NATIONAL GEOGRAPHIC

RESOURCE LIBRARY
ACTIVITY : 3 HRS

The Right Balance: Mixing Energy Resources

Students investigate how different mixtures of energy resources are used to provide electricity in different parts of the country. They investigate the conversion efficiency and carbon dioxide (CO2) emissions for each energy resource and analyze how different mixtures of energy resources affect the overall efficiency and CO2 emissions for a region.

GRADES

6 - 8

SUBJECTS

Geography, Human Geography, Mathematics

CONTENTS

16 Images, 4 PDFs, 4 Links

OVERVIEW

Students investigate how different mixtures of energy resources are used to provide electricity in different parts of the country. They investigate the conversion efficiency and carbon dioxide (CO_2) emissions for each energy resource and analyze how different mixtures of energy resources affect the overall efficiency and CO_2 emissions for a region.

For the complete activity with media resources, visit:
http://www.nationalgeographic.org/activity/right-balance-mixing-energy-resources/

Program

CONNECT! TRANSFORM THE FUTURE

DIRECTIONS

1. Activate students' prior knowledge by viewing the Energy Resources photo gallery.

As you scroll through the images, have students identify each type of energy resource shown and indicate if it is a renewable energy resource or non-renewable energy resource. Briefly discuss some benefits and drawbacks of each type of resource shown. Then ask:

- *Which of these energy resources do you think the local electric company uses to provide the electricity in this building?*
- *Do you think most of the electrical energy used in this building comes from coal? Natural gas? Hydropower?*
- *Do you think any of it comes from solar power? Wind power?*
- *How could we find out where the electricity we use comes from?*

Share the mixture of energy resources provided by your local electric company and ask: *How do these resources compare to what you expected? What factors affect the amount of energy used by people in the United States?* Prompt students to think about energy conservation and the efficiency of converting an energy resource into electricity, as well as how efficiently we transport and use that electricity. Divide students into small discussion groups and have them discuss the following questions:

- *How does energy conservation relate to the amount of energy we consume?* (The more energy we conserve, the less we need to consume.)
- *How does the efficiency with which we use energy resources relate to the amount we consume?* (If we use energy resources more efficiently, we need fewer resources to produce the same amount of electricity.)

Allow groups to share their ideas with the class.

2. Discuss the use of a mixture of energy resources to produce electricity.

Explain to students that most electricity is generated from a variety of energy resources and that the energy resources used can vary from place to place. Ask students to brainstorm some reasons that energy resources might vary from place to place throughout the United States. Ask: *Why wouldn't a community want to rely on just one energy resource for all its electricity? What is the advantage of using a mixture of resources?* Introduce the ideas of availability, cost,

reliability, the efficiency of converting an energy resource into electricity, and the amount of energy used per capita. Note that the amount of energy different people use may vary significantly based on their socioeconomic status, the work they do, and where they live, so averages are used for comparisons and calculations. Discuss how these factors might contribute to a need for the diversification of energy resources. For illustrative purposes, introduce an example such as a community that has relied heavily on coal energy and is facing increasing demand as energy use per capita rises. Such a community might choose to diversify its energy mixture by adding wind energy. Some communities may rely more heavily on hydroelectric power because of their proximity to a major river. Other communities may get a portion of their electricity from solar power, but still provide the base of their electricity from a resource that is more reliable, such as coal or hydroelectric power. Communities may choose a higher percentage of one energy resource because it has a lower cost in their area than another resource or because political incentives or policies encourage or limit the use of some types of resources.

3. Have students explore a fuel diversity map.

Divide students into small groups of three or four and distribute a copy of the map Different Regions of the Country Use Different Fuel Mixes to Generate Electricity to each group. Give groups a few minutes to explore the map. Then discuss the map as a class. Ask: *Do any of these combinations surprise you? Why or why not?* Draw students' attention to the Pacific Contiguous, West North Central, and South Atlantic regions. Ask: *What are some possible reasons for the differences in fuel use in these areas? What role might geography play? What role might cost play?* Prompt students to think about how geography might affect which renewable energy resources are viable and cost-effective for an area. For example, places located near a major river can take advantage of hydroelectric power, while places away from any major rivers cannot do so as easily. Similarly, rainy Seattle could use solar power, but it would not be as cost-effective as the same setup in sunny parts of California, since the equipment would cost about the same in both places but yield far less electricity in Seattle. Then prompt students to consider the role of proximity in determining cost. For example, a lot of natural gas is mined in Texas, so the transportation costs to use this fuel would be lower for communities in and around Texas than for communities in California. *Does the efficiency of how an energy resource is converted into electricity influence which resources are used? What role might environmental concerns play?* Ask students to think about the factors they would use to determine which energy resource to use if two resources were equally viable for their area and cost about the same amount.

4. Have students examine the Data Table and consider the efficiency of converting each energy resource into electricity.

Distribute a Data Table worksheet to each small group. Explain that the efficiency percentage included on the worksheet describes the conversion efficiency of the method used for converting the resource to electricity. The higher the conversion efficiency, the less energy "escapes" during conversion. The better the conversion efficiency, the less resource material it will take to generate the same amount of electricity. Make sure students understand that the conversion efficiencies listed are averages and that the efficiencies of individual power plants can vary significantly. Have students create a list of the energy resources represented on the data table and rank them from most efficient to least efficient.

5. Have students consider carbon dioxide (CO_2) emissions.

Have students read the information on the provided U.S. EPA Air Emissions webpage. Briefly discuss the information, making sure students understand how carbon dioxide emissions are related to electricity production. Have students look up the CO_2 emissions for each energy resource listed on the Data Table worksheet using the webpage. Have them record that information on the table in the appropriate column. Then have students create a list of the energy resources represented on the table, ranking them from lowest to highest CO_2 emissions.

6. Have small groups create graphic representations of conversion efficiency and CO_2 emissions for each regional energy resource mixture.

Assign each small group one of the regions shown on the Different Regions of the Country Use Different Fuel Mixes to Generate Electricity map. Give groups markers and poster board, and have them reproduce the pie chart shown on the map for their assigned region. In addition to labeling the pie chart as shown on the map, have students add labels to each pie piece with the efficiency conversion percentage and the CO_2 emissions data. Make sure students have titled their pie chart with the name of the region. Display all the pie charts.

7. Have students examine the Different Regions of the Country Use Different Fuel Mixes to Generate Electricity map and the displayed pie charts.

As a class, have students identify the four energy resources that are the least efficient. Ask: *In which regions are these resources used the most?* Then have students identify the two energy resources that are the most efficient. Ask: *In which regions are these resources used the most?* Draw students' attention to the Pacific Contiguous Region and the East North Central Region. Ask: *Of these, which has the most efficient energy mixture overall? Why?* Have students identify which energy resources emit the least CO_2. Ask: *In which regions are these resources used the most?* Have students identify which energy resources emit the most CO_2. Ask: *In which regions are these resources used the most?* Have students identify two regions that appear to have the lowest CO_2 emissions and two that appear to have higher CO_2 emissions overall. Have each small group select a region that it feels has a good mixture of high efficiency and low CO_2 emissions. Have each group present its choice to the class and explain why it made that selection.

8. Discuss the data.

Have students refer to the data as they answer questions. Ask: *Is the efficiency of the system the only factor to consider when creating a mixture of energy? What other factors are important?* List these factors on the board as students name them. Factors might include the availability of the energy resource, the effect of the energy resource on the environment, the reliability of the energy resource, political and social support for the energy resource, and the cost of the energy resource. Discuss some of these other factors. Ask:

- *Which regions would be most affected by an increase in the price of fuel oil? Why?* (Regions that rely heavily on fuel oil, such as the Pacific Noncontiguous Region, would be most affected.)
- *How would an increase in the price of oil affect the population of this region?* (The cost of electricity would likely increase in this region.)
- *What effect would increased CO_2 emissions have?* (Increased CO_2 emissions might possibly lead to increased health problems and environmental impacts due to climate change.)
- *Why is this a factor to consider when designing different fuel combinations?* (The more efficient the conversion of a fossil fuel to electricity, the less of the fossil fuel is needed to generate the same amount of electricity. This translates into fewer CO_2 emissions per unit of electricity.)

- *Which combinations of energy resources do you think might have a negative impact on quality of life in an area? Why?* (Combinations that use a high percentage of fossil fuels will increase air pollution; inefficient combinations might cause the price of electricity to be higher.)
- *Which factors do you think are most important to consider when designing a mixture of energy resources for a specific area?* (Answers will vary, but students might cite cost, environmental impact, public support, or efficiency as important.)

9. Introduce the energy mixture plan project.

Explain that students will have a chance to propose a new mixture of energy resources for their local area. Point out your region on the Different Regions of the Country Use Different Fuel Mixes to Generate Electricity map. Ask: *Which energy resource is most used in our region? Why might that be the case?* Distribute the Cornell Note Taking worksheet and Presentation Rubric and review them with students. Answer any questions they may have. Have students regroup in their small groups and work together to answer the following questions in writing before beginning their research:

- Which factors affecting the mixture of energy resources are most important to you? Why?
- What are some geographic features of your local area that could affect the types of energy resources available? Explain.
- Why do you think your community should rethink the current fuel combination found in the region?
- What is the goal of your energy mixture redesign? Why?

Have groups conduct basic research into some of the energy resources using the provided websites. Students may also want to visit the website of a local power company for additional information. Have students take notes on the Cornell Note Taking worksheet.

10. Have groups develop and present their alternative energy mixture plans.

Have students use the information they gathered during their research to inform their energy mixture plan. Once students have developed the mixture they want to propose, have them create a brief presentation to introduce their ideas to the class. Remind them to use the rubric to make sure they include all the required elements in their presentation. Give each group

about three minutes to present their plan to the class. After each group presents, allow time for other students to ask questions. When all groups have presented, discuss the different proposals. Ask: *What ideas did these proposals have in common? Why might that be? What ideas did you think were particularly innovative? Why?*

TipTeacher Tip

Write the discussion questions on the board for students to refer to throughout the activity.

Modification

If students are having a difficult time understanding how increased efficiency decreases the amount of a resource being used, try this analogy: Imagine you want to fill a bucket with water. You could dip the bucket directly in the water and fill it up without spilling anything. Or you could dip a smaller cup in the water, carry it over to the bucket, sloshing water out of it as you walk, and pour it in. In the end, you will have the same amount of water in the bucket, but you will have used up a lot more of the water from the original source in the second scenario.

Informal Assessment

Use the provided presentation rubric to assess groups' oral presentations.

Extending the Learning

Have each group create a more formal written or oral proposal to present to representatives from local government, utility companies, or conservation groups. Have students follow the guidelines for a RAFT paper, in which they pay special attention to the role of the writer, the audience, the format, and the topic. If possible, mail written proposals to representatives, or invite a representative from one of these groups to listen to students' oral proposals.

OBJECTIVES

Subjects & Disciplines

Geography

- Human Geography
- Mathematics

Learning Objectives

Students will:

- analyze and compare different energy resource combinations, and rank the energy resources from most to least efficient and from lowest to highest level of CO2 emissions
- develop and present an energy plan for their geographic locale that considers a variety of energy resources and their impact on quality of life
- create a graphic representation that accurately reflects their proposed mixture of energy resources

Teaching Approach

- Interdisciplinary
- Learning-for-use

Teaching Methods

- Cooperative learning
- Discussions
- Information organization

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information Literacy
  - Learning and Innovation Skills
    - Communication and Collaboration

    - Critical Thinking and Problem Solving
  - Life and Career Skills
    - Initiative and Self-Direction
- Critical Thinking Skills
  - Analyzing
- Geographic Skills
  - Organizing Geographic Information
- Science and Engineering Practices
  - Analyzing and interpreting data
  - Obtaining, evaluating, and communicating information

National Standards, Principles, and Practices

ENERGY LITERACY ESSENTIAL PRINCIPLES AND FUNDAMENTAL CONCEPTS

• **Fundamental Concept 6.5:**
Social and technological innovation affects the amount of energy used by human society.
• **Fundamental Concept 6.8:**
Amount of energy used can be calculated and monitored.

IRA/NCTE STANDARDS FOR THE ENGLISH LANGUAGE ARTS

• **Standard 7:**
Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and nonprint texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience.
• **Standard 8:**
Students use a variety of technological and informational resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.

NATIONAL SCIENCE EDUCATION STANDARDS

• **(5-8) Standard F-2:**
Populations, resources, and environments

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

• **Speaking and Listening Standards 6-12:**
Presentation of Knowledge and Ideas, SL.6.4

ISTE STANDARDS FOR STUDENTS (ISTE STANDARDS*S)

• **Standard 2:**
Communication and Collaboration

Preparation

What You'll Need

MATERIALS YOU PROVIDE

- Calculators
- Paper
- Pencils

REQUIRED TECHNOLOGY

- Internet Access: Required
- Tech Setup: 1 computer per small group, Projector

PHYSICAL SPACE

- Classroom

GROUPING

- Large-group instruction

OTHER NOTES

This activity should be conducted over two class periods. Before teaching this activity, identify the energy resources used by your local power company to provide electricity in your area. Check your electric company's website or call the company to request the information.

Background Information

In the United States, most communities do not rely on a single type of energy resource to provide their electricity. There are many factors affecting the particular mixture of energy resources used to generate electricity for an area. The United States is a geographically diverse country, and the natural resources and geographic features found in a certain area can shape the kinds of energy resources that are used in that area. For example, the large volume of water in the Columbia River makes it possible for a large percentage of the electricity in the Pacific Contiguous region to come from hydropower. The proximity of natural gas in Texas makes it easy and cost-effective for the West South Central region to get almost half its electricity from natural gas.

Other factors make it important for energy resources to be diversified. The reliability of the electrical grid in an area refers to its ability to supply a constant flow of electricity. Disruption to the flow of electricity can cause blackouts. An area supplied by a mixture of energy resources is better able to react to any supply fluctuations in a particular resource. A main reason for having a mix of energy resources is to ensure that power sources can meet the changing demands placed upon them. The amount of electricity used per capita (per person) varies throughout the day and at different times of year. Coal and nuclear plants are very cost-effective to run in general, but they take a long time (sometimes days) to turn on and are not cost-effective to run at less than their maximum output. Thus, these types of generators tend to be on at all times and are used to serve the basic energy demands. More expensive types of generators, such as small natural gas generators, are used during times of high demand, such as the period just after midday in many regions. How renewables such as wind and solar power are put into this mix varies by region. The amount of time that the resource will be used, its startup cost, and its ability to ramp up and down quickly are all factors that need to be addressed when looking at a generation mix. Ongoing cost is another factor to consider. The costs of energy resources vary and can change depending on natural and world events. For example, the cost of fuel oil rose after the *Deepwater Horizon* disaster on the Gulf Coast. Politics can also play a role in energy diversification, as incentives and laws passed at various levels of government can influence energy projects.

Energy efficiency refers to the ability to use less energy to produce the same result. There are many ways to increase energy efficiency, from weatherizing a home to introducing grid modernization technology. Another way is to increase the percent of an energy resource's energy that is actually converted to electricity. For example, when coal is burned to produce electricity, only about two-thirds of the energy stored in the coal is converted to electrical energy. The rest is "lost" to the system as it is transformed into other forms of energy, such as heat. This energy is not destroyed; however, it is no longer available for producing electricity. Some energy resources can be converted to electricity more efficiently than others, although the efficiency of different power plants converting the same energy resource can vary greatly. Increasing the efficiency of fossil-fuel-burning power plants can help reduce CO_2 emissions, which have been linked to global climate change, and conserve limited fuel supplies. Increasing the efficiency of renewable energy resources is also important. For example, increasing the efficiency of wind turbines can result in fewer turbines needed to produce the same amount of electricity or the ability to use the turbines more effectively in places with less wind.

A diverse mixture of energy resources can include some renewable and non-renewable resources that are not commonly known. In addition to the better-known wind, solar, biomass, and geothermal resources, renewable resources can also include use of waste products to generate electricity. For example, methane gas can be recovered from landfills and burned much like natural gas. Agricultural and municipal waste can also be burned to generate electricity. Other non-renewable methods of generating electricity involve using chemicals, tires, batteries, and other manufactured waste products.

Prior Knowledge

["Energy Literacy Principle 1: Energy is a physical quantity that follows precise natural laws.","Energy Literacy Principle 2: Physical processes on Earth are the result of energy flow through the Earth system.","Energy Literacy Principle 3: Biological processes depend on energy flow through the Earth system."]

Recommended Prior Activities

- None

Vocabulary

Term	Part of Speech	Definition
availability	*noun*	usefulness or readiness to use.
average	*verb*	to calculate the middle amount among a group of numbers.
carbon dioxide	*noun*	greenhouse gas produced by animals during respiration and used by plants during photosynthesis. Carbon dioxide is also the byproduct of burning fossil fuels.
carbon dioxide emission	*noun*	quantity of carbon dioxide added to the atmosphere by human activities, such as fossil fuel combustion.
climate change	*noun*	gradual changes in all the interconnected weather elements on our planet.
conversion efficiency	*noun*	efficiency of converting an energy source into electricity. The higher the conversion efficiency, the less energy "escapes" during conversion. The better the conversion efficiency, the less source material it takes to generate the same amount of electricity.
electricity	*noun*	set of physical phenomena associated with the presence and flow of electric charge.
energy conservation	*noun*	process of using less energy, or using it more efficiently and sustainably.
energy efficiency	*noun*	use of a relatively small amount of energy for a given task, purpose, or service; achieving a specific output with less energy input.
energy resource	*noun*	source of energy found in nature that has not been subject to any human-induced energy transfers or transformations; for example, oil, coal, gas, wind, or sunlight.
energy source	*noun*	location in which the energy resource (oil, coal, gas, wind, etc.) is converted into electrical energy.
global warming	*noun*	increase in the average temperature of the Earth's air and oceans.

Term	Part of Speech	Definition
non-renewable energy	*noun*	energy resources that are exhaustible relative to the human life span, such as gas, coal, or petroleum.
per capita	*adjective*	for each individual.
population	*noun*	total number of people or organisms in a particular area.
region	*noun*	any area on Earth with one or more common characteristics. Regions are the basic units of geography.
renewable energy	*noun*	energy obtained from sources that are virtually inexhaustible and replenish naturally over small time scales relative to the human life span.

For Further Exploration

Websites

- International Energy Agency: Energy Efficiency Indicators
- U.S. EIA: Factors Affecting Electricity Prices
- National Geographic Maps: Energy Realities—The Right Balance

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