CLEAN ENERGY BRIGHT FUTURES

LESSON PLAN

The 50 Year Energy Plan Project

Lesson 5: How Do We Evaluate Energy Sources?

AUTHOR

Bradford Hill

CONTACT

Teacher Contact: Bradford_hill@beaverton.k12.or.us
CE Editor Contact: CEbrightfutures@b-e-f.org, 503-553-395

DESCRIPTION:

Building on student's understanding of energy production methods developed over previous lessons, Lesson 5 asks the class to identify and measure trade-offs between environmental impacts – human needs – and practical costs of different power generation methods to help inform their capstone project to create a 50-year Energy plan for their community. As a class, students engage in a brainstorming session to deliberate what factors should be included in their evaluation rubric. After their brainstorming session, educators carry out a lesson looking at the natural functions of multiple Earth Systems, as well as modern energy generation's impact on those systems - including climate. From this, students develop models that demonstrate the flow of Carbon on Earth and use that knowledge to inform their capstone projects.

ACTIVITY LENGTH

3 90-minute periods.

LEARNING GOAL(S)

1. Students will develop models of the interaction between atmospheric composition and surface temperature using simple diagrams.
2. Students will reflect on the impact of energy sources and power production on the environment.

CONTENT BACKGROUND

STUDENT BACKGROUND

- Background on energy, energy transformations and basics of electricity as gathered from Lessons 1 and 2 of this Unit
- Understanding of parallel and series circuits from Lesson 2
- Experience using Vernier Labquests; Labquest 2s; or GoDirect Sensors from Lesson 3
- Understanding of the U.S. Power Grid, Transmission, Social Energy Needs, Environmental Impacts of Generation from prior Lessons in this Unit.

EDUCATOR BACKGROUND

Educators wanting to be prepared should read through the EMPP Unit Slides for Lesson 3 or found online at https://goo.gl/EYCyT2). Moreover, click through to explore videos and resources embedded within those slides

The Framework for K-12 Science Education (which the NGSS was based upon) is an excellent, short resource for background information on Earth Science, Weather and Climate, as well as Global Climate Change – Educators can read through these sections online here from pages 186 – 200
https://www.nap.edu/read/13165/chapter/11#186

Have understanding of the basics of Renewable Energy and contemporary US power production methods →

- Read the most recent Oregon Energy Plan, as it provides a lot of relevant, real-world background information. Another tool is the official State of Oregon's interactive, online "Electricity Mix in Oregon" map found here (https://www.oregon.gov/energy/energy-oregon/Pages/Electricity-Mix-in-Oregon.aspx).
- Explore the U.S. Energy Information Administration website for more background, including the U.S. Overview map to find information on another state.

MATERIALS NEEDED

HANDOUTS/PAPER MATERIALS

- Unit Packet
- 50 Year Energy Plan Spreadsheet
- Sankey Diagram Manipulative

CLASSROOM SUPPLIES

- Access to internet-connected devices
- General Audio Visual Equipment

ACTIVITY SUPPLIES (PER GROUP OF 3-4 STUDENTS)

Note the classroom list above as well as the Supply List in the unit materials for sourcing.

LESSON PROGRESSION

PLANNING AND PREP

Review the Unit Slides and calendar for days 12-14. Review the Unit Slides 220-288 as well for context surrounding the investigation into climate change and creation of a rubric for the final steps of the project.

LESSON SEQUENCE

Electricity, Magnetism & Power Production – Understanding Earth Systems to Inform Our Climate Rubric

DAY 1

- Warm up Question: Go to http://authoring.concord.org/activities/279/pages/1735/c05ea8e7-f131-447d-8b68-ef31c4d2206b
    - *"The Sun, Earth's atmosphere, and other systems interact to create conditions favorable to our life on Earth. The model shows a simplified Earth system with land, atmosphere, and solar radiation. The yellow arrows show energy coming from the Sun.*

      Start the model, and experiment with the controls to see how the model works."

      Follow prompts and have students record in their engineering notebooks "3 things you notice, and 2 things you wonder"

- **Climate vs Weather**? According to the Framework for K-12 Science Education:

  "Weather, which varies from day to day and seasonally throughout the year, is the condition of the atmosphere at a given place and time. Climate is longer term and location sensitive; it is the range of a region's weather over 1 year or many years.

  Weather and climate are shaped by complex interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions can drive changes that occur over multiple time scales—from days, weeks, and months for weather to years, decades, centuries, and beyond—for climate."

- **Atmospheric Circulation:**

  According to the Framework for K-12 Science Education:

  "Sunlight heats Earth's surface, which in turn heats the atmosphere. The resulting temperature patterns, together with Earth's rotation and the configuration of continents and oceans, control the large-scale patterns of atmospheric circulation."

- **How do these patterns impact Solar Power Systems?**
  1. Differential intensity of sunlight over the earth
     - *Think:* different optimal angles for a solar cell
  2. Earth's surface varies
     - *Think:* water vs. land vs mountain ranges
  3. Earth is big and always moving
     - *Think:* it is not simple

- **Review Graphs, Models, Animations**
  - **Atmospheric Circulation:** Discuss how Earth's warm, humid air rises at certain latitudes; after rising it cools and sinks, losing water, then repeats the cycle. Pattern of circulation results in predictable patterns in global temperature and precipitation (i.e. climates) along latitudes. I.e. why most deserts exist along Earth's 30° Latitude.
  - **Prevailing Winds:** Discuss air streams across oceans and continents
    - Tropical Easterlies: From 0-30 degrees latitude (Trade Winds)
    - Prevailing Westerlies: From 30-60 degrees latitude (Westerlies)
    - Polar Easterlies: From 60-90 degrees latitude
    - How do large mountain ranges impact temperature and precipitation?
  - **Sankey Diagrams –** Have students annotate diagrams in their packets

- Use Sankey Diagrams to discuss the fundamental functions and processes of how Earth's atmosphere insulates the planet, increasing habitability for living organisms. Burning fossil fuels increases atmospheric greenhouse gases that absorb and retain solar and thermal energy (heat), in turn, increasing local temperatures and shifting precipitation rates (i.e. changing climate).
- **E_{in} versus E_{out} → Discuss** energy transfers in Earth Systems, warming climates gaining energy, cooling climates losing energy
- **Investigate** 10 factors and analyze their primary effect on Earth's Climate and the timescale in which they operate. After student pairs/groups complete a Think, Pair, Share of their critical thinking/predictions, go through the EMPP Unit Slides for Lesson 5 to discuss Sankey Diagrams to understand climate impacts of the following factors:
    - Atmospheric composition
    - Volcanic activity
    - Circulation of the Oceans
    - Deforestation
    - Earth's orbit and the orientation of its axis
    - Circulation of the Atmosphere
    - Glaciation
    - Human activities
    - Increase in sun's energy output
    - Decrease in sun's energy output

- **Science and Engineering Practices**
    - **Examine** other graphic representations of real Climate Data from varying geographies:
        - **ASK:** What trends are observable? What is happening on Earth that can explain why data is cyclical? Can you estimate a mathematical model? What is the value of creating a model? What other models would you think of creating? What other questions do we have?
        - **Examine** NOAA Earth System Research Laboratory Global Monitoring Division CO2 level graph – **ASK:**
            - How is this graph different?
            - How is this graph similar?
            - Where is Barrow?
            - Why is Barrow's oscillations so big and American Samoa small?

- Why does the South Pole always stay below average?

- **Examine** animated NOAA Graph, "History of atmospheric carbon dioxide from 800,000 years ago until January, 2016" www.esrl.noaa.gov/gmd/ccgg/trends/history.html

  Global changes usually happen too slowly for individuals to recognize, but accumulated human knowledge, together with further scientific research, can help people learn more about these challenges and guide their responses.

  At the **2-minute** mark **ASK**:
  - How is this graph different?
  - How is this graph similar?
  - Why is this graph named the "Pump Handle"?
  - Why is the northern hemisphere different than the southern hemisphere?
  - Why are measurements usually taken away from cities?

DAY 2

- **Quiz – the Basic Physics of Climate Science –** See key for EMPP Unit Packet
- **Watch:** PBS News Hour Video "Demand for Clean Energy Inspires New Generation to Innovate Nuclear Power" www.youtube.com/watch?v=ITbx1ywYG7A&feature=youtu.be

  Additional: Frontline Video "Inside Japan's Nuclear Meltdown" https://www.pbs.org/wgbh/frontline/film/japans-nuclear-meltdown/)

  (NOTE - video is 56 min long, but excerpts offer additional viewpoints on nuclear power as a viable option – Using this film can also help fuel Lesson Extensions)

  ASK – Pros and Cons of Nuclear? In groups, students Think Pair Share ideas
- **Activity: Philosophical Chairs for Climate Impact Rubric**

  Room Set Up – Create signage to label each energy generation source that is part of the 50 Year Energy Plan capstone project. Create signage for numbers 1 through 5 and place next to each energy generation source. Go one by one and present to students a type of energy source – i.e. Solar, Coal, Natural Gas, Wind, Hydro, etc. Ask the class to:
  - Stand next to the number 1 (least) to 5 (best) that you think best represents the Climate/Environmental impact of that source

- Each collection of students presents two ideas behind their reasoning
- If persuaded, give students a chance to move to another number
- Explain why they moved
- Ask if any other students want to change numbers again?
- Count which number has highest rating by the class, or take an average
- Record, move on to next energy generation source, repeat process

- **Capstone Project**: 50 Year Energy Plan
  - **Problem Statement:**
    - We as the Energy Plan Commission seek to create a 50 Year Energy Plan that must address the energy needs of Oregonians for the State of Oregon.
  - **Constraints:** What we must accomplish
    - Meet the energy needs of the state for the next 50 years
    - Stay within the projected growth each decade
    - Provide reliable power
    - Be off coal by 2035
  - **Criteria:** How we judge our plan
    - Environmental Impact / Land Use
    - Climate Impact / Air Quality
    - Start Up Cost / Maintenance
  - **Calculator: Introduce the online modeling tool and how to use it** https://docs.google.com/spreadsheets/d/1VJwW9AUsWupBkmTimngYUgjwcsQB4AZBCOkkYnJEStg/edit#gid=981370401
  - **Strategize:** Have students look back to the first paragraph of their final essays from Lesson 1 of this Unit, use that information to inform a strategy for developing an Energy Plan.

    Start with first thoughts, iterate to improve plan, reasoning and writing.

    Grow slowly over time

    Have students complete 3 plans overall to find the best options

In this section, students will be investigating the impacts of different environmental inputs and conditions on the flow of energy on the surface of the Earth. They will use pages 16-19 in their packet to create and modify "Sankey" diagrams showing arrows demonstrating inputs and outputs of energy. These diagrams can be created by hand, cutting out the arrows in the attached Sankey Manipulative Diagram document. In this section of the lesson, students will be given various factors that influence their Sankey diagram in the presentation, and then will connect this to their own diagram and note the energy inputs, outputs, and storage points. Following this activity, students will take a quiz on climate science.

Finally, as a preparation for the final steps of the project, students will engage in philosophical chairs, positioning their groups on a 1-5 scale demonstrating the environmental/climate impact of each energy source they will use in their 50-Year Energy Plans.

ASSESSMENT AND EXTENSIONS

FORMATIVE ASSESSMENT

Note the Key for EMPP Unit Packet. This guide contains sample answers for each day's activities, which vary between usability as formative or summative assessments.

SUMMATIVE ASSESSMENT

Note the Key for EMPP Unit Packet. This guide contains sample answers for each day's activities, which vary between usability as formative or summative assessments. In addition, there is a quiz for students to complete focusing on the basics of climate science, attached in the materials for this section with a key.

EXTENSIONS

Students can continue to modify their design in an out-of-school setting to compete in a local KidWind Challenge.