EXPLORING DIFFERENT **RENEWABLE RESOURCES** ACROSS THE U.S.

TEACHERS HANDOUT

Utah SEEd Standard ESS.4.3
Next Generation Science Standard HS-ESS3-2
Grade and Topic: High School Earth Science

THE UNIVERSITY OF UTAH
College of Education

UTAH FORGE
U.S. Department of Energy

Exploring Different Renewable Resources Across the U.S.

Curriculum developed as a collaboration between the Utah FORGE project and the University of Utah College of Education, supported by the Department of Energy. This curriculum is aligned with national NGSS standards as well as the Utah SEEd standards. The curriculum provides support for diverse learners in diverse environments.

Contents

Overview

In order to engage with K-12 students and their teachers in a more formal setting, the Utah FORGE project partnered with the College of Education to develop curriculum that can be used in classrooms across Utah and the United States. Curriculum developed through this collaboration will meet standards set forth by the Next Generation Science Standards (2013). These standards have been adopted by 20 states and the District of Columbia. In addition, 24 other states have adopted standards based on this framework. Utah has adopted a set of closely aligned standards, the Utah State Science with Engineering Education Standards (SEEd) (2015).

The NGSS framework varies from a more historical approach to learning, in that the focus is on the practice of doing science rather than route memorization or fact-based learning about science (National Research Council, 2012). In the NGSS framework, there are three dimensions of science learning: **science and engineering practices (SEPs), crosscutting concepts (CCCs), and disciplinary core ideas (DCIs)**. Each standard engages students in all three of these dimensions.

The **science and engineering practices** are meant to be the actions that scientists and engineers engage in to learn about the external world and build knowledge. Specifically, this dimension includes *Asking Questions, Planning and Carrying Out Investigations*, *Engaging in Argument from Evidence* and others. By engaging in scientific and engineering practices, students become better able to understand the process of how scientific knowledge develops.

Crosscutting concepts are tools that scientists use to reason about phenomena. These are meant to be an organizational framework for connecting knowledge across disciplines, and includes concepts such as *Patterns*, *Cause and effect*, *Structure and function*, and *Energy and matter: Flows, cycles and conservation,* among others. Explicit reference to these concepts across disciplines is meant to help students develop a more coherent understanding of different disciplines, including biological sciences, physical sciences, earth and space sciences, and engineering design.

Finally, the **disciplinary core ideas** are the phenomena that scientists study. These are the limited number of core ideas within a discipline that are broadly important and key for understanding more complex ideas and solving problems. Additionally, these DCIs are teachable and learnable over multiple grade levels with increasing depth and complexity.

The vision of science teaching and learning based on these three-dimensions is meant to better prepare students to understand and engage with science and engineering while also building proficiency, appreciation, and interest across grade levels and disciplines. Given the multidisciplinary nature of the Utah FORGE project, it easily connects to many of the SEPs, DCIs, and CCCs.

Exploring different renewable resources across the U.S.

This lesson, "Exploring different renewable resources across the U.S." is meant to support students in using a variety of reasoning tools to conduct a cost/benefit analyses and to propose sustainable energy solutions including advanced geothermal solutions. The lesson is designed to align with state and national standards, as described below. The relevant Utah SEEd Standard is from the standards for Earth and Space Science. The relevant NGSS standard is from the standards for Earth

and Human Activity. Both these standards align with the disciplinary core idea of *Natural resources*. The scientific and engineering practices include *Analyzing and interpreting data*, *Constructing explanations and designing solutions*, and *Engaging in argument from evidence*. The crosscutting concepts primarily focuses on scale, proportion, and quantity.

Furthermore, the primary disciplinary core idea is "**ESS3.A: Natural Resources:** All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS3-2)" (NGSS Lead States, 3013). Students will learn about this DCI by exploring the ways that renewable energy can be produced and the costs associated with this production. This is particularly relevant to the Utah FORGE project as the advanced geothermal techniques represents a new technology that changes the cost benefit ratio compared to traditional geothermal technologies.

To engage in all three-dimensions, during the lesson, students will first analyze and interpret data regarding types of renewable energy in various locations and the cost/benefits of harnessing this energy. They will use this information to design energy solutions for a small community. Finally, they will then present their energy proposal to the class, arguing with evidence why their proposal should be adopted by this community. In creating this proposal, students will use the crosscutting concepts of scale, proportion, and quantity.

Further information the Utah SEEd Standards and the NGSS standards can be found at NGSS Lead States (2013) and Utah Science with Engineering Education (SEEd) Standards (2015).

Lesson Plan: Exploring Different Renewal Resources Across the U.S.

Grade and Topic:

High School Earth Science

Standards:

This lesson aligns with the following state and national standards:

Utah SEEd Standard ESS.4.3 - Evaluate design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios on large and small scales. *Define the problem, identify criteria and constraints, analyze available data on proposed solutions, and determine an optimal solution.* Emphasize the conservation, recycling, and reuse of resources where possible and minimizing impact where it is not possible. Examples of large-scale solutions could include developing best practices for agricultural soil use or mining and production of conventional, unconventional, or renewable energy resources. Examples of small-scale solutions could include mulching lawn clippings or adding biomass to gardens. (ESS3.A, ETS1.A, ETS1.B, ETS1.C)

Next Generation Science Standard: HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

Learning Outcomes:

- Students will analyze and interpret data regarding types of renewable energy in various locations.
- Students will analyze and interpret data regarding and the cost/benefits of harnessing this energy.
- Students will define the energy needs of a given community and identify the criteria and constraints imposed by the resources and needs of this community.
- Students will create an energy solution proposal for this community.
- Students will use evidence to argue why their proposal should be adopted by this community.

Timeline:

This should take approximately four 90-min block class periods.

Materials:

1. Computers with internet access
2. Large paper or posters, markers

3. Paper and pencils

Accommodations:

The "Exploration" activities can be done individually or in small groups as needed. These activities can also be finished at home. If some students are short on time, they could go in-depth with one of the renewable resources and skip the other stations. Additional stations such hydroelectric or nuclear could be added. Maps can be printed and enlarged to allow participation off-line. Discussion questions can be answered in verbal or written format. Also, at the stations, the teacher could include relevant photographs that represent the different kinds of renewal energy to help students make connections with their everyday lives and prior experiences. Throughout the exploration of the stations, the teacher could also ask questions that connect to student's prior experiences if they have lived in or visited various locations (e.g. Where have you visited in the US with lots of wind/sun?)

In the "Elaboration" section, the web-pages can be printed out to allow offline access. The poster presentation could be done on by creating physical posters or through electronic presentation software. The presentation could be pre-recorded as a video presentation to minimize the need for on-the-spot public speaking.

Overview:

In this lesson, students working in small groups of 3-5, will play the role of an engineering firm tasked with designing renewable energy solutions for a city. They will spend a couple of weeks investigating types of renewable energy, costs associated with the renewable energy, and make decisions about which type of renewable energy would be best for this city. They will then create a proposal which they will present to the whole class. The class will act as the city council to review the engineering proposals.

In the activities that follow, the city is Everton. To make this more relevant, teachers could assign students their own city, and investigate the power needs of that city, assuming similar energy goals. Similarly, the engineering firm is referred to as Generic Engineering. Each group may wish to rename their engineering firm.

Preparation

Before Beginning

- Read entire lesson sequence.
- Decide what modifications to make, if any.
- Decide how to organize small class groups (students select own groups, teacher assigns groups, teacher assigns groups with input from students, etc.) and how to assign the rotating leadership roles.

- Decide where to locate Everton. You might want this to be where you live or a similar city nearby. You might want to assign each group a different region or state for Everton. You might want to let each group decide for themselves where to locate Everton. Etc. The students will need to use Wikipedia pages to locate similar power plants in that state to the one they are proposing. Wikipedia pages do not exist for all states. In addition, some of the pages are better organized and contain more information than others.
- Decide if there will be additional criteria for Everton's energy needs. For example, if you decide to make Everton the city where the students live, you will need to find out what are the energy needs of this city.
- Decide which states students will investigate in the power station exploration. As with the location of Everton, Wikipedia pages do not exist for all states; some of the pages are better organized and contain more information than others.
- Decide the format of the final proposals and presentations.

Day 1

- Prepare slides or lecture with the anchoring phenomenon, energy criteria for Everton, and vocabulary words for class discussion.
- Prepare slides with assigned groups, instructions for the leadership roles, and instructions for how to rotate the leadership roles.
- Prepare for Activity 1: Set-up the stations around the room (or online) that are dedicated to different types of renewable energy sources (solar, wind, geothermal, and biofuel). Each station will have the following:
    - Instructions for the students about the students' roles and expectations.
    - A page of talk moves to facilitate discussion
    - A short reading describing the type of renewable energy, some of its benefits, and some of its drawbacks.
    - A map showing potential resource development with probing questions to guide students' exploration (e.g. What regions on the graph have a high potential for development and what regions have a low potential? What information is the graphic telling me? What is it not telling me? What questions do I have still?).
        - Most maps and background information below come from the following: https://www.c2es.org/content/renewable-energy/
        - Additional references include: https://utahforge.com/wp-content/uploads/sites/96/2019/11/FAQ-Geothermal-Energy.pdf
- Prepare student handouts, there is a 1-page handout for each station. Decide whether the students will need to submit a single group assignment or individual assignments.

Day 2

- Set-up the renewable energy stations that were not completed on Day 1.
- Prepare slides with instructions for the jigsaw assignment and instructions for which student in the group will be assigned each state.
- Prepare for Activity 2: There is only one station. Each group will need the following:
    - Instructions for the students about the students' expectations.

    - Computer with internet access for each student. (If this is not possible, you can print out the wiki page for the relevant state for each student.)
- Prepare 1-page student handout for Activity 2. Decide whether the students will need to submit a single group assignment or individual assignments.
- Prepare slides for full class discussion.

Day 3

- Prepare slides with instructions on which state Everton is in (for larger states you may need to select a region of the state). The teacher may assign the state(s) or allow students to select a state. Not all states have Wikipedia pages for their power plants so be careful when choosing states.
- Prepare for Activity 3: There are 3 stations, most work is done online. Each group will need the following:
    - Instructions for the students about the students' expectations.
    - Computer with internet access for each group.
    - Graphs of energy resources from Activity 1.
- Prepare 1-page student handouts for Activity 3. Decide whether the students will need to submit a single group assignment or individual assignments.
- Prepare materials for creating posters/presentations, whether as physical posters or as electronic presentations.

Day 4

- Upload student presentations.
- Prepare slides with students' expectations for being a good presenter and for being an active listener.
- Prepare slides with appropriate student responses.
- Prepare final assessment if desired.

Engage: Anchoring Phenomenon (10-15 min)

The teacher will present the following anchoring phenomenon to the full class. A local city wants to develop renewable energy, the students will be an engineering firm submitting proposals for the city to consider.

The requirements of the proposal are listed below. In advance of the class, the teacher should write the requirements on a slide, poster, or posted online, to be referred to during the lesson.

For an in-person or broadcast class this can be done as a full class presentation. For asynchronous classes this can be done as a prerecorded lecture or as a reading. For hybrid courses, it might be beneficial to begin on an in-person day, so that students can select groups and start on the investigations on the in-person day and plan for how to continue the investigations during the online days.

Suggested Teacher Script:

The city of Everton is offering your Engineering firm, Generic Engineering, to identify and develop plans for high potential forms of renewable energy in their area. You will make a proposal to present to the board who will review your proposal as well as several others from competing engineering firms. The board will compare how well each solution meets the criteria, cost, and feasibility and award the project to the best proposal.

Your job is to create a proposal and then present it to the town board. Specifications of the power plant must meet the needs of Everton which are listed as follows:

- Capacity of power consumed should be 230-250 MWatts or more.
- Currently 90% of the electricity Everton uses is from non-renewable energy sources, mainly coal and natural gas, while the remaining 10% comes from hydroelectric power. In 5 years, Everton wants 70% or more of its energy to come from sustainable energy sources.
- Due to environmental concerns, expanding hydroelectric energy is not an option for Everton.

In your proposal, you should estimate: the cost to construct the facility, land required to build he facility, the cost of upkeep and the lifetime of the facilities. In addition, you need to argue why you chose this particular type of renewable energy, as well as how you will mitigate the negative effects of this type of renewable energy.

The teacher may wish to discuss with the class why Everton wants to have a larger percentage of its energy come from sustainable energy sources.

Tapping into prior knowledge:

The following are vocabulary terms that are necessary for this investigation. Likely students are already familiar with these some of these terms.

For in-person classes, teachers may choose to list the words on the board or poster and ask students to define the vocabulary words as a full class discussion. For broadcast courses, the words could be included on a slide, which students can discuss in class, and then defined on a second slide which can be posted later, or using interactive technology such as Nearpod where students can post their responses to be shared with the full class. For asynchronous classes, the teacher may put the vocabulary words on a discussion board and ask each student to select a word to define.

- Renewable energy source – A natural resource used to make energy which will replenish to replace the amount used.

- Non-renewable energy source – A natural resource used to make energy which does not replenish or cannot replenish quickly enough to keep up with consumption.
- Watt (W) – A unit of power. The rate of energy transferred to an appliance.
- Kilowatt (kW) – 1,000 watts
- Megawatt (MW) – 1,000 kilowatts
- Kilowatt hour (kWh) – A unit of energy. Since power is a rate of energy, total energy is power multiplied by time. A kilowatt hour is the energy used by an appliance with a unit of power of one kilowatt operating for one hour.
- Geothermal/hydrothermal energy – Heat energy that is made and stored in the Earth
- Enhanced Geothermal Systems (EGS) – An engineered geothermal energy plant
- Biofuel – Fuel made or derived directly from living things
- Solar energy/photoelectric energy – Energy which is produced from energy gathered from sunlight
- Wind energy – Energy which is produced from wind turning turbines

Additional criteria to be discussed as a class:

The teacher may wish to include additional criteria, or the class might want to add criteria. This can be discussed as a class and the above criteria can be subsequently modified.

Example of how the aforementioned criteria might be met: A solar farm near Milford Utah is called the Escalante Solar Project. The solar farm is 1,900 acres (3.0 square miles) and has a capacity of 240 MWatts. The project cost approximately $488 million dollars.

The amount of land, capacity of the powerplant, and cost are all known. The questions that need to be asked are if the conditions of the Escalante Solar Project are similar enough to Everton, that a similar project would produce a similar amount of electricity for the cost.

Transitioning (10 min)

Student Expectations:

Before beginning the explorations, the teacher should check in with the students to make sure they understand the expectations.

They will be exploring 5 different types of renewable energy (in 4 stations). They will then be asked to determine which type of energy plant might be the best fit for Everton. Finally, they will be asked to create a proposal and present their proposal to the class. They will need to come to consensus about their proposals before presenting.

At each station, they will be asked to read background information about the type of renewable energy, discuss advantages and disadvantages, then explore a map that with the energy resources to determine where this type of energy might be a good alternative.

Rotating Roles:

At each station there are several tasks for the students to complete: reading the background information, having a discussion on the background information, having a discussion on the graph, recording notes for each of these discussions, answering questions about the readings and graphs.

Roles are assigned at each station such that the leadership is shared amongst the group members. Teachers should assign the rotating roles of Group Leader and Discussion Leader (see below for the job descriptions). Students are encouraged to volunteer for the roles of reader and scribe.

Depending on the classroom and learner needs, the teacher can assign these roles to students in the group or instruct students to choose these roles themselves. When assigning roles or instructing students to choose roles, this should be done such that they rotate roles between stations. Each student should have the opportunity to be the group leader and discussion leader. The roles of reader and scribe do not need to rotate through all group members (some students might like writing notes or reading to the group, others might not, but the teacher should make sure that one student is not dominating the group.) The teacher should decide if the students will submit the questions as a group or individually.

Example of how to assign rotating roles: On a slide, list the names of the students in each group. Label the students in each group A, B, C, and D. At station 1, Student A will be the group leader and Student B will be the discussion leader. At station 2, Student A will rotate to a group member, Student B will rotate to the group leader, and Student C will become the discussion leader. At station 3, Student B will rotate to a group member, Student C will rotate to the group leader, and Student D will become the discussion leader. At station 4, Student C will rotate to a group member, Student D will rotate to group leader, and Student A will become the discussion leader. Continue this rotation for the remaining activities.

Talk Moves: Contributing to a group discussion can be intimidating for many types of learners. Sentence stems are one way to help students formulate their ideas. Included in the student instructions are some sentence stems, labeled "talk moves" to help students with facilitating and contributing to the group discussions.

Suggested Teacher Script:

For the next couple class periods you will be exploring types of renewable energy in your small groups. At each station, you will be asked to read background information about the different types of renewable energy and explore a graph of how this source of energy is distributed in the United States. You will be asked to discuss things in your group.

Because talking in groups can sometimes be intimidating, you will be provided with some talk moves to help you figure out how to say what you want to say. When you are having the group discussions, everyone needs to contribute, and when you are not talking, you need to be active listeners. The talk moves can help you both with contributing and with active listening.

There are several roles for the group members, the roles will rotate as you go through the stations. We will discuss how to know which role you have at which station.

Group Leader: Your task is to make sure that your group stays on task. Keep track of the time spent on each item, make sure that your group is progressing. You also need to help chose the roles of reader and scribe. These are volunteer positions, but you need to make sure that everyone who wants to read gets to read, and that everyone who wants to be the scribe gets the opportunity. If necessary, the group leader or discussion leader could be the reader. It is better if the scribe is a group member.

Discussion Leader: Your task is to lead the discussion. Use the talk moves to make sure that each of the members in your group are able to contribute to the discussion and have their voice heard. If necessary, you could also volunteer to be the reader. You cannot be the scribe and also lead the discussion.

Group Member: Your task is to contribute to the discussion. Use the talk moves to express your ideas and check your understanding of your group members ideas.

- Reader: If you are assigned the role of group member, you can also choose to be the reader. The reader will read the background information to the full group. This is a volunteer position. When volunteering, make sure that everyone who wants to read has the chance to read.
- Scribe: The scribe is also a volunteer position. The scribe's job is to take notes on the group discussions. Your teacher will let you know if you need to submit your notes, or if you just need to keep them as reference for when you develop your engineering proposal. As with the reader, when volunteering for this position, make sure that everyone who wants to be the scribe gets the chance. You might also be asked to write the group answers for the questions if your teacher tells you to submit one set of answers for each group.

[Give instructions on forming groups and rotating leadership roles. Also instruct students on what they need to submit for this assignment (as a group, individually, no submission, etc.).]

Once students have formed their groups and understand the expectations, they will begin the explorations.

Exploration Part 1 (80-100 min total)

Activity #1 – Students will explore different types of renewable resources.

Each group of students will explore 4 different stations to learn about different types of renewable energy, including benefits and drawbacks. Students should spend approximately 20-25 minutes at each station. For a block schedule, students will be able to explore 2-3 stations on the first day. For a traditional schedule, students may only be able to explore 1-2 stations on the first day.

For an in-person class, the teacher should set up the stations in advance. Relevant COVID precautions could include: having students work in pairs rather than groups, so that they can sit at opposite ends of the table and not face one another; having sets of all 4 stations for each group, so that students are not handling materials previously handled by other students; sanitizing stations before students rotate from one station to the next; placing reference material online and having students access it using their dedicated chromebook or similar device rather than sharing hard copies of the materials.

For online (broadcast or asynchronous) and hybrid classes, the teacher should have electronic versions of the materials available to the students, using LMS and educational environments approved by the district/school. For a broadcast class, once students have selected their groups, they can join breakout rooms to explore the 4 stations. (If the district does not allow breakout rooms for students the teacher could decide to have full group discussions and individual answers, or arrange group discussions to occur online using the discussion board in the LMS or similar.) For asynchronous classes, once the teacher has assigned groups, students can use discussion boards or other district approved meeting environments to explore the 4 stations.

While the students are following the instructions at each station, the in-person teacher will walk around the class, dropping into the various discussions, highlighting productive ideas, asking probing questions. For a broadcast class, the teacher can join various breakout rooms to do the same. The teacher should decide if the students are required to submit written responses to the small group discussions; this might not be necessary for in-person and broadcast classes, as the teacher can check on each group's progress. For an asynchronous class, the teacher may require a written or recorded answer, and can then provide feedback to the group that highlights productive ideas and ask probing questions.

For in-person and broadcast classes, the teacher should signal the time to finish the current activity and transition to the next.

Station 1: Wind (20-25 min)

In each group, select one student to read the following background information aloud to the rest of the group. There will be 4 stations, and readings at each station. Make sure that everyone who wants to read gets the opportunity to read.

Background Information:

"Wind was the second largest renewable energy source (after hydropower) for power generation. Wind power produced more than 5 percent of global electricity in 2018 with 591 GW of global capacity (568.4 GW is onshore). Capacity is indicative of the maximum amount of electricity that can be generated when the wind is blowing at sufficient levels for a turbine. Because the wind is not always blowing, wind farms do not always produce as much as their capacity. With around 210 MW, China had the largest installed capacity of wind generation in 2018. The United States, with 96.5 GW, had the second-largest capacity; Texas, Oklahoma, Iowa, and Kansas provide more than half of U.S. wind generation. Although people have harnessed the energy generated by the movement of air for hundreds of years, modern turbines reflect significant technological advances over early windmills and even over turbines from just 10 years ago. Generating electric power

using wind turbines creates no greenhouse gases, but since a wind farm includes dozens or more turbines, widely-spaced, it requires thousands of acres of land. For example, Lone Star is a 200 MW wind farm on approximately 36,000 acres in Texas. Average turbine size has been steadily increasing over the past 30 years. Today, new onshore turbines are typically in the range of 2 – 5 MW. The largest production models, designed for off-shore use can generate 12 MW; some innovative turbine models under development are expected to generate more than 14 MW in offshore projects in the coming years. Due to higher costs and technology constraints, off-shore capacity, approximately 22.6 GW in 2018, is only a small share (about 4 percent) of total installed wind generation capacity." (https://www.c2es.org/content/renewable-energy/)

Take 5-10 minutes to discuss in small groups: What are some advantages and disadvantages of wind power? Select one student to record key ideas from the discussion. Just like with the readings, make sure that everyone who wants the be the scribe gets the opportunity to do so.

Station 1: Wind Graph Exploration

Background Information:

This figure was developed to show estimates of average wind speed at 80 meters above the ground. The wind speed at 80 meters is important because that is how high larger wind turbines are. The wind speed is measured in meters per second. The different colors on the figure correspond to average wind speed shown in the key on the right.

Before discussing the graph, take 3-5 minutes, without talking, to figure out the graph for yourself. What is the graph is showing? How do you read the graph? Is there anything about the graph you do not understand? What patterns do you see? What information do you think is important or interesting? Write down your thoughts and ideas.

Take 5-10 minutes to discuss the following in your small groups:

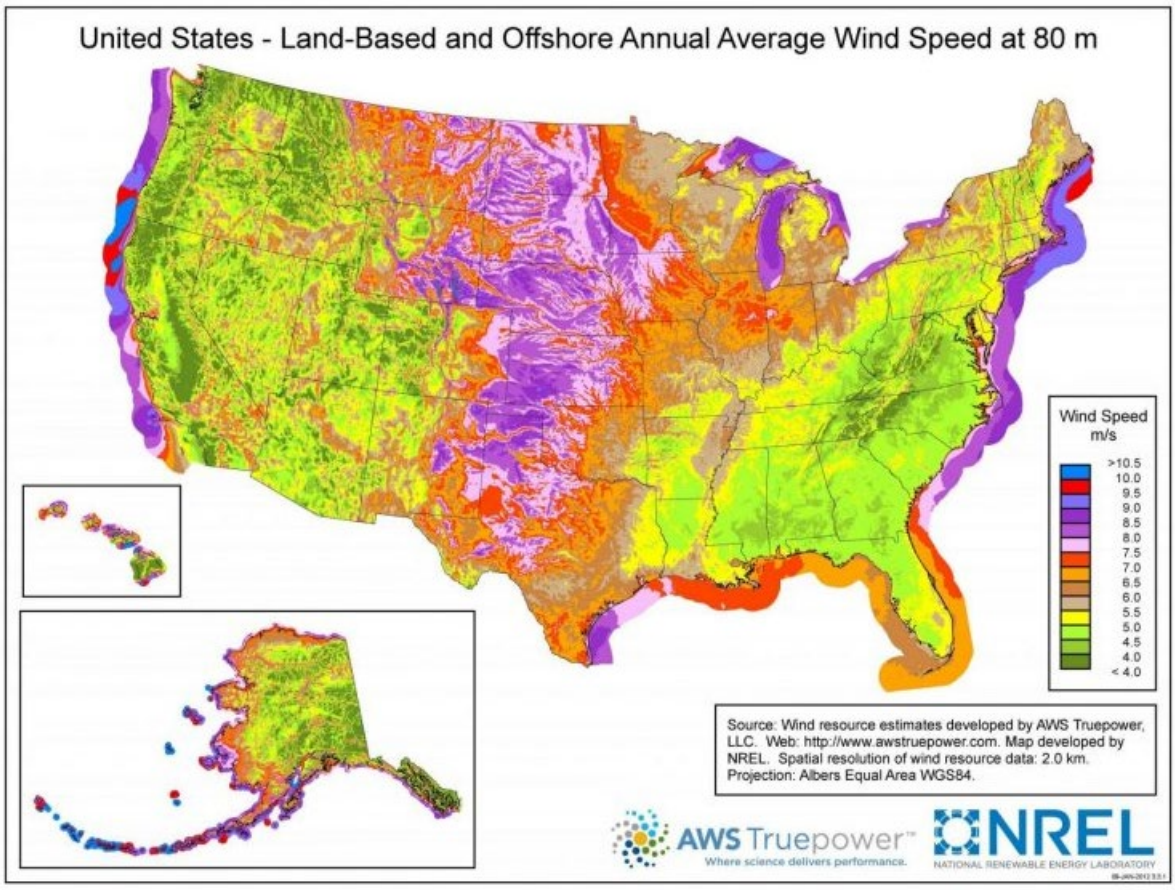
- How do you read the graph?
- Where do you find areas with high wind speed? Low wind speed?
- Why does the graph tell you the windspeed 80 meters above the ground instead of at ground level?
- What patterns do you see?
- What additional information do you need?

Using the Information:

Either as a group or individually, please answer the following questions based on the wind graph shown:

1. Rank these states in order of decreasing average wind speed: Alabama, Indiana, Nebraska
2. Choose a major US city (ex. Seattle). What is that average wind speed of that city based on the figure below?
3. Which state do you think has better potential for wind power as a renewable resource, Arizona or South Dakota? Why?
4. Given everything you already know about geography of the US, brainstorm three reasons, why is the central part of the map purple (high wind speed)?

5. Based on the background reading, the graph below, and everything else you already know about the geography of the US, write three questions you are wondering about as related to wind power?



For additional information, see:

https://www.nrel.gov/gis/assets/images/wtk-80m-2017-01.jpg

https://www.nrel.gov/gis/wind.html

Draxl, C., B.M. Hodge, A. Clifton, and J. McCaa. 2015. *Overview and Meteorological Validation of the Wind Integration National Dataset Toolkit*PDF (Technical Report, NREL/TP-5000-61740). Golden, CO: National Renewable Energy Laboratory.

Draxl, C., B.M. Hodge, A. Clifton, and J. McCaa. 2015. "The Wind Integration National Dataset (WIND) Toolkit." *Applied Energy* 151: 355366.

Station 2: Solar (20-25 min)

In each group, select one student to read the following background information aloud to the rest of the group. There will be 4 stations, and readings at each station. Make sure that everyone who wants to read gets the opportunity to read.

Background Information:

"Solar energy resources are massive and widespread, and they can be harnessed anywhere that receives sunlight. The amount of solar radiation, also known as insolation, reaching the Earth's surface every hour is more than all the energy currently consumed by all human activities each year. A number of factors, including geographic location, time of day, and weather conditions, all affect the amount of energy that can be harnessed for electricity production or heating purposes.

Solar photovoltaics are the fastest growing electricity source. In 2018, around 100 GW of global capacity was added, bringing the total to about 505 GW and producing a bit more than 2 percent of the world's electricity.

Solar energy can be captured for electricity production using:

1. A solar or photovoltaic cell, which converts sunlight into electricity using the photoelectric effect. Typically, photovoltaics are found on the roofs of residential and commercial buildings. Additionally, utilities have constructed large (greater than 100 MW) photovoltaic facilities that require anywhere from 5 to 13 acres per MW, depending on the technologies used.
2. Concentrating solar power, which uses lenses or mirrors to concentrate sunlight into a narrow beam that heats a fluid, producing steam to drive a turbine that generates electricity. Concentrating solar power projects are larger-scale than residential or commercial PV and are often owned and operated by electric utilities.

Solar hot water heaters, typically found on the roofs of homes and apartments, provide residential hot water by using a solar collector, which absorbs solar energy, that in turn heats a conductive fluid, and transfers the heat to a water tank. Modern collectors are designed to be functional even in cold climates and on overcast days.

Electricity generated from solar energy emits no greenhouse gases. The main environmental impact of solar energy come from the use of some hazardous materials (arsenic and cadmium) in the manufacturing of PV and the large amount of land required, hundreds of acres, for a utility-scale solar project."

https://www.c2es.org/content/renewable-energy/

Take 5-10 minutes to discuss in small groups: What are some advantages and disadvantages of solar power? Select one student to record key ideas from the discussion. Just like with the readings, make sure that everyone who wants the be the scribe gets the opportunity to do so.

Station 2: Solar Graph Exploration

Background Information:

This figure shows an estimate of the amount of energy that can be produced on average from sunlight. The information used to make this figure was gathered by a satellite. The colors of the figure correspond to the key one the right side of the figure which gives the average energy produced per meter squared per day. Solar power is dependent on the area of solar energy collected which is why meters squared is important in the graph.

Before discussing the graph, take 3-5 minutes, without talking, to figure out the graph for yourself. What is the graph is showing? How do you read the graph? Is there anything about the graph you do not understand? What patterns do you see? What information do you think is important or interesting? Write down your thoughts and ideas.

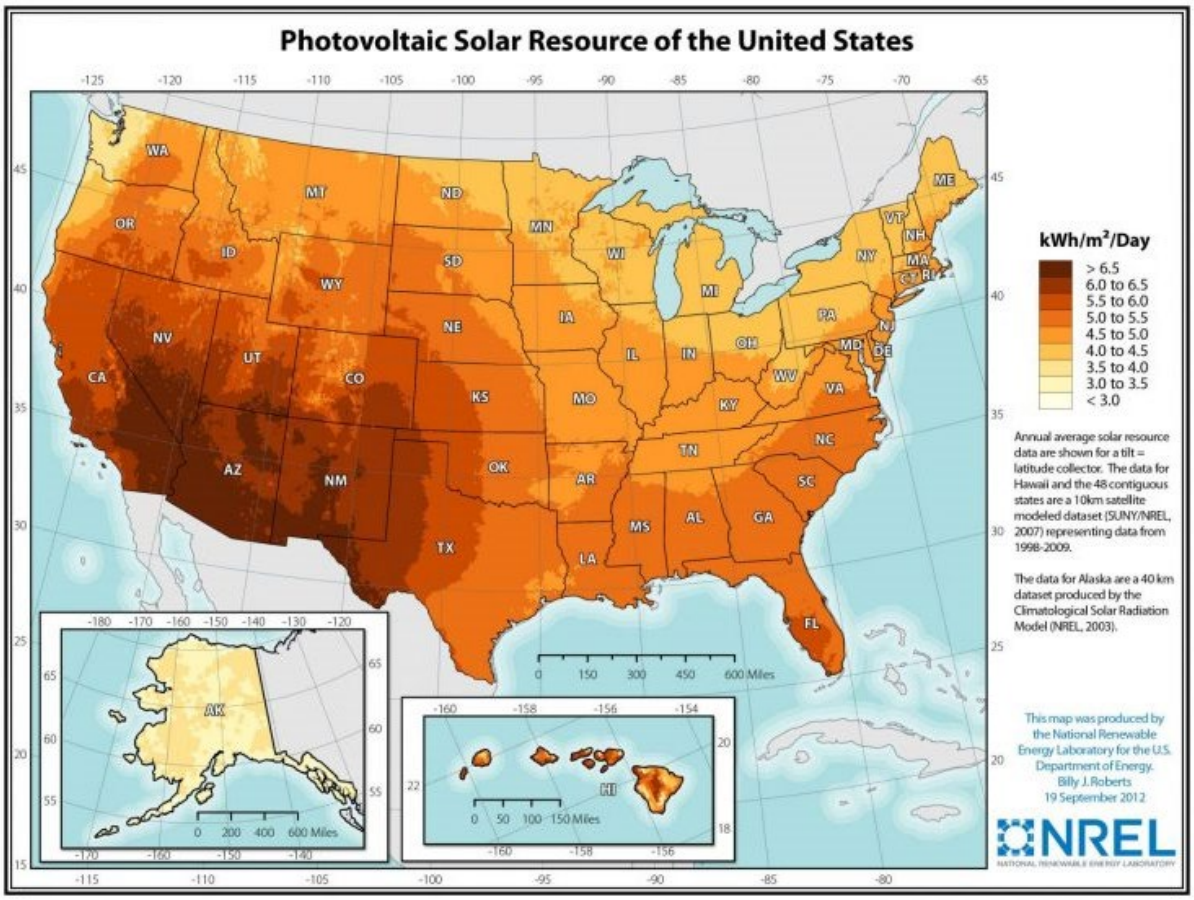
Take 5-10 minutes to discuss the following in your small groups:

- How do you read the graph?
- Where do you find areas with high photovoltaic solar resources? Low photovoltaic solar resources?
- What are some patterns you see in the photovoltaic solar resources? What do you think contributes to high or low resources?
- Are there places that are different from what you expect? What could cause these differences?
- What additional information do you need?

Using the Information:

Either as a group or individually, please answer the following questions based on the wind graph shown:

1. What is estimated range for the kWh/m^2/Day value for the state of Michigan?
2. Rank the following states in order of increasing potential for solar energy? Alabama, Arizona, Florida, Tennessee, New York
3. Given everything you already know about geography of the US, brainstorm, why is the south west part of the map dark red?
4. Based on the background reading, the graph below, and everything else you already know about the geography of the US, write three questions you are wondering about as related to solar power?



For additional information, see: https://www.nrel.gov/gis/solar.html

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Station 3: Biomass (20-25 min)

In each group, select one student to read the following background information aloud to the rest of the group. There will be 4 stations, and readings at each station. Make sure that everyone who wants to read gets the opportunity to read.

Background Information:

"Biomass energy sources are used to generate electricity and provide direct heating, and can be converted into biofuels as a direct substitute for fossil fuels used in transportation. Unlike intermittent wind and solar energy, biomass can be used continuously or according to a

schedule. Biomass is derived from wood, waste, landfill gas, crops and alcohol fuels. Traditional biomass, including waste wood, charcoal and manure, has been a source of energy for domestic cooking and heating throughout human history. In rural areas of the developing world, it remains the dominant fuel source. Globally in 2017, traditional biomass accounted for about 7.5 percent of total energy consumption. The growing use of biomass has resulted in increasing international trade in biomass fuels in recent years; wood pellets, biodiesel, and ethanol are the main fuels traded internationally.

In 2018, global biomass electric power capacity stood at 130 GW. In 2018, the United States had 16 GW of installed biomass-fueled electric generation capacity. In the United States, most of the electricity from wood biomass is generated at lumber and paper mills using their own wood waste; in addition, wood waste is used to generate the heat for drying wood products and other manufacturing processes. Biomass waste is mostly municipal solid waste, i.e., garbage, which is burned as a fuel to run power plants. On average, a ton of garbage generates 550 to 750 kWh of electricity. Landfill gas contains methane that can be captured, processed and used to fuel power plants, manufacturing facilities, vehicles and homes. In the United States, there is currently more than 2 GW of installed landfill gas-fired generation capacity at more than 600 projects.

In addition to landfill gas, biofuels can be synthesized from dedicated crops, trees and grasses, agricultural waste and algae feedstock; these include renewable forms of diesel, ethanol, butanol, methane and other hydrocarbons. Corn ethanol is the most widely used biofuel in the United States. Roughly 38 percent of the US corn crop was diverted to the production of ethanol for gasoline in 2018, up from 20 percent in 2006. Gasoline with up to 10 percent ethanol (E10) can be used in most vehicles without further modification, while special flexible fuel vehicles can use a gasoline-ethanol blend that has up to 85 percent ethanol (E85).

Closed-loop biomass, where power is generated using feedstocks grown specifically for the purpose of energy production, is generally considered to be carbon dioxide neutral because the carbon dioxide emitted during combustion of the fuel was previously captured during the growth of the feedstock. While biomass can avoid the use of fossil fuels, the net effect of biopower and biofuels on greenhouse gas emissions will depend on full lifecycle emissions for the biomass source, how it is used, and indirect land-use effects. Overall, however, biomass energy can have varying impacts on the environment. Wood biomass, for example, contains sulfur and nitrogen, which yield air pollutants sulfur dioxide and nitrogen oxides, though in much lower quantities than coal combustion."

https://www.c2es.org/content/renewable-energy/

Take 5-10 minutes to discuss in small groups: What are some advantages and disadvantages of biomass power? Select one student to record key ideas from the discussion. Just like with the readings, make sure that everyone who wants the be the scribe gets the opportunity to do so.

Station 3: Biomass Graph Exploration

Background Information:

This is a map of the United states showing biomass resource potential. The colors of the area show how many tons of biomass are produced in an area over a given year. The biomass that is shown in this map refers mostly to corn and other grain production.

Before discussing the graph, take 3-5 minutes, without talking, to figure out the graph for yourself. What is the graph is showing? How do you read the graph? Is there anything about the graph you do not understand? What patterns do you see? What information do you think is important or interesting? Write down your thoughts and ideas.

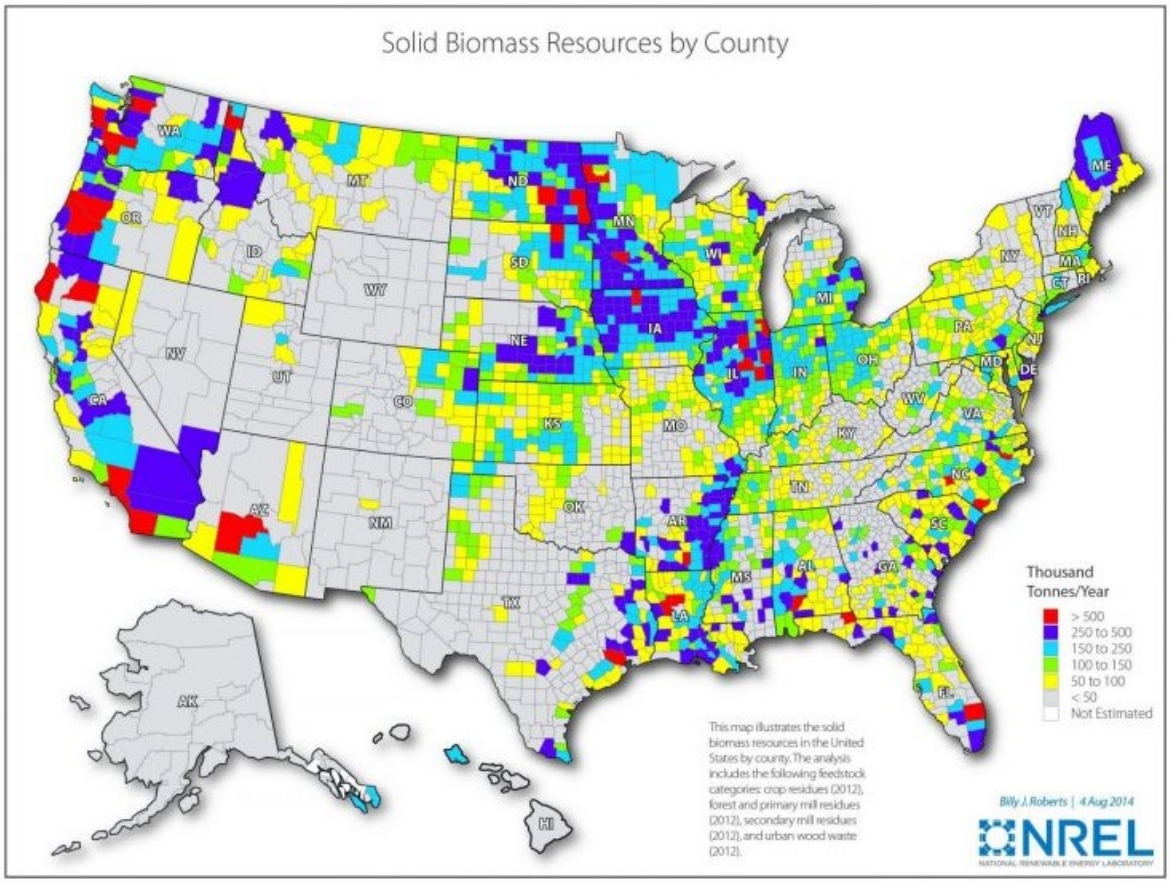
Take 5-10 minutes to discuss the following in your small groups:

- How do you read the graph?
- Where do you find areas with high biomass resources? Low biomass resources?
- What patterns do you see?
- What additional information do you need?

Using the Information:

Either as a group or individually, please answer the following questions based on the wind graph shown:

1. Rank the following states in order of increasing biomass production: New Mexico, Tennessee, and Iowa.
2. Based on what you already know, why is there lots of biomass resources in the upper Midwest and few biomass resources in the intermountain west?
3. Hypothetically, if Wyoming wanted to increase their biomass, what three things could the state do differently?
4. Based on the background reading, the graph below, and everything else you already know about the geography of the US, write three questions you are wondering about as related to biomass resources.



For additional information, see: https://www.nrel.gov/gis/biomass.html

Station 4: Geothermal (20-25 min)

In each group, select one student to read the following background information aloud to the rest of the group. There will be 4 stations, and readings at each station. Make sure that everyone who wants to read gets the opportunity to read.

Background Information:

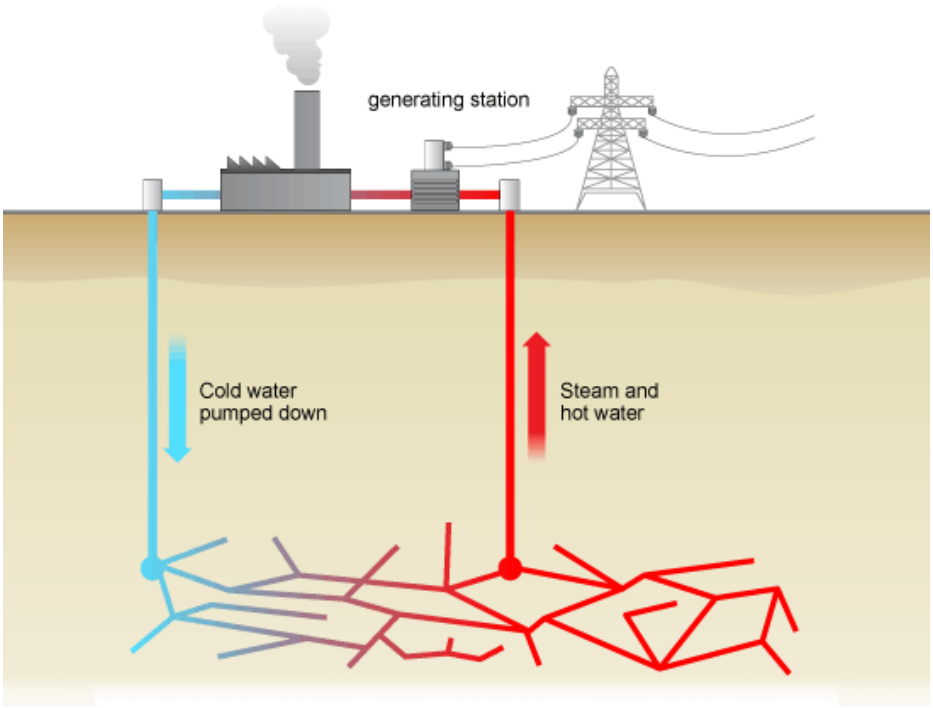
"Geothermal provided an estimated 175 TWh globally in 2018, one half in the form of electricity (with an estimated 13.3 GW of capacity) and the remaining half in the form of heat. (Total global electricity generation in 2018 was 26,700 TWh).

In the United States, 16 billion kWh of geothermal energy was generated in 2018, making up about 4 percent of non-hydroelectric renewable electricity generation, but only 0.4 percent of total electricity generation. Seven states generated electricity from geothermal energy: California, Hawaii, Idaho, Nevada, New Mexico, Oregon and Utah. Of these, California accounted for 80 percent of this generation.

Traditional geothermal energy exploits naturally occurring high temperatures, located relatively close to the Earth's surface in some areas, to generate electric power and for direct uses such as heating and cooking. Geothermal areas are generally located near tectonic plate boundaries, where there are earthquakes and volcanoes. In some places, hot springs and geysers have been used for bathing, cooking and heating for centuries

Generating geothermal electric power typically involves drilling a well, perhaps a mile or two in depth, in search of rock temperatures in the range of 300 to 700°F. Water is pumped down this well, where it is reheated by hot rocks. It travels through natural fissures and rises up a second well as steam, which can be used to spin a turbine and generate electricity or be used for heating or other purposes. Several wells may have to be drilled before a suitable one is in place and the size of the resource cannot be confirmed until after drilling. Additionally, some water is lost to evaporation in this process, so new water is added to maintain the continuous flow of steam. Like biopower and unlike intermittent wind and solar power, geothermal electricity can be used continuously. Very small quantities of carbon dioxide trapped below the Earth's surface are released during this process."

https://www.c2es.org/content/renewable-energy/



Enhanced Geothermal Systems- (EGS)

"What are Enhanced Geothermal Systems?

Most conventional geothermal power plants rely on hot rock, and a conductive channel in the crust (fracture or fault) that allows hot water to circulate through the rock. In conventional geothermal

systems one or more wells are drilled to intersect these conductive channels and heated water/steam is brought to the surface to spin a turbine and generate electricity. This works effectively in parts of the country where temperature increases relatively rapidly with depth. Suppose that we can drill deeper to find hot rock but there are no conductive fractures/faults and no water can be produced? We can still create geothermal energy but we need to intervene by creating the fractures and providing an infrastructure to circulate water through this engineered reservoir. Cool water can be pumped underground down one well, where it is heated by the hot rock as it travels to the second well where it is pumped back up to the earth's surface to the power plant. We call this Enhanced - or Engineered - Geothermal Systems (EGS).

Will EGS development result in the earthquakes like those occurring in oil and gas operations?

It is important to understand the differences between EGS development and oil and gas operations. All geothermal systems naturally experience some seismic activity, but it is generally too small to be felt by humans. When oil and gas are produced, water naturally present in these reservoirs is co-produced with the hydrocarbons. In many places, the produced water is reinjected into deep dedicated disposal wells. If the disposal wells are not appropriately engineered, the large injected volumes can lead to earthquakes.

In EGS development, two or more wells are drilled into the same volume of rock and water circulated through the hot fractured rock heats up. The volume of water injected into an EGS reservoir is very similar to the volume produced. This is different from oil and gas development where the fluids are extracted from one area of the subsurface and injected into another. The balance of water put into, and removed from the ground in an EGS system minimizes the environmental impact and reduces the potential of large earthquakes resulting from human activities."

https://utahforge.com/wp-content/uploads/sites/96/2019/11/FAQ-Geothermal-Energy.pdf

Take 5-10 minutes to discuss in small groups: What are some advantages and disadvantages of traditional geothermal power? What are some advantages and disadvantages of Enhanced Geothermal Systems? Select one student to record key ideas from the discussion. Just like with the readings, make sure that everyone who wants the be the scribe gets the opportunity to do so.

Station 4: Geothermal Graph Exploration

Background Information:

This graphic shows the potential of different sites in the United States for the development of Deep EGS. Unlike some of the other graphics, this one does not actually give any numbers showing the amount of energy that can be produced, but measures how favorable the area is. Things that affect favorability are the type of rock beneath the surface of the earth, the temperature of that rock, and how close that rock is to the surface. The graphic also contains locations of already developed geothermal sites.

Before discussing the graph, take 3-5 minutes, without talking, to figure out the graph for yourself. What is the graph is showing? How do you read the graph? Is there anything about the graph you do not understand? What patterns do you see? What information do you think is important or interesting? Write down your thoughts and ideas.

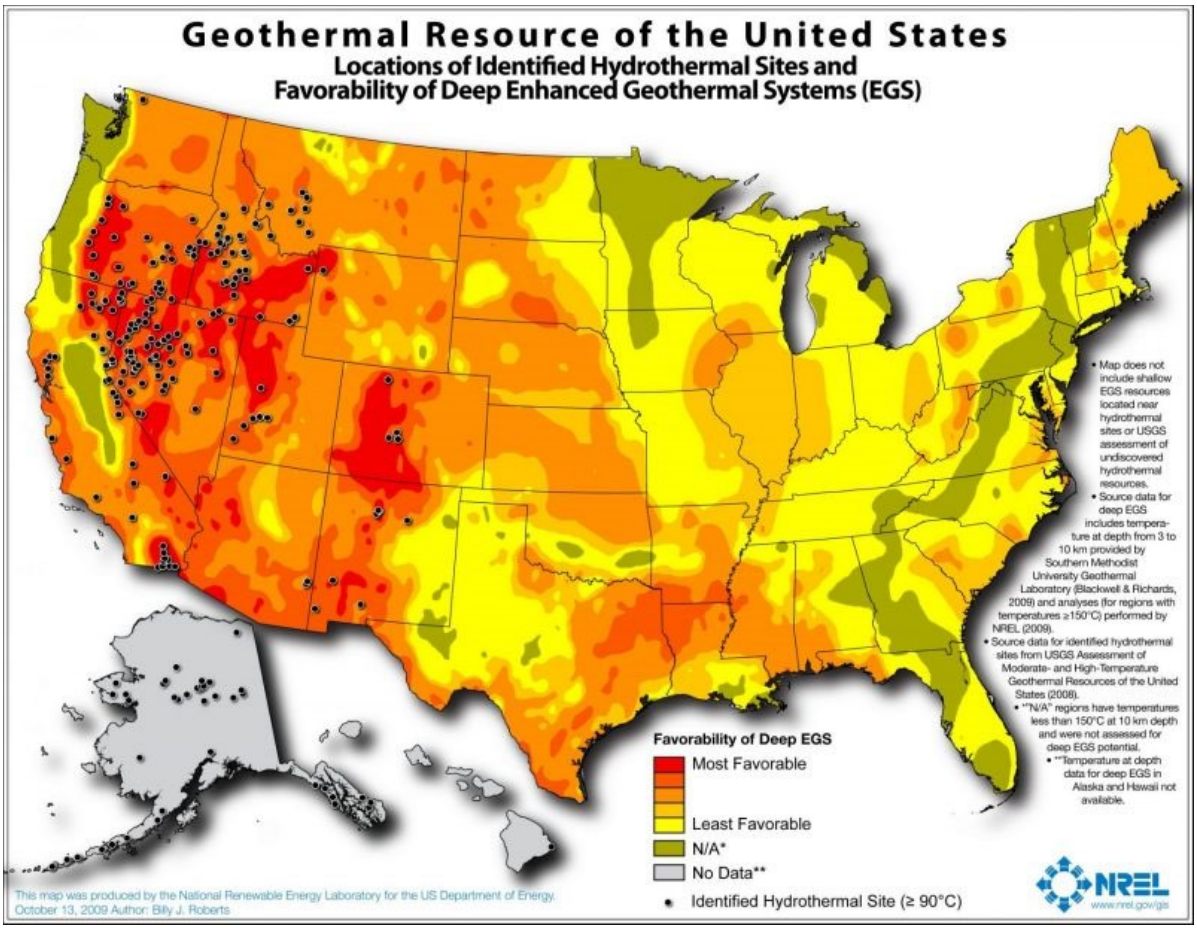
Take 5-10 minutes to discuss the following in your small groups:

- How do you read the graph?
- Where do you find areas with high hydrothermal potential? Low hydrothermal potential?
- What does it mean for an area to be marked N/A (olive green color)?
- What patterns do you see?
- What additional information do you need?

Using the Information:

Either as a group or individually, please answer the following questions based on the wind graph shown:

1. Rank the following states in order of increasing geothermal potential: Arkansas, Idaho, Minnesota
2. Based on your knowledge of geography in the US, why might the western United States show more potential for geothermal energy?
3. Are there any states with high potential for geothermal energy that do not have any identified hydrothermal sites? Why might these states not be developing this resource?
4. Based on the background reading, the graph below, and everything else you already know about the geography of the US, write three questions you are wondering about as related to geothermal energy production.



For additional information, see: https://www.nrel.gov/gis/geothermal.html

Transitioning (5 min)

Student Expectations:

Before transitioning to the next activity, the teacher should check to make sure the students understand the expectations. This assignment will be done as a jigsaw with each student in the group investigating a different state, then reporting their findings to the whole group.

Example of how to assign states: If the teacher assigned the rotating leadership roles by labeling the students in the group A, B, C, and D, the teacher can assign all A students to investigate Utah, all B students to investigate Pennsylvania, all C students to investigate Ohio, and all D students to investigate North Carolina.

Suggested Teacher Script:

Now that you have explored types of renewable energy in your small groups you are going to research how power is actually generated across the U.S. This will be done using a jigsaw format. In a jigsaw, each member of a group will investigate part of the problem, then report their findings to the rest of the group. In this jigsaw, each group member will investigate the power stations in one state, and report their findings to the group.

After each member reports their findings, the group will answer the discussion questions together.

[Give instructions on which state each student will investigate. Also instruct students on what they need to submit for this assignment (as a group, individually, no submission, etc.).]

We will continue to use the rotating leadership roles that we used to explore types of renewable energy.

Once the students understand their roles and expectations, they will begin the activity.

Exploration Part 2 (15-20 min)

Activity #2 – Students will explore power stations across the U.S.

Each student will use a computer with internet access to explore the types of power stations in their assigned state, then report their finding to their group, and answer the group discussion questions.

The COVID modifications for in-person and online learning are the same as for Exploration Part 1. The investigation part can be assigned as homework, or given early to students who need additional time or support with the research.

Power Stations Across the U.S. Jigsaw

In a jigsaw assignment, each member of a group will investigate part of the problem, then report their findings to the rest of the group. After each member reports their findings, the group will answer the discussion questions together.

Your teacher will assign you a state to research. Use the website "List of power stations in the United States" https://en.wikipedia.org/wiki/List_of_power_stations_in_the_United_States to navigate to your assigned state. Take 5-10 minutes to read the web-site and answer the following questions. Be prepared to share your results with your group members.

- What different types of power stations are located in your state?
- How many are there of each type?

After you have finished your research, take turns sharing your results with your group members.

Next spend 5-10 minutes discussing your findings. Record the answer to the following question:

- Notice there are difference in what types of power stations are located in these states. Brainstorm three reasons for these differences based on what you already know.

Full Class Discussion (30-35 min total)

The teacher will lead a full class discussion on the results of the explorations and revisit the anchoring phenomenon before transitioning to creating the renewable energy proposal.

For an in-person or broadcast class this can be done as a full class discussion. For asynchronous classes this can be done by assigning some groups to post their pros and cons for one type of energy on the discussion board and assigning other groups to post information they found about types of power plants in one area of the U.S on the discussion board. For hybrid courses, it might be beneficial to revisit the anchoring phenomena on an in-person day.

Renewable Resources (15-20 min)

The teacher should ask groups or individuals to share their ideas about the various types of renewable energy as well as the types of power plants currently in operation in various places across the U.S.

Things to highlight in this class discussion:

- pros of each type of renewable resource
- cons of each type of renewable resource
- places in the U.S. where different resources are cost effective
- places where they are not cost effective
- patterns of energy resources across the U.S.
- places that are using a reasonable percentage of renewable resources
- places that are underutilizing renewable resources

The teacher might also want to discuss other types of renewable energy the students are familiar with, such as nuclear and hydroelectric.

After reviewing the types of renewable energy resources, and the types of power plants in operation in various parts of the U.S. return to the anchoring phenomena. Remind students that their engineering firm needs to submit a proposal to the city of Everton to build a renewable energy power plant. Review the criteria for the power plant.

Revisiting the Anchoring Phenomena (15 min)

For the final part of the project, the students will create their renewable energy power plant proposal for the city of Everton and present their proposals to the class (Everton's "board").

The teacher can either allow students to choose a state for Everton, or assign a state. Once the students know where Everton is located, they will need to use the energy graphs from Activity 1 to determine what energy resources are available to Everton, and finally they will decide which type of renewable energy power plant to propose to the city of Everton. The teacher needs to decide whether to assign the same state to each group, assign different states to each group, or allow groups to select their own state.

Before beginning these activities, the teacher should check in with the students to make sure they understand the expectations.

To help scaffold the presentations, first the students will research an existing power plant that might be a good fit for Everton. Next the students will determine the energy resources available in Everton. After this, they will need to decide which type of power plant to propose to the city of Everton, and finally, they will need to create a proposal. Once their proposals are finished, they will present their proposals to the class.

Since the proposals will be created as a group, the students need to agree on the type of proposal. The teacher may wish to include instructions on how to create consensus in groups. Talk moves are provided to help the students form consensus.

The teacher will also need to explain to the students the format they will be using for the proposals and presentations. Possibilities include making electronic proposals using software such as Powerpoint or Prezi which can then be shown to the class. Alternately, the students can make an electronic proposal and record their presentation in advance. Students can create posters, which can them be presented to the full class. Alternately, the students could share their posters in a "poster session" or "science/engineering fair" type format. Make sure that the students know what format they will be using for both the proposal and for the presentation.

Suggested Teacher Script:

For the next couple class periods you will be working on creating the proposal that your engineering firm will present to the city of Everton. Remember, the criteria are

- Capacity of power consumed should be 230-250 MWatts or more.
- Currently 90% of the electricity Everton uses is from non-renewable energy sources, mainly coal and natural gas, while the remaining 10% comes from hydroelectric power. In 5 years, Everton wants 70% or more of its energy to come from sustainable energy sources.
- Due to environmental concerns, expanding hydroelectric energy is not an option for Everton.

In your proposal, you should estimate: the cost to construct the facility, land required to build the facility, the cost of upkeep and the lifetime of the facilities. In addition, you need to argue why you chose this particular type of renewable energy, as well as how you will mitigate the negative effects of this type of renewable energy.

In your presentation, you will need to address each of the following:

- Name and location of your powerplant
- Type of renewable energy the plant uses
- Cost estimate to construct the facility
- Land estimate required
- Argue for the benefits of the chosen type of renewable energy
- Present solutions to limit the cons of the chosen type of renewable energy
- The name and location of the powerplant which this powerplant is modeled on (the results from Activity 3, part 2)

[Give instructions on which state Everton is located in.]

As we go through these remaining activities, we will continue the rotating leadership structure. Remember, the group leader's role is to keep the group on task, and to help choose the scribe. The discussion leader's role is to lead the discussion, making sure that each group member is able to contribute to the discussion and that all group members ideas are heard. The scribe will take notes; this is a volunteer position, but it is important that the same person isn't the scribe the full time, so remember to give everyone a chance to be the scribe. All group members are expected to contribute to the discussion. Remember that since these roles are rotating, if you do not have a leadership role at this station, you will in the next couple of stations.

In addition, you will need to agree as a group which type of power plant to propose to the city of Everton. So, you will be provided with some talk moves to help your group come to consensus.

[Give instructions on the format for the final presentation. Also instruct students on what they need to submit for the preparation part of the assignment (as a group, individually, no submission, etc.).

To help you get started on this, first you are going to look at an example of a power plant that might be a good fit for Everton. Next, you are going to determine which type of resources are available to Everton, finally you will create a proposal and present that proposal to the class.

Once the students understand the expectations, they will begin working on creating their proposals.

Elaboration (50-70 min total)

Activity #3 –Creation of Engineering Proposal

Each group of students will research one example of how Everton's energy needs might be met, then determine what resource are available to Everton, and finally create an energy proposal.

The teacher needs to determine what format to use for the proposals and presentations. Any of the possibilities listed could work for an in-person class. For online (broadcast or asynchronous)

classes, a prerecorded Powerpoint or Prezi presentation might work well. For a broadcast course, the Powerpoint can be made in advance, but presented to the class during the synchronous meeting. For an asynchronous class, the teacher might require students to post feedback on some or all of their peers' presentations. For a hybrid class, students can create the presentations on an online day, and present these on an in-class day.

For an in-person class, students need at least one computer with internet access per group. Relevant COVID precautions could include: having students work in pairs rather than groups, so that they can sit at opposite ends of the table and not face one another; having students access the online resources using their dedicated chromebook or similar device rather than sharing a computer.

For online (broadcast or asynchronous) and hybrid classes, the teacher should have electronic versions of the materials available to the students, using LMS and educational environments approved by the district/school. For a broadcast class, students can join breakout rooms to complete the research. (If the district does not allow breakout rooms for students the teacher could decide to have full group discussions and individual answers, or arrange group discussions to occur online using the discussion board in the LMS or similar.) For asynchronous classes, students can use discussion boards or other district approved meeting environments to share the results of their research.

While the students are following the instructions at each station, the in-person teacher will walk around the class, dropping into the various discussions, highlighting productive ideas, asking probing questions. For a broadcast class, the teacher can join various breakout rooms to do the same. For an asynchronous class, the teacher may require a written or recorded answer, and can then provide feedback to the group that highlights productive ideas and ask probing questions.

For in-person and broadcast classes, the teacher should signal the time to finish the current activity and transition to the next.

Troubleshooting:

The ability of the students to find estimates for construction costs, land requirements, the cost of upkeep, the expected lifetime, etc. is highly dependent on which state the students select, the type of power plant the students select, and the quality/existence of the wiki pages on specific power plants in that state. It might not be possible to answer all the questions about the cost estimates for a given type of power plant in a given state. The teacher should be cognizant of this when assigning/selecting states. If students choose a state/type of power plant for which this information is not readily available on the wiki page, the teacher might need to direct the students to look at the pages of similar states where this information is available, or help the student use other resources to determine this information.

Part 1: Example of a Renewable Energy Power Plant (5-10 min)

In each group, navigate to the Three Cedars Solar farm found on the Utah powerplant Wikipedia page (see: https://en.wikipedia.org/wiki/Three_Cedars_Solar_Project). Spend ~5 minutes looking at the page to find out about this solar plant.

Next, spend ~5 minutes discussing the answers to the following questions.

1. How much money did it cost to construct?

2. How much land does the plant cover?
3. Do you think it would be a good fit for Everton? List three reasons why it might be a good fit for Everton. List three reasons why it might not be a good fit for Everton.

Select one student to record the answers from the discussion. Make sure that everyone who wants the be the scribe gets the opportunity to do so. Make sure that the same person is not always the scribe.

Part 2: Renewable Energy Possibilities for Everton (20-25 min)

Your teacher will let you know where the city of Everton is located. You might be assigned a state for the city of Everton, or your teacher might instruct each group select a state.

Once your group has chosen a state, spend ~5 minutes revisiting the prior graphs. Identify the relevant available energy resources in your state. What renewable resources would work well for Everton?

Next return to the Wikipedia page to find the list of the power stations in that state (see: https://en.wikipedia.org/wiki/List_of_power_stations_in_the_United_States). Find a powerplant which fits the criteria for Everton. (You may need to be flexible when choosing a state because not all states have a Wikipedia page for their power stations.) If a larger state is chosen, like California or Montana, you will need to consider what specific area of the state a power plant is in as states have diverse availability of energy resources.

Spend 5-10 minutes in the chosen state looking at several different types of powerplants. Identifying various powerplants will provide you with enough data to compare which type of powerplant is most cost effective. Find several powerplants which fit the criteria for Everton.

As a group, take a couple more minutes to choose one of the power plants that fits the criteria for Everton. All members of the group need to agree on the power plant you have chosen. The discussion leader should make sure that all group members are able to express their opinions and all members should listen actively to these opinions.

Once you have agreed on a type of power plant, take another 10-15 minutes to research information needed for the proposal. Since the available resources are comparable, you can use the land and cost of the chosen powerplant as an estimate for your proposal. You will need to do some additional research to gather information to include in your group's proposal. Use the websites below to help you answer these questions.

Driving questions:

- What are challenges associated with the chosen type of renewable energy?
- How have people tried to fix challenges with that type of renewable energy?
- Any questions that you have for the chosen type of energy from the Exploration part 1 activity.

The websites below will help you dig deeper to find out more about the types of renewable energy. You are also encouraged to dig deeper and seek out your own sources to your questions.

- For geothermal energy see: https://energyinformative.org/geothermal-energy-pros-and-cons/

- For wind energy see: https://www.energy.gov/eere/wind/advantages-and-challenges-wind-energy
- For solar energy see: https://www.greenmatch.co.uk/blog/2014/08/5-advantages-and-5-disadvantages-of-solar-energy
- For biofuel see: https://www.energytoday.net/energy-conversion-storage/the-grand-challenge-of-cellulosic-biofuels/

All group members should contribute notes to answer these questions. You will use these findings to create your proposal.

Part 3: Make a Poster/Presentation which will be presented to the town "board" of Everton (20-30 min)

Now that you have all the necessary information go ahead and create your proposal. Your teacher will have provided you with the specifications of the proposal and presentation.

Your poster/presentation should include the following:

- Name and location of this powerplant
- Type of renewable energy the plant uses
- Cost estimate to construct the facility
- Land estimate required
- Argue for the benefits of the chosen type of renewable energy
- Present solutions to limit the cons of the chosen type of renewable energy
- Name and location of the powerplant which the cost and land estimate is based on (from Activity 3 part 2).

Remind students to upload their presentations before leaving class.

Transitioning (5 min)

Student Expectations:

Before beginning the student presentations, the teacher should set the classroom expectations. Students should listen actively during the presentations, and be prepared to contribute to the discussions following the presentations. All responses should be polite and respectful. During the full class discussion after the presentations, students should be prepared to respond to the presentations. Here are some possible responses:

- Students may agree with the presentations, and provide reasons to support the claims.
- Students may disagree with the presentations, and provide reasons for the disagreement.
- Students may ask questions about the proposals.

Evaluation (30-50 min)

Activity #3 – Presenting Engineering Proposal to the "town board" of Everton

The teacher will determine how to do this. This could be done as full class presentations, as online presentations, or in a "poster session" format. Whichever way this is done, the students who are the "audience" should engage with the "presenters" in the ways described above.

The teacher can use these presentations as the final assessment for this unit. Alternatively, if a separate assessment is desired, the teacher can ask students to choose one of the types of renewable types of energy that have been discussed during this assignment and then conduct online research about that type of energy and its use in a foreign country of their choosing.

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