Activity #1 – Exploring Renewable Energy Resources

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.

There are several roles for the group members, the roles will rotate as you go through the stations. Your teacher will let you know which role you have at each station.

- Group Leader: Your task is to make sure that your group stay 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. You can 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. You can use the talk moves to help you 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 part 2. 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.

Talk Moves

Sometimes people get stuck when asked to contribute to group discussions. Having sentence stems can help make it easier. Here are some talk moves that you can use to help with your conversation. You can always contribute a new idea, agree with a group member and build on their ideas, disagree with a group member and give evidence for why you disagree, or ask a question about something a group member said.

One advantage I noticed from the reading is _____.

One disadvantage I noticed from the reading is _____.

I think the reading said this _____. Is that what you understood it to mean?

I was confused when the reading said _____. What do you think that meant?

When reading the graph, I notice that the color _____ represents _____ and the color _____ represents _____.

There appears to be more of the energy source in _____regions.

There appears to be less of the energy source in _____regions.

I agree with what you said and I also want to add that _____.

I disagree with what you said, and my reason is _____.

I think you said _____ is that what you meant?

Can you clarify what you meant by _____?

Station 1: Wind

Directions:

1. Selecting roles: (<1 min)
    a. The group leader will help choose volunteers to fill the roles of reader and scribe.
    b. Record the group member names next to their assigned/self-selected roles.
2. Background reading: (2-3 min)
    a. The reader will read the background information to the group.
    b. Group members will listen and/or read along, pay particular attention to the advantages and disadvantages of wind energy. Think about: What did you already know about wind energy? What information is new? Do you have any experiences with wind energy? Do you think wind would be a good renewable energy source in your area?
3. Discussion, part 1: (5-10 min)
    a. The discussion leader will lead a discussion on advantages and disadvantages of wind energy.
    b. Each group member will contribute both new ideas and active listening responses.
    c. Use the talk moves to facilitate and contribute to the discussion.
    d. The scribe will take notes on important ideas.
4. Graph Exploration: (5 min)
    a. Each group member needs to take 3-5 minutes, without talking, to look at the graph. 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 some of your ideas about the graph to prepare for the group discussion.
5. Discussion, part 2: (5-10 min)
    a. The discussion leader will lead a discussion on the information from the graph. Here are some questions to help facilitate the discussion:
        i. How do you read the graph?
        ii. Where do you find areas with high wind speed? Low wind speed?
        iii. Why does the graph tell you the windspeed 80 meters above the ground instead of at ground level?
        iv. What patterns do you see?
        v. What additional information do you need?
    b. Use the talk moves to facilitate and contribute to the discussion.
    c. Each group member will contribute both new ideas and active listening responses.
    d. The scribe will take notes on important ideas.
6. Using the information: (5-10 min)
    a. Either as a group, or individually, answer the questions about wind energy and the graph of wind speeds.
7. Rotate to the next station

Station 1: Wind

Group leader _____

Reader _____

Other members _____

_____

Notes on Advantages and Disadvantages of Wind Energy

_____

Notes on Reading the Wind Speed Graph

_____

Please answer the following questions based on the wind graph provided:

1. Rank these states in order of decreasing average wind speed: Alabama, Indiana, Nebraska

Names of Group members

Discussion leader _____

Scribe _____

Other members _____

_____

2. Choose a major US city (ex. Seattle). What is that average wind speed of that city based on the graph?

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 provided, and everything else you already know about the geography of the US, write three questions you are wondering about as related to wind power?

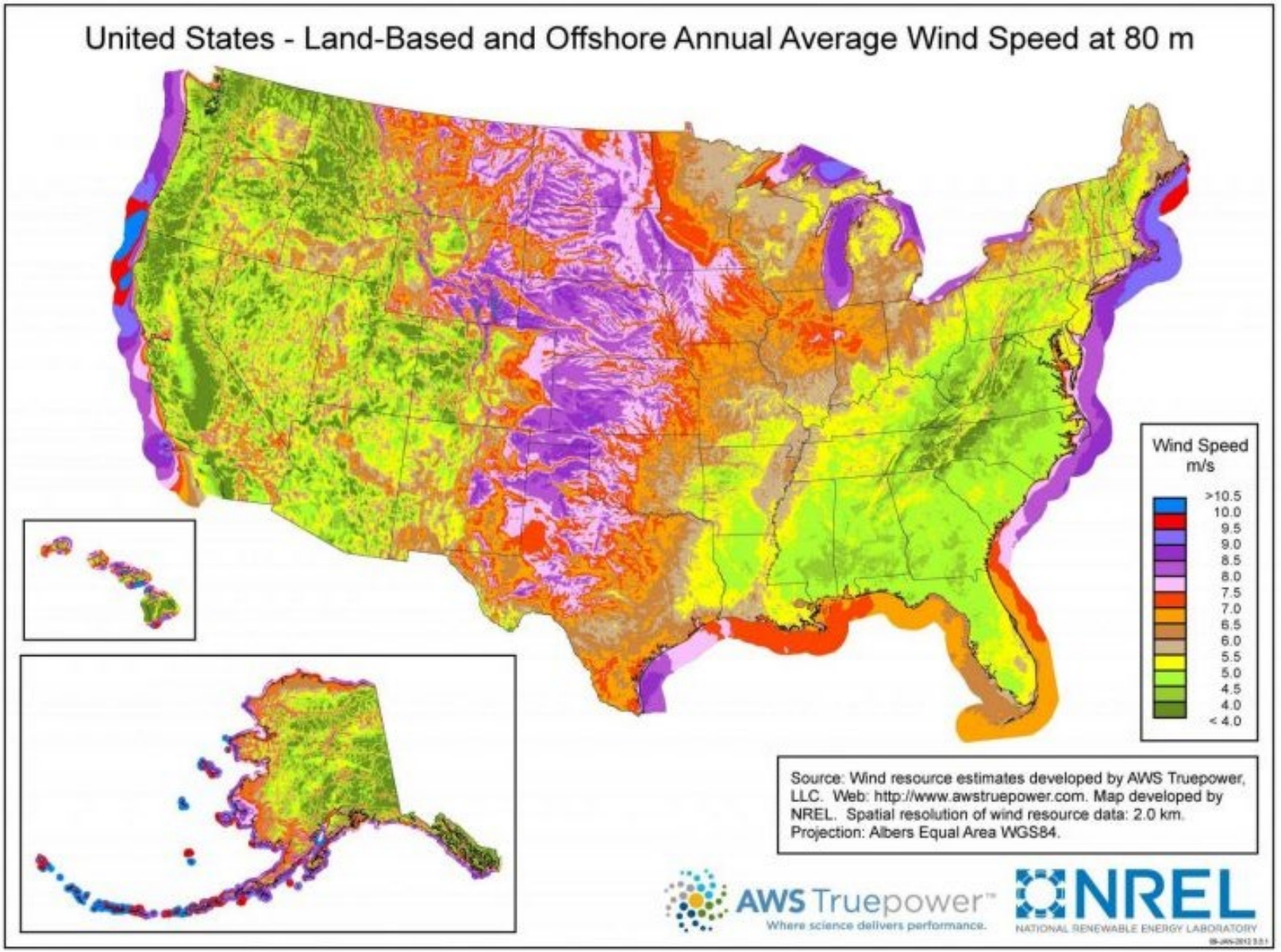
Station 1: Wind – Background Reading

"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/

Station 1: Wind

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.
For additional information see: https://www.nrel.gov/gis/assets/images/wtk-80m-2017-01.jpg https://www.nrel.gov/gis/wind.html



Station 2: Solar

Directions:

1. Selecting roles: (<1 min)
    a. The group leader will help choose volunteers to fill the roles of reader and scribe.
    b. Record the group member names next to their assigned/self-selected roles.
2. Background reading: (2-3 min)
    a. The reader will read the background information to the group.
    b. Group members will listen and/or read along, pay particular attention to the advantages and disadvantages of solar energy. Think about: What did you already know about solar energy? What information is new? Do you have any experiences with solar energy? Do you think solar would be a good renewable energy source in your area?
3. Discussion, part 1: (5-10 min)
    a. The discussion leader will lead a discussion on advantages and disadvantages of solar energy.
    b. Each group member will contribute both new ideas and active listening responses.
    c. Use the talk moves to facilitate and contribute to the discussion.
    d. The scribe will take notes on important ideas.
4. Graph Exploration: (5 min)
    a. Each group member needs to take 3-5 minutes, without talking, to look at the graph. 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 some of your ideas about the graph to prepare for the group discussion.
5. Discussion, part 2: (5-10 min)
    a. The discussion leader will lead a discussion on the information from the graph. Here are some questions to help facilitate the discussion:
        i. How do you read the graph?
        ii. Where do you find areas with high photovoltaic solar resources? Low photovoltaic solar resources?
        iii. What are some patterns you see in the photovoltaic solar resources? What do you think contributes to high or low resources?
        iv. Are there places that are different from what you expect? What could cause these differences?
        v. What additional information do you need?
    b. Each group member will contribute both new ideas and active listening responses.
    c. Use the talk moves to facilitate and contribute to the discussion.
    d. The scribe will take notes on important ideas.
6. Using the information: (5-10 min)
    a. Either as a group, or individually, answer the questions about solar energy and the graph of solar resources.
7. Rotate to the next station

Station 2: Solar

Group leader _____

Reader _____

Other members _____

_____

Notes on Advantages and Disadvantages of Solar Energy

_____

Notes on Reading the Solar Resources Graph

_____

Please answer the following questions based on the solar energy graph provided:

1. What is estimated range for the kWh/m2/Day value for the state of Michigan?

Names of Group members

Discussion leader _____

Scribe _____

Other members _____

_____

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?

Station 2: Solar – Background Reading

“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.

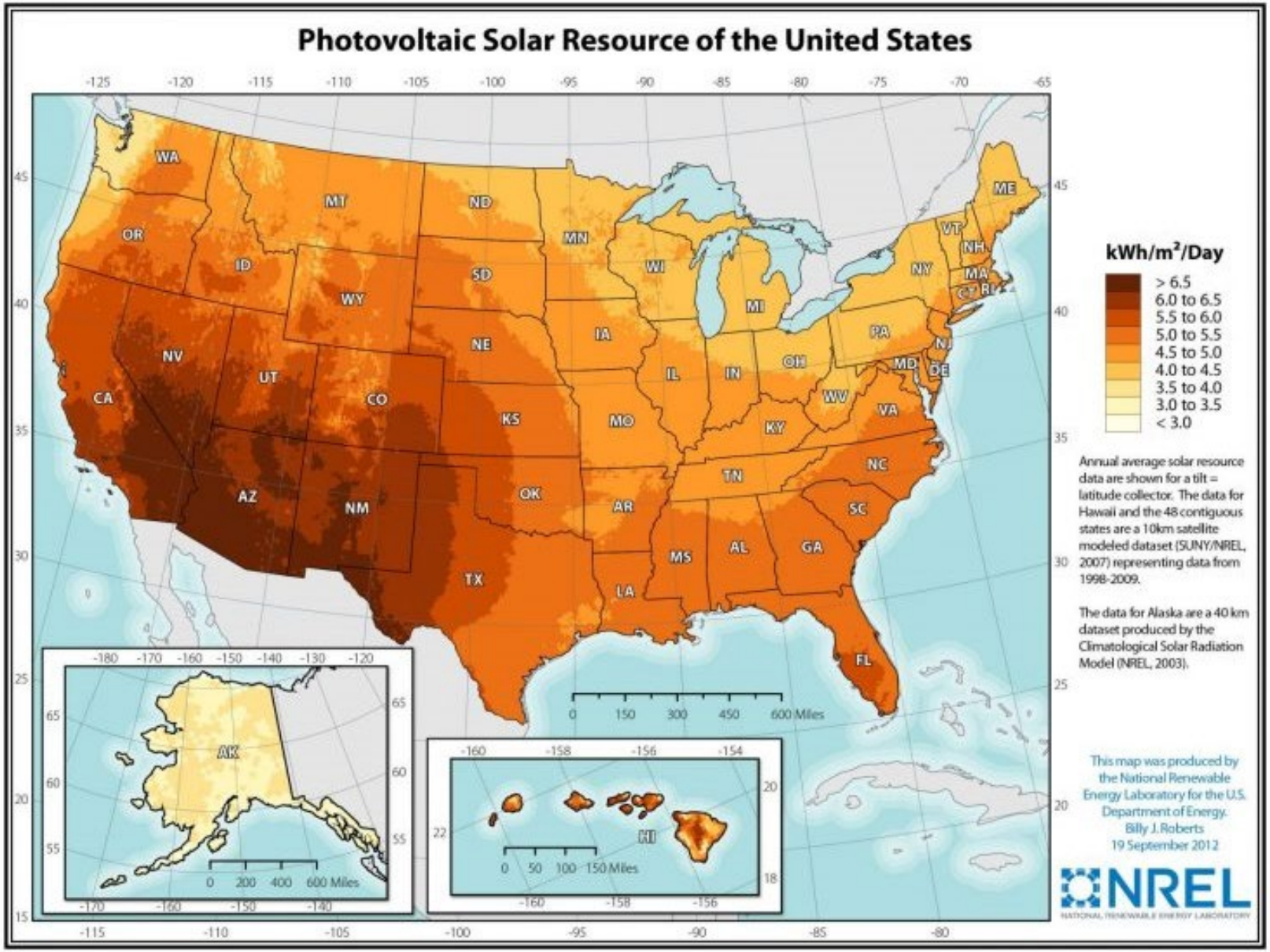
Solar hot water heaters, typically found on the roofs of homes and apartments, provide residential hot water by using a solar collector, which absorbs solar energy, that in turn heats a conductive fluid, and transfers the heat to a water tank. Modern collectors are designed to be functional even in cold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

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



Station 3: Biomass

Directions:

1. Selecting roles: (<1 min)
    a. The group leader will help choose volunteers to fill the roles of reader and scribe.
    b. Record the group member names next to their assigned/self-selected roles.
2. Background reading: (2-3 min)
    a. The reader will read the background information to the group.
    b. Group members will listen and/or read along, pay particular attention to the advantages and disadvantages of biomass energy. Think about: What did you already know about biomass energy? What information is new? Do you have any experiences with biomass energy? Do you think biomass would be a good renewable energy source in your area?
3. Discussion, part 1: (5-10 min)
    a. The discussion leader will lead a discussion on advantages and disadvantages of biomass energy.
    b. Each group member will contribute both new ideas and active listening responses.
    c. Use the talk moves to facilitate and contribute to the discussion.
    d. The scribe will take notes on important ideas.
4. Graph Exploration: (5 min)
    a. Each group member needs to take 3-5 minutes, without talking, to look at the graph. 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 some of your ideas about the graph to prepare for the group discussion.
5. Discussion, part 2: (5-10 min)
    a. The discussion leader will lead a discussion on the information from the graph. Here are some questions to help facilitate the discussion:
        i. How do you read the graph?
        ii. Where do you find areas with high biomass resources? Low biomass resources?
        iii. What patterns do you see?
        iv. What additional information do you need?
    b. Each group member will contribute both new ideas and active listening responses.
    c. Use the talk moves to facilitate and contribute to the discussion.
    d. The scribe will take notes on important ideas.
6. Using the information: (5-10 min)
    a. Either as a group, or individually, answer the questions about biomass energy and the graph of biomass resources.
7. Rotate to the next station

Station 3: Biomass

Group leader _____

Reader _____

Other members _____

_____

Notes on Advantages and Disadvantages of Biomass Energy

_____

Notes on Reading the Biomass Resources Graph

_____

Please answer the following questions based on the biomass graph provided:

1. Rank the following states in order of increasing biomass production: New Mexico, Tennessee, and Iowa.

Names of Group members

Discussion leader _____

Scribe _____

Other members _____

_____

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.

Station 3: Biomass – Background Reading

“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.

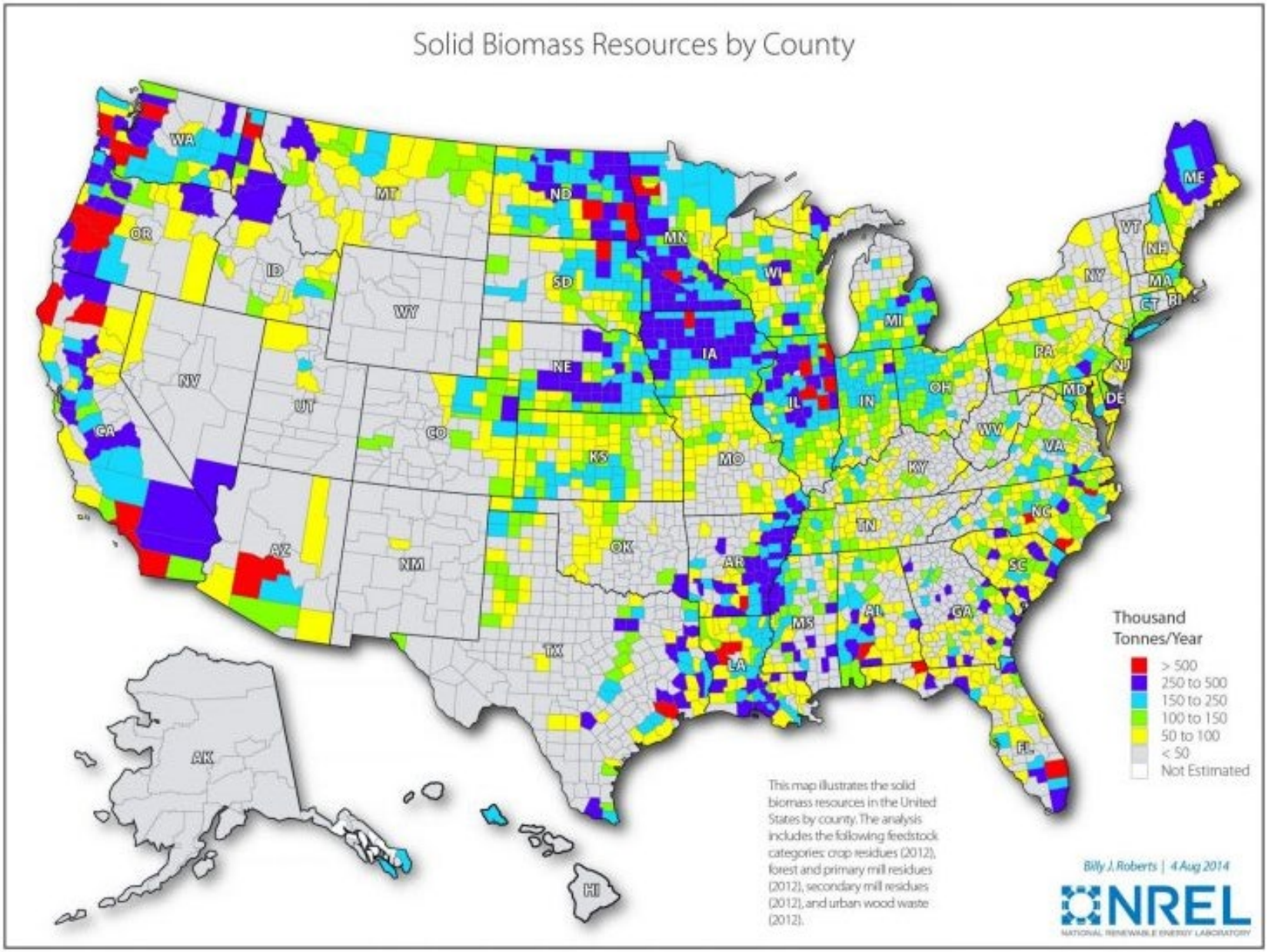
In addition to landfill gas, biofuels can be synthesized from dedicated crops, trees and grasses, agricultural waste and algae feedstock; these include renewable forms of diesel, ethanol, butanol, methane and other hydrocarbons. Corn ethanol is the most widely used biofuel in the United States. Roughly 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/

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



Station 4: Geothermal

Directions:

1. Selecting roles: (<1 min)
    a. The group leader will help choose volunteers to fill the roles of reader and scribe.
    b. Record the group member names next to their assigned/self-selected roles.
2. Background reading: (2-3 min)
    a. The reader will read the background information to the group.
    b. Group members will listen and/or read along, pay particular attention to the advantages and disadvantages of geothermal energy. Think about: What did you already know about geothermal energy? What information is new? Do you have any experiences with geothermal energy? Do you think geothermal would be a good renewable energy source in your area?
3. Discussion, part 1: (5-10 min)
    a. The discussion leader will lead a discussion on advantages and disadvantages of traditional geothermal energy and Enhanced Geothermal Systems. Be sure to discuss both types of energy.
    b. Each group member will contribute both new ideas and active listening responses.
    c. Use the talk moves to facilitate and contribute to the discussion.
    d. The scribe will take notes on important ideas.
4. Graph Exploration: (5 min)
    a. Each group member needs to take 3-5 minutes, without talking, to look at the graph. 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 some of your ideas about the graph to prepare for the group discussion.
5. Discussion, part 2: (5-10 min)
    a. The discussion leader will lead a discussion on the information from the graph. Here are some questions to help facilitate the discussion:
        i. How do you read the graph?
        ii. Where do you find areas with high hydrothermal potential? Low hydrothermal potential?
        iii. What does it mean for an area to be marked N/A (olive green color)?
        iv. What patterns do you see?
        v. What additional information do you need?
    b. Each group member will contribute both new ideas and active listening responses.
    c. Use the talk moves to facilitate and contribute to the discussion.
    d. The scribe will take notes on important ideas.
6. Using the information: (5-10 min)
    a. Either as a group, or individually, answer the questions about geothermal energy and the graph of geothermal resources.
7. Rotate to the next station

Station 4: Geothermal

Group leader _____

Reader _____

Other members _____

_____

Notes on Advantages and Disadvantages of traditional Geothermal Energy

_____

Notes on Advantages and Disadvantages of Enhanced Geothermal Systems

_____

Notes on Reading the Geothermal Resources Graph

Names of Group members

Discussion leader _____

Scribe _____

Other members _____

_____

Please answer the following questions based on the geothermal graph provided:

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.

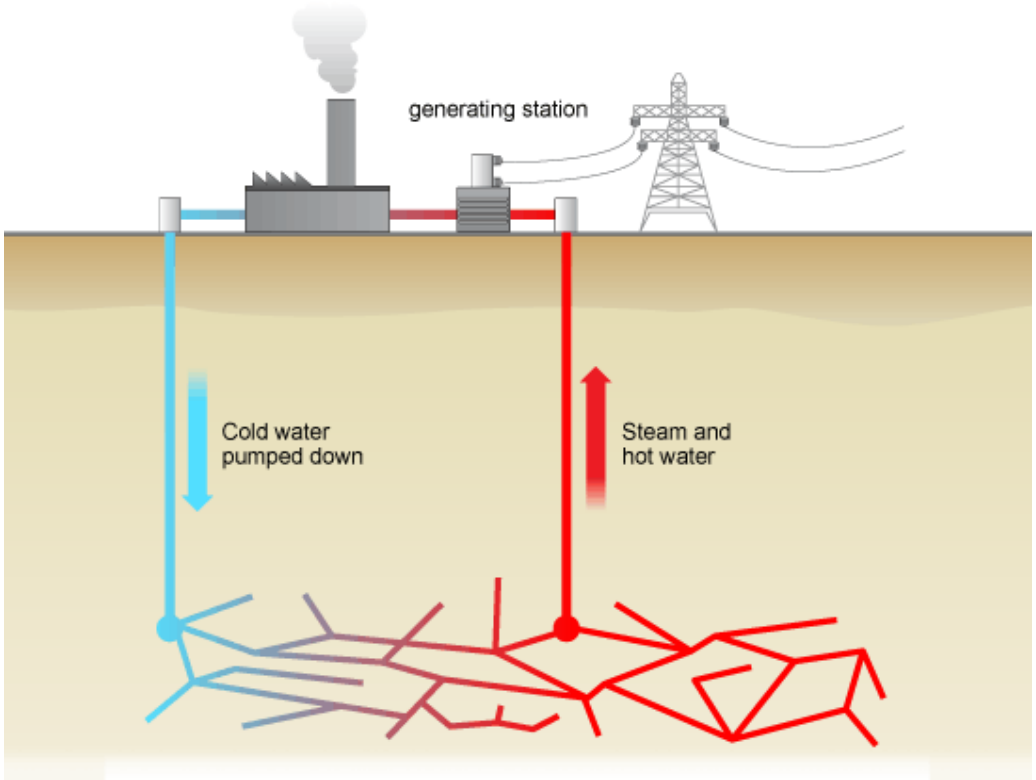
Station 4: Geothermal – Background Reading, pg. 1

“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/



Station 4: Geothermal – Background Reading, pg. 2

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?

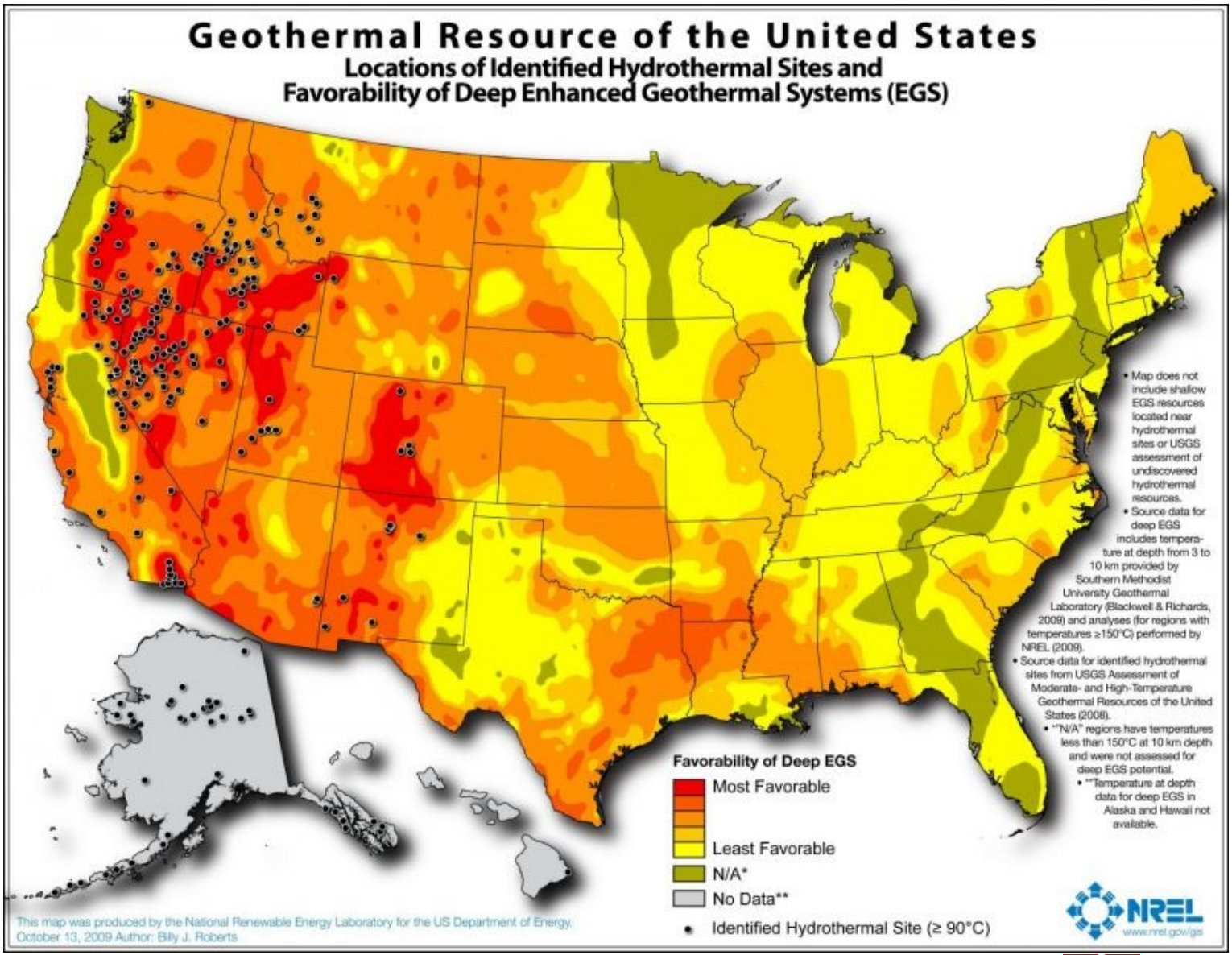
It is important to understand the differences between EGS development and oil and gas operations. All geothermal systems naturally experience some seismic activity, but it is generally too small to be felt by humans. When oil and gas are produced, water naturally present in these reservoirs is co-produced 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

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



Activity #2 –Exploring Power Stations Across the U.S. Jigsaw

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 which 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.

For small groups, keep using the rotating leadership from Activity #1. For individual work, your teacher will assign you two states to investigate.

Directions:

1. Selecting roles: (<1 min)
    a. The group leader will help choose volunteers to be the scribes, if applicable.
    b. Record the group member names next to their assigned/self-selected roles.
    c. Record the names of the states you have been assigned to investigate.
2. Background reading: (5-10 min)
    a. Individually, each group member will navigate to their assigned state through the webpage "List of power stations in the United States" https://en.wikipedia.org/wiki/List_of_power_stations_in_the_United_States
    b. Each group member will use that webpage to answer questions about the power stations in their assigned state.
    c. Each group member will prepare to share their findings with their group.
3. Discussion: (5-10 min)
    a. Each group member will present the information they found about the types of power stations in their state.
    b. The discussion leader will facilitate the presentations, making sure that each member has a chance to present.
    c. The discussion leader will then facilitate a discussion about the differences in the types of power stations found in the relevant states.
    d. Use the talk moves to facilitate and contribute to the discussion.
    e. The scribe will take notes on important ideas.

Exploring Power Stations Across the U.S. Jigsaw

Group leader _____ State _____

Scribe _____ State _____

Other members _____ State _____

_____

State #1 _____

What different types of power stations are located in this state?

How many are there of each type?

State #2 _____

What different types of power stations are located in this state?

How many are there of each type?

State #3 _____

What different types of power stations are located in this state?

How many are there of each type?

Names of Group members

Discussion leader _____ State _____

Scribe _____ State _____

Other members _____ State _____

_____

State #4 _____

What different types of power stations are located in this state?

How many are there of each type?

State #5 _____

What different types of power stations are located in this state?

How many are there of each type?

_____

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.

Activity #3 – Exploring Renewable Energy Resources

For the final part of this project, you will create your renewable energy power plant proposal that your engineering firm will present to the city of Everton and present your proposal to Everton's "board." (The rest of your class will play the role of Everton's board.)

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 for materials, the upkeep of facilities, the lifespan of the facilities, and the space needs.

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)

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.

Part 1: Example of a Renewable Energy Power Plant

Directions:

1. Selecting roles: (<1 min)
    a. The group leader will help choose volunteers to fill the role of scribe.
    b. Record the group member names next to their assigned/self-selected roles.
    c. Record the names of the states you have been assigned to investigate.
2. Background reading: (5-10 min)
    a. 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).
3. Discussion: (5-10 min)
    a. The discussion leader will lead a discussion on your findings. Here are some questions to help facilitate the discussion:
        i. How much money did it cost to construct?
        ii. How much land does the plant cover?
        iii. Do you think it would be a good fit for Everton?
        iv. What are some reasons why it might be a good fit for Everton.
        v. What are some reasons why it might not be a good fit for Everton.
    b. Each group member will contribute both new ideas and active listening responses.
    c. Use the talk moves to facilitate and contribute to the discussion.
    d. The scribe will take notes on important ideas.
    e. Either as a group, or individually, answer these questions.
4. Rotate to the next station

Part 1: Example of a Renewable Energy Power Plant

Group leader _____

Scribe _____

Other members _____

_____

Names of Group members

Discussion leader _____

Scribe _____

Other members _____

_____

The Three Cedars solar farm in Utah might be a good fit for Everton. From your reading, answer these questions about this solar farm.

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.

Part 2: Renewable Energy Possibilities for Everton, pg 1

Directions:

1. Selecting roles: (<1 min)
    a. The group leader will help choose volunteers to fill the role of scribe.
    b. Record the group member names next to their assigned/self-selected roles.
2. Review: (~5 min)
    a. Each group member will revisit the graphs from Activity 1.
    b. Individually, identify the renewable energy resources in your state. Think about: What renewable resources would work well for Everton?
3. Background reading: (5-10 min)
    a. Navigate to your state through the webpage "List of power stations in the United States" https://en.wikipedia.org/wiki/List_of_power_stations_in_the_United_States
    b. Either individually or as a group, look at several different types of powerplants. Find several powerplants which fit the criteria for Everton. Think about: Which type of power plant is the most cost effective?
4. Discussion: (varies)
    a. The discussion leader will lead a discussion on which type of power plant your group will choose.
    b. The discussion leader should make sure that all group members are able to express their opinions.
    c. Each group member will contribute both new ideas and active listening responses.
    d. Use the talk moves to help come to consensus.
    e. All members of the group need to agree on the chosen type of power plant.
    f. The scribe will take notes on important ideas.
5. Selecting tasks: (<1 min)
    a. You will need to conduct additional research to answer the questions required for the proposal.
    b. The group leader will help group members decide how to divide the research tasks.

Part 2: Renewable Energy Possibilities for Everton, pg 2

Directions, cont.:

6. Further Research: (10-15 min)
    a. Use the land and cost of the powerplant selected from the background reading as a starting point.
        i. Cost to build the plant
        ii. Land needed
        iii. Energy produced
    b. Each group member will need to do some additional research to gather information to include in your group's proposal.
    c. Driving questions:
        i. What are challenges associated with the chosen type of renewable energy?
        ii. How have people tried to fix challenges with that type of renewable energy?
        iii. Any questions that you have for the chosen type of energy from the Exploration part 1 activity.
    d. The websites below will help you find out more about the types of renewable energy. You are also encouraged to find your own sources to your questions.
        i. For geothermal energy see: https://energyinformative.org/geothermal-energy-pros-and-cons/
        ii. For wind energy see: https://www.energy.gov/eere/wind/advantages-and-challenges-wind-energy
        iii. For solar energy see: https://www.greenmatch.co.uk/blog/2014/08/5-advantages-and-5-disadvantages-of-solar-energy
        iv. For biofuel see: https://www.energytoday.net/energy-conversion-storage/the-grand-challenge-of-cellulosic-biofuels/
    e. Each group member will need to contribute their findings.
7. Rotate to the next station
    a. Check in with your teacher to make sure that you have collected enough information to begin the final proposal presentation.

Part 2: Renewable Energy Possibilities for Everton

Name _____

_____

Using the graphs from Activity 1, what are the renewable energy resources for your state? List the level for each of the 4 types.

Which energy resources would work well for Everton?

_____

From the Wikipedia page that lists power plants for your state, find several powerplants which fit the criteria for Everton.

Which type of power plant is the most cost effective?

_____

What type of power plant will your group propose to Everton?

_____

What are challenges associated with the chosen type of renewable energy?

How have people tried to fix challenges with that type of renewable energy?

_____

Additional notes:

Part 2: Renewable Energy Possibilities for Everton

Group leader _____

Scribe _____

Other members _____

_____

Notes on energy resources for Everton

_____

Notes on power plants that will work well for Everton

_____

What type of power plant will your group propose to Everton?

How much will this cost to build?

How much land will it require?

Names of Group members

Discussion leader _____

Scribe _____

Other members _____

_____

Notes on discussion about which type of powerplant to propose to Everton's "board"

_____

How much energy will it produce?

How much will it cost to maintain (if available)?

What is its expected lifespan (if available)?

What is the name of the power plant that these estimates are based on?

Talk Moves to Come to Consensus

Coming to a group consensus can be challenging. It is important that everyone's voice is heard and their opinions are respected. By listening to each other, it is possible for everyone to be able to agree on the final decision. Here are some talk moves to help you express your opinion and listen to your group members.

I agree that we should propose _____ type of power plant because our state has high energy resources in this area.

I agree that we should propose _____ type of power plant because this type of power plant is cost effective in our state.

I agree that we should propose _____ type of power plant because this type of power plant has these advantages _____.

I disagree with proposing _____ type of power plant because our state has low energy resources in this area.

I disagree with proposing _____ type of power plant because this type of power plant is not cost effective in our state.

I disagree with proposing _____ type of power plant because this type of power plant has these disadvantages _____.

I am undecided about _____ type of power plant and would like more information on why this would be a good type of power plant in our state.

I am unsure about _____ type of power plant because I have concerns about _____. How can we address my concerns?