.IC.B

Common Core Language Arts Standards

- CCSS.ELA-LITERACY.W.11-12.2
- CCSS.ELA-LITERACY.W.11-12.4
- CCSS.ELA-LITERACY.W.11-12.9
- CCSS.ELA-LITERACY.RI.11-12.7
- CCSS.ELA-LITERACY.SL.11-12.1
- CCSS.ELA-Literacy.RST.11-12.2

OBJECTIVES

Science and Energy Literacy

- Students will be able to explain the importance of efficiency in converting natural resources to energy end products.
- Students will be able to describe how new technology impacts conversion of natural resources into energy through improved efficiency.

Stewardship and Community

- Students will describe how new energy production and conversion technologies lead to different economic, environmental, and cultural outcomes for communities.

STEM Careers and Leadership Development

- Students will be able to describe innovative new technology in the field of energy development.

Place

- Students will be able to relate development of new energy technology to the future of natural resource production in Wyoming.

Applied Problem Solving & 21st Century Skills

- Students will be able to describe the relationship between new technologies and the future of energy production.
- Students will use concept maps to analyze relationships and changes in understanding.
- Students will make predictions for the future based on current evidence.

ASSESSMENT EVIDENCE

Diagnostic:

At the beginning of the unit, students will demonstrate understanding by:

- Completing a quick-write activity that synthesizes prior knowledge to help predict future scenarios.

Formative:

During the unit, students will demonstrate understanding by:

- Creating a poster and brief presentation on specific energy production technologies.

Summative:

By the end of the unit, students will demonstrate understanding by:

- Adding to, reevaluating, and reflecting on a concept map relating to energy and natural resources.

DIAGNOSTIC ASSESSMENT: WHAT'S THE OUTLOOK?

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

Standards:

Next Generation Science Standards	Common Core Standards	Wyoming Science Standards
DCI - Earth & Space Science **CCC -** Energy & Matter; Patterns **SEP -** Constructing explanations/ Designing solutions	ELA-Literacy.W.11-12.2 ELA-Literacy.SL.11-12.1 MATH.Content.HSS.IC.B	SC11.1.7 SC11.3 **WY Social Studies Standards** SS12.3.1 SS12.3.3 SS12.4.1 SS12.4.2

Instructions:

Prompt students to complete a quick-write or draw to the following question: In your opinion, what is the future of coal? Students should consider the geologic, economic, and environmental components of Wyoming's energy production as well as the myriad cultural values at play in the conversation.

Ask a few students to share their opinions, draw out key conclusions.

LESSON 1: FUTURE OF ENERGY

Standards:

Next Generation Science Standards	Common Core Standards	WY Science Standards
DCI - Earth & Space Science; Engineering **CCC -** Energy & matter; Structure & function; Scale, proportion & quantity **SEP -** Obtaining, evaluating & communicating information; Constructing explanations/ Designing solutions; Connection to engineering, technology & applications	ELA-Literacy.W.11-12.2 ELA-Literacy.W.11-12.9 ELA-Literacy.RI.11-12.7 ELA-Literacy.SL.11-12.1	SC11.1.12 SC11.3 **WY Social Studies Standards** SS12.3.1 SS12.3.3 SS12.4.1 SS12.4.2 SS12.4.3 SS12.5.4

Lesson Overview:

Students will be introduced to innovative technologies designed to reduce the impacts of energy production and improve efficiency of conversion to meet current and growing demands. Students will split into small groups to research and better understand clean coal, enhanced oil recovery, cogeneration, and smart grids. Each group will create a poster and brief presentation to share with the class.

Guiding Question:

What new technology is being developed to improve how industry can meet energy demands?

Duration:

90-120 minutes

Materials:

Energy technology resource sheets from **Lesson 1 Resources** and/or computers with Internet, flipchart paper or butcher paper, markers

Engage: Outlook on energy

Complete the **Diagnostic Assessment**

Explore: Student Expert Groups

Split students into four expert groups (3-4 students). Each group will be assigned to a different energy source (coal, oil, natural gas, or wind). There may be more than one group per source. Provide each group with the corresponding energy technology resource sheets from **Lesson 1 Resources**. Students should spend an entire class period researching using the resource sheet provided and/or other web or text based resources and putting together a poster with bullet points on their technology and a 5-8 minute presentation that will be shared the following class period.

Explain: Share presentations

Students will share a 10-minute presentation with rest of the class about the future of energy in their designated energy resource. Presentations can have a technological component but must include a display (poster, flow chart, etc.) that can be shared with the school and community. Presentations should include:

- What the technology is;
- How the technology works;
- How the technology improves the usefulness of a certain energy source; and
- What the drawbacks are of the technology.

Elaborate: Collaborate

Lead a class discussion about the different technologies. Based on the presentations, which technology do students think is the most realistic? Which has the lowest cost/benefit scenario? What will be some outcomes of implementing or not implementing this technology in Wyoming?

Evaluate: Reflect

Revisit the diagnostic assessment quick-write or quick-draw from the beginning of this lesson. Discuss as a class how the vision for energy in the future has changed, if it has, and how.

Extend: Design the future

To extend for a more creative project, students can design a power plant/station or add to an existing power plan/station system with their researched technology. Their presentation will need a plan/drawing of the project, economic analysis, potential environmental and social impacts (either positive or negative), locations, etc.

LESSON 1 RESOURCES

Clean Coal Resources

Background information:

For Immediate Release:

CHEYENNE, Wyo. – Governor Matt Mead is proposing Wyoming and private partners invest in a world-class research center to develop and test new uses for carbon captured from coal-based power plants. The goal is to develop new markets for carbon in addition to enhanced oil recovery. As carbon capture technology advances across the country there will be more CO2 than can be used for that process. Wyoming coal is sent to 34 states and not all of them have enhanced oil projects available.

"Wyoming and many private companies have invested significantly in carbon capture and sequestration (CCS) research. I want to advance the conversation to look at what happens when CCS technology is commercially viable and to try to add value to CO2, which has significant potential as a resource," Governor Mead said. "I am asking the Legislature to look closely at the idea of Wyoming joining with utilities, power plants and other private companies to build a test center - essentially setting up a laboratory for a select group of scientists to experiment with uses of carbon."
Governor Mead is proposing that the State set aside $15 million to cover some capital costs for the center and for University of Wyoming research to take place there. In Wyoming there is lot of demand for CO2 to be used in enhanced oil recovery. This test center would be complimentary to work on enhanced oil recovery.

"Wyoming has an opportunity to make strides in establishing new beneficial uses of CO2," Governor Mead said. "I believe this would be best suited to occur in a location that incorporates real world conditions – namely, the heart of coal country." Wyoming is home to the largest coal mines in the United States and provides 40% of the nation's coal. Coal in turn provides 37% of America's electricity. There are several private companies that would be involved with this project and they would work with the University of Wyoming's School of Energy Resources. Governor Mead recognizes that this plan is still in its early stages. As a result, he is proposing to set aside the $15 million and it would not be spent until an implementation plan has been reviewed by the Legislature and approved by the Advanced Conversion Technology Task Force and the Governor.

"There are many details that need to be worked out on this proposal, but I want Wyoming to maintain a position of leadership when it comes to carbon research," Governor Mead said. "This is a bold project, but it could position Wyoming and the country well to ensure we have a diverse energy portfolio for generations to come." The State of Wyoming has been in talks with Tri-State Generation and Transmission Association, a not-for-profit wholesale power supplier headquartered in Colorado and serving power to Wyoming electric cooperatives, about Tri-State's pursuit of an inducement prize for research on this issue. The test center could be used by Wyoming researchers and competitors seeking the prize.

-end-

Web Resources:

- EPA Clean power plan http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule
- The basics of the Clean Power Plan (UCS): http://www.ucsusa.org/our-work/global-warming/reduce-emissions/what-is-the-clean-power-plan#.VOqlu5NdUok
- Clean Coal tech video: http://www.americaspower.org/our-commitment-clean-energy-future
- Clean Coal Technology Information:
    - http://energy.gov/fe/science-innovation/clean-coal-research/major-demonstrations/clean-coal-technology-and-clean-coal
    - http://energy.gov/sites/prod/files/2013/04/f0/HS_Coal_Studyguide_draft1.pdf
    - http://www.switchenergyproject.com/education/CurriculaPDFs/SwitchCurricula-Secondary-Coal/SwitchCurricula-Secondary-CoalFactsheet.pdf

Clean Coal questions:

- How does this technology work? (Technologies include Fluidized Bed Combustion, Coal Gasification, Carbon Capture, Utilization, and Storage)
- In what stage of coal production can this technology be used?
- How does this technology specifically address the challenges faced by coal?
- Discuss the economics of this project: How much would it cost? What needs to be built?
- What are the economic and environmental benefits of this project?
- What are the strengths and weaknesses of this technology? Do you think it is realistic?
- Has this technology been implemented in any power plants or other facilities?
- How would you incorporate this technology into Wyoming?

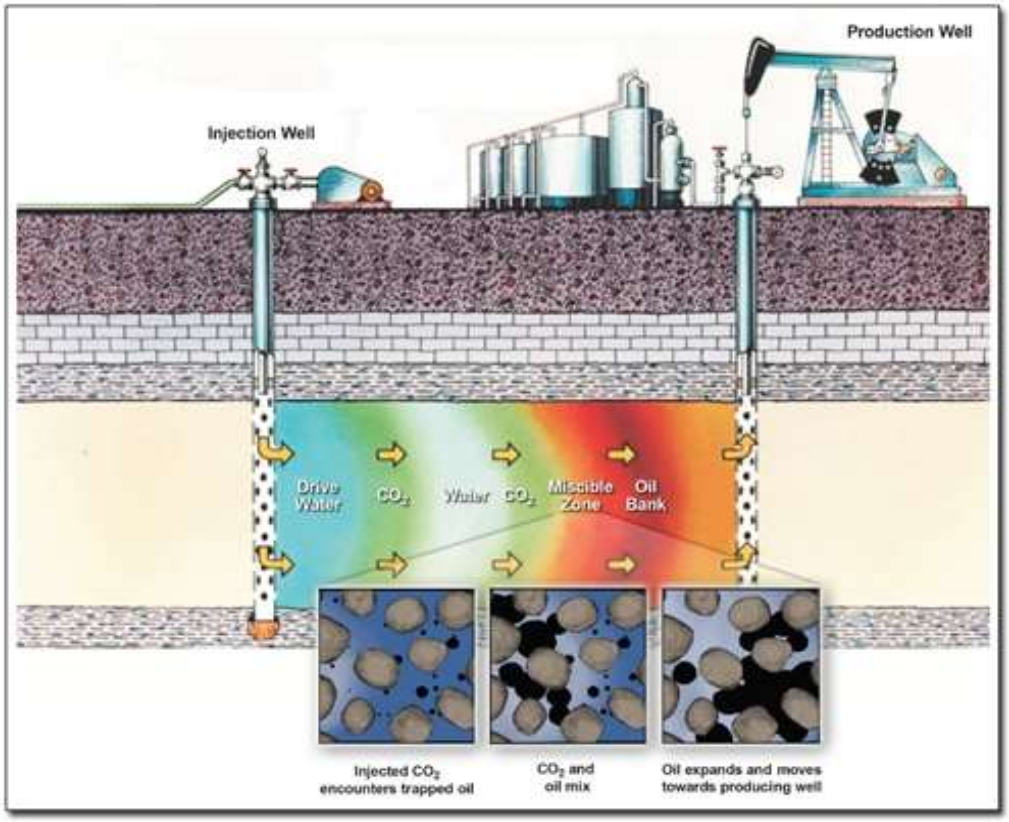
Enhanced Oil Recovery Resources

Background Information:

What is Enhanced Oil Recovery?
Enhanced Oil Recovery utilizes techniques that alter the original properties of oil. Its purpose is not only to restore formation pressure, but also to improve oil displacement or fluid flow in the reservoir. The three major categories of EOR that have been found to be commercially successful to varying degrees include: Thermal recovery, Gas injection / Miscible displacement, and Chemical injection or flooding.

Why?
Today, it is estimated approximately 40 to 60% of all hydrocarbons are locked deep within reservoirs. Enhanced Oil Recovery provides mechanisms for increasing the recovery of these hydrocarbons to make them usable for other products.

How?
During primary recovery, the natural pressure of the reservoir, and/or gravity, drive oil into the wellbore. Artificial lift techniques (such as pumps) then bring the oil to the surface. Only about 10% of a reservoir's original oil is typically produced during primary recovery. Crude oil development and production then utilizes secondary recovery techniques to extend a field's productive life generally by injecting water or gas to displace oil and drive it to a production wellbore, resulting in the recovery of 20-40%of the original oil.



UNIT 8: WHAT'S NEXT?

Today, much of the easy-to-produce oil is already recovered from U.S. oil fields and operators attempt several tertiary, or enhanced oil recovery (EOR), techniques that offer the possibility for producing 30-60%, or more, of the reservoir's original oil in place. 12% (~ 5-6 million barrels) of oil in Wyoming is produced using CO2 Enhanced Oil Recovery (EOR). At this point, not having enough CO2 limits EOR in Wyoming.

Web Resources:

- http://energy.gov/fe/science-innovation/oil-gas-research/enhanced-oil-recovery
- http://info.drillinginfo.com/enhanced-oil-recovery-need-know/
- http://neori.org/resources-on-co2-eor/how-co2-eor-works/
- http://www.rigzone.com/training/insight.asp?insight_id=313&c_id=4
- http://neori.org/other-resources/

Questions to answer about EOR:

- How does this technology work? The three technologies include: Gas injection or Miscible displacement, and Chemical injection or flooding. Include a diagram.
- How does this technology change the impact of oil production in the energy market?
- Discuss the economics of this project: How much would it cost? What needs to be built?
- What are the economic and environmental benefits?
- What are the strengths and weaknesses of this technology? Do you think it is realistic?
- How would you incorporate this technology into Wyoming?

Cogeneration Resources

Background Information:

Definition: co·gen·e·ra·tion (ˌkōjenəˈrāSH(ə)n/) *noun*

1. the generation of electricity and other energy jointly, especially the utilization of the steam left over from electricity generation to produce heat.

Cogeneration, also known as combined heat and power (CHP), is the simultaneous production of electricity and heat from a single fuel source, such as: natural gas, biomass, biogas, coal, waste heat, or oil. Cogeneration is not a single technology, but an integrated energy system that can be modified depending upon the needs of the energy end user.

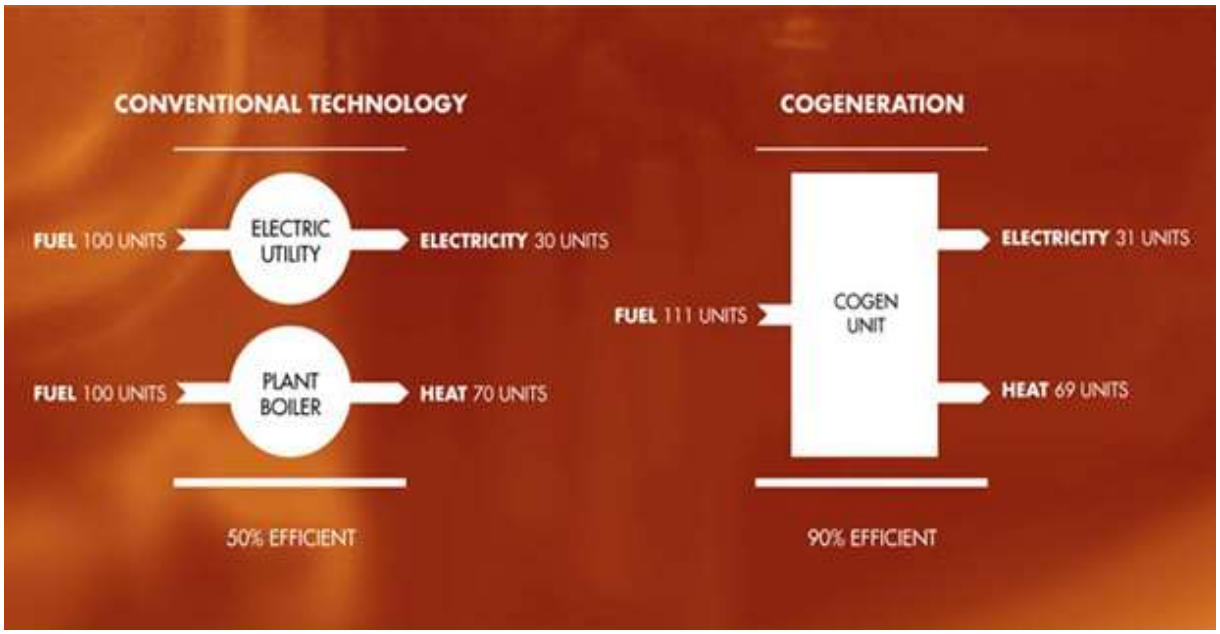
Cogeneration provides:

- Onsite generation of electrical and/or mechanical power.
- Waste-heat recovery for heating, cooling, dehumidification, or process applications.
- Seamless system integration for a variety of technologies, thermal applications, and fuel types into existing building infrastructure.

What can cogeneration contribute in the future? An additional 50 GW of capacity—equal to about half of current U.S. nuclear generation capacity—could be cost-effectively deployed by 2020 and would produce annual savings of $77 billion.

"A cogeneration system uses less fuel to produce the same amount of energy -saving money and helping to protect the environment."

Diagram comparing cogeneration to traditional technology



Web Resources:

- http://www.epa.gov/chp/basic/
- http://www.epa.gov/chp/documents/faq.pdf
- http://intelligenpower.com/whatiscogen.htm

Questions to answer about Cogeneration:

- How does this technology work? The two most common systems are 1) gas turbine or engine with heat recovery unit and 2) steam boiler with steam turbine.
- How does this technology change the impact of natural gas in the electricity market?
- Discuss the economics of this project: How much would it cost? What needs to be built?
- What are the economic and environmental benefits?
- What are the strengths and weaknesses of this technology? Do you think it is realistic?
- Has this technology been implemented in any power plants or other facilities?
- How would you incorporate this technology into Wyoming's energy industry?

Smart Grid Resources

Background information:
Electrical grids are interconnected networks that deliver electricity from suppliers to consumers. They consist of electrical generating stations that produce power, high-voltage transmission lines that carry power from sources to demand centers, and distribution lines that connect individual customers. Electricity is often produced far from where it is consumed, which is especially frequent with renewable energy electric sources like wind, and up to 30% of electricity can be lost during transmission. Electricity must also be produced as it is consumed and extra electricity that is not consumed will be lost, making it challenging to maintain efficient electricity production systems.

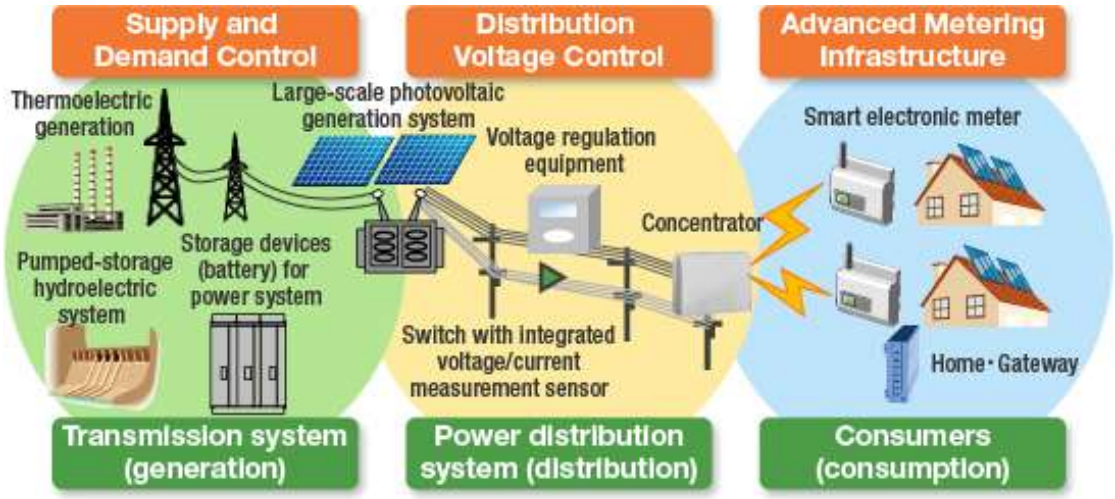
The smart grid system is a possible solution. A smart grid is a modernized electrical grid that uses computers to automate parts of energy production like tracking meters, locating broken equipment, and monitoring overall performance. Smart grids can also gather and act on information - such as information about the behaviors of suppliers and consumers - in an automated fashion to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity. Electronic control of the production and distribution of electricity are important aspects of the smart grid.

Smart grid advocates list a number of reasons why they are a beneficial technology for the future of electricity consumption:

- It overhauls aging equipment and facilitates real-time troubleshooting.
- It equips the grid to meet increasing demand.
- It decreases brownouts, blackouts, and surges.
- It reduces expenses to energy producers.
- It makes renewable power feasible.
- It maintains global competitiveness of US energy industries.

"***Reliability, cost savings, and energy independence are just three of the many benefits of smart grid. These and more make it the energy technology not just for the future, but for today."***

Diagram of a smart grid system



Web Resources:

- http://energy.gov/oe/services/technology-development/smart-grid
- http://www.mitsubishielectric.com/company/environment/report/products/randd/smartgrid/
- http://smartgrid.ieee.org/questions-and-answers/964-smart-grid-consumer-benefits
- http://www.whatissmartgrid.org/smart-grid-101/consumer-benefits

Questions to answer about Smart Grids:

- How does this technology work?
- In what stage of coal production can this technology be used?
- How does this technology specifically reduce the impact of coal?
- Discuss the economics of this project: How much would it cost? What needs to be built?
- What are the strengths and weaknesses of this technology? Do you think it is realistic?
- Has this technology been implemented in any power plants or other facilities?
- How would you incorporate this technology into Wyoming?

SUMMATIVE EVALUATION: REVISIT 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 & Space 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 ELA-Literacy.W.11-12.4 ELA-Literacy.RI.11-12.7	SC11.1.13 SC11.3 **WY Social Studies Standards** SS12.6.1

Materials:

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

Instructions:

Ask students to revisit their concept maps from Unit 1. 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.