Section II: Digging Deeper

Can Energy Be Sustainable?

SUMMARY
Students learn about the concept of sustainability and how it relates to energy production. In groups, students practice systems thinking as they research various energy sources and compare the potential effect of each energy source on the three components of sustainability: environment, economy, and society. Groups present this information to the class using visual aids.

BACKGROUND

Today, every community is faced with the challenge of finding ways to meet growing energy needs. Energy decisions affect the health of the environment, the economy, and society, and these effects can be organized by using the concept of sustainability. Sustainability can be defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs (U.N. World Commission on Environment and Development, 1987).

The concept of sustainability requires stakeholders and citizens to strike a balance by considering how to make decisions that are socially just, economically feasible, and environmentally sustainable.

Most people think about the environment when they consider sustainability. As you may have already learned, energy production has many effects on the environment. However, the environment is only one key component of sustainability. In assessing sustainability, it is necessary to consider the health and vitality of three areas over time: environment, economy, and society (Wheeler et al., 2005). These components are related to one another and are often illustrated by three overlapping circles (Figure 1).

Sustainability and Energy

Energy is essential to all aspects of life and development and, therefore, is a key aspect of sustainable development. Today, the world is faced with the challenge of finding ways to meet growing energy needs without compromising the health of the environment, the economy, or society. The effects of an energy decision can be organized by using the concept of sustainability. For example, when making decisions about energy generation and consumption, we can ask three primary questions: How does this method of generating energy impact future generations and nonhuman organisms, ecosystem services, natural resources, and climate? How does this method create a viable and secure economy? How does this method fairly contribute to quality of life for all groups of people who are impacted by such a decision? The following sections summarize some of the important environmental, economic, and social impacts of using wood for energy.

FIGURE 1. Sustainable decisions require consideration for potential impacts and outcomes to the economy, environment, and society.

should we use wood for energy? • section ii – activity 9: can energy be sustainable? 99
Environmental Impacts

Energy production affects the environment in different ways depending on how the energy source is extracted or developed, transported, and converted. Compared to fossil fuels, woody biomass has fewer negative impacts on air and water quality and does not increase the overall amount of carbon dioxide (CO₂) in the atmosphere.

Air Quality

When any substance is burned, emissions are produced. Many people have seen the smoke that results from campfires or forest fires and may imagine that a wood-fueled power plant will emit such smoke. However, when wood is burned in a power plant, operators control the combustion temperatures, fuel moisture, air flow, and the size of the fuel. Burning wood in a controlled environment decreases the amount and types of pollutants that are emitted.

The most commonly regulated pollutants emitted by the combustion of oil, gas, coal, and wood are nitrogen oxides (NOₓ), carbon monoxide (CO), sulfur dioxide (SO₂), mercury (Hg), and particulate matter (very small airborne particles). The U.S. Environmental Protection Agency and state and local agencies are responsible for managing air quality through the enforcement of clean air standards and regulations. All power facilities, including those that burn wood, are required to meet these regulations.

Wood-fired power plants produce little sulfur dioxide (SO₂) and mercury (Hg) and lower levels of nitrogen oxides (NOₓ) than coal-fired power plants (U.S. EPA, 2007b). In addition, wood-fired power plants produce 90 percent less ash than coal-fired power plants. The ash and soot produced when wood is burned can be controlled with pollution-control devices, such as filters and scrubbers. Table 1 provides a comparison of emissions from different fuel sources if no control devices were present.

Soil

Harvesting and collecting wood for energy can have both positive and negative effects on soil quality. Proper management practices should be used to minimize negative impacts, such as planting and using trees for the fuel, which enhances soil quality compared to growing and using agricultural crops.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>NOₓ</th>
<th>SO₂</th>
<th>Hg</th>
<th>Particulate Matter</th>
<th>Greenhouse Gases</th>
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</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>Medium</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Oil</td>
<td>Medium</td>
<td>Medium to High</td>
<td>Medium</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Coal</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Wood</td>
<td>Low</td>
<td>Low</td>
<td>Negligible</td>
<td>Medium</td>
<td>Low</td>
</tr>
</tbody>
</table>

(U.S. EPA, 2007b)
While agricultural crops are harvested multiple times a year, planted pine trees are grown for 12 to 18 years before they are harvested for pulpwood. During this time, the tree roots and leaf litter add nutrients to the soil. Some hardwood trees can sprout back from the stump after they are harvested. Using trees that can resprout from the stump reduces the need for soil tilling and planting. This can help to reduce soil erosion and shorten the growing cycle.

Soil quality can also be affected by physical disturbance and compaction. The construction of roads and the use of heavy machinery during harvesting operations can lead to soil compaction, erosion, and water run-off. Run-off can contaminate nearby water bodies with soil, silt, and chemicals. In addition, collecting residues from forestry operations for use in a woody biomass facility can reduce soil fertility, unless leaves and roots are left on site.

**Water**

Energy production affects water quality in various ways. When energy sources are extracted, nearby waterways may change topographically and may suffer from erosion and chemical run-off. Using proper management practices can reduce these effects.

Most power plants use water for steam production and cooling. The water used for cooling is warmer after circulating through the system. Warm water contains lower levels of dissolved oxygen, which alter nearby aquatic plants and animals and ecosystem functions. Power plants that release water used for cooling are usually required to be regulated and monitored (U.S. EPA, 2007b).

**Economic Impacts**

When communities are considering using wood for energy, stakeholders and citizens want to know the costs of the woody biomass resources, the costs of construction and operation of the facility, and if job opportunities will be available for the community. The answers depend on which sources of woody biomass will be chosen, how much woody biomass will be available, how far the woody biomass will be transported, how much electricity the facility will generate, and what technologies will be used to convert woody biomass into electricity. A local economic assessment is necessary for any community seriously considering using wood for energy.

Urban waste wood and forestry residues are among the cheapest sources of woody biomass in urban communities and in regions with forestry operations. In contrast, trees grown specifically for energy represent one of the most expensive sources of woody biomass. The local assessment will also have to look into what systems will be designed to efficiently harvest, collect, process, and transport woody biomass resources. The amount of wood available depends on how many people live in the area, how many acres of forest are managed.
Ethical decisions can be based on a mix of rational thinking, including cost/benefit analysis (for example, whether or not biomass is a viable economic investment) and emotions, including our emotional responses to trees and forests or attachment to inexpensive energy sources that maintain our lifestyle.

for forests products, and the objectives of the forest landowner.

The production, harvesting, and transportation of local wood can provide job opportunities for people in the community, which in turn stimulates the economy as money circulates when employees spend earnings on food, clothing, housing, transportation, and other services and products. As a result the local economy can grow.

Once a community has identified the need to construct a new facility to meet energy demands, members must consider the costs to build and operate the facility. New construction of any energy facility, regardless of the fuel source, requires an investment of money. To gain a better understanding of costs, economists can compare the costs of different energy sources and technologies for a specific location.

Social Impacts

Wood burning energy facilities also affect the social fabric of a community, including quality of life and public health. Ethical principles or morals that guide our lives and the decisions we make in a complex world are pertinent to environmental and social issues, such as where resources come from; what are the consequences of using those resources; and how do decisions about resource usage affect others, including both human and nonhuman organisms.

In the case of using wood for energy, these questions should be asked about those who live near or are impacted by the forests as well as the facility. The responses can be compared to the same questions about other energy resources, such as coal or nuclear power. They are important questions when considering how to make a good decision about energy resources.

Ethical decisions can be based on a mix of rational thinking, including cost/benefit analysis (for example, whether or not biomass is a viable economic investment) and emotions, including our emotional responses to trees and forests or attachment to inexpensive energy sources that maintain our lifestyle.

In this way, ethics is related to making fair and just decisions about energy systems. It recognizes that any resource decision related to energy will affect various life forms and ecosystems, including the humans who reside in those communities.

People who live near or are impacted by a proposed energy facility or nearby forests should be involved in decision-making processes.
Teacher Instructions

It is highly recommended that students complete Activity 1: Energy in the U.S. Web-quest prior to doing this activity. Activity 1 provides students with important knowledge and information about energy that better enable them to complete this activity and understand the major concepts.

Preparation
1. Read the Background Information provided at the beginning of this activity and make copies if you plan to assign reading before this activity. More background information is available in Activity 1: Energy in the U.S. Web-quest and Activity 5: Case Study Jigsaw. Additional, more detailed information is also available in the Environmental Impacts and Economic Impacts of Generating Electricity fact sheets in the Supplemental Reading section.
2. Make copies of Group Handout and Worksheet and Student Worksheet (one copy of each per student).
3. Before beginning the activity, you will need to find out what energy sources are currently used in your region to produce electricity. Follow these instructions for finding this information:
4. If your students completed Activity 1, they gathered this information in Section VII. Power Profiler: How Clean Is the Electricity I Use?
5. If your students did not complete Activity 1, go to http://www.epa.gov/cleanenergy/energy-and-you/how-clean.html to retrieve this information. Make sure to record the percentage of each energy source or fuel type used in your region. You can also call your local utility or visit their Web site to find out this information.

Procedure

Part I: Learning About Sustainability and Energy
1. Review the concept of sustainability and the terms environment, economy, and society. Stress that the connections and consequences are challenging to determine, yet essential to making good decisions. One way to explore consequences is to think about impacts using different time (immediate versus future) and spatial scales (local, regional, national, and global).
2. Ask students to brainstorm individual actions that use energy (e.g., driving to school, using public transportation, buying new clothes, purchasing locally-produced food).
3. Invite students to share their ideas. Choose one action to investigate as a class. Prompt students to consider several possible effects caused by this action. Write these on the board. Also, as a class, try to categorize the impacts into environmental, economic, social, or some combination of these components.
4. Next, explain that this activity will help them consider the sustainability of various energy sources by considering the impacts of energy sources on the environment, economy, and society.
5. Make two columns on the board: “Current Energy Sources” and “Potential Energy Sources.”
6. In the “Current Energy Sources” column, record the information about your region’s energy sources (including the percentages of each energy source). Circle the two energy sources that account for the majority of electricity production in your region and tell students that they will further investigate these energy sources.
7. In the “Potential Energy Sources” column ask students to consider other energy sources.

Assessment Suggestions

OBJECTIVE 1: During group presentations, each group should clearly identify impacts of the energy source on the economy, environment, and society. In addition, review Group Worksheets to verify groups have filled in all sections of the chart completely.

OBJECTIVE 2: Review answers to Student Worksheet and verify that students were able to differentiate the effects of various energy sources and explain their determination of the feasibility.

OBJECTIVE 3: A rubric for assessing the group poster presentation is provided.
resources that could be used in your community to help meet growing energy demands. The class should choose three potential energy sources they want to investigate. Prompt students to consider feasible energy options (e.g., geothermal is typically not feasible in Florida). Add these three potential energy sources in the column. If students don’t identify woody biomass, modify the list so this energy option can be investigated.

8. Divide students into five groups, and assign each group one of the “Potential Energy Sources” or “Current Energy Sources.”
9. Pass out copies of the Group Handout and Group Worksheet. Ask the groups to conduct research on the Internet and at the library to find out more about the effects of the energy source assigned to their group using questions provided in the Group Handout. If students need assistance doing the research, direct them to the Web sites provided in the Resources section of this activity.
10. After conducting research, groups should complete the Group Worksheet and create a poster or other large graphic to summarize the information they collected. Groups should present key points to the class about how the energy source affects the environment, economy, and society. Research and presentation development can be conducted in or outside of class, depending on time constraints.

Part II: Group Poster Presentations
1. Ask the groups to present information on their energy source using posters as visual aids.
2. Assign an order for presentations and give groups 5 minutes to get together and prepare.
3. As groups present, instruct students in the audience to complete the Student Worksheet—fill in information for the other energy sources. This worksheet will be turned in for assessment.
4. After all presentations are finished, lead a class discussion comparing energy sources and summarizing what students have learned about sustainability. Use the following questions to guide the discussion:
   a. How does sustainability relate to energy production?
   b. Why is it important to examine impacts on all three components of sustainability—environment, economy, and society?
   c. What does sustainability mean to you? (Encourage students to share individual interpretations of the concept.)
   d. Considering the energy sources we’ve learned about:
      i. Which energy source is the most environmentally sustainable at this time for your region? In what ways could other energy sources become more environmentally sustainable?
      ii. Which energy source is the most economically sustainable at this time for your region? In what ways could other energy sources become more economically sustainable?
      iii. Which energy source is the most socially sustainable at this time for your region? In what ways could other energy sources become more equitable?
   e. Taking all three components of sustainability into consideration, what energy source do you think is the most sustainable at this time for your region?
Extensions

• Call the utility company or electricity provider for your region and set up a class tour of the generating station.
• Invite a representative from the local utility company to be a guest speaker in your class and ask each student to develop one to two questions to ask the speaker.

<table>
<thead>
<tr>
<th>Category</th>
<th>4 Above Standards</th>
<th>3 Meets Standards</th>
<th>2 Approaching Standards</th>
<th>1 Below Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparedness</td>
<td>Group is completely prepared and has obviously rehearsed.</td>
<td>Group seems prepared, but might have needed more rehearsal.</td>
<td>The group is somewhat prepared, but it is clear that rehearsal was lacking.</td>
<td>Group does not seem at all prepared to present.</td>
</tr>
<tr>
<td>Comprehension</td>
<td>Group is able to accurately answer almost all questions posed by classmates about the topic.</td>
<td>Group is able to accurately answer most questions posed by classmates about the topic.</td>
<td>Group is able to accurately answer a few questions posed by classmates about the topic.</td>
<td>Group is unable to accurately answer questions posed by classmates about the topic.</td>
</tr>
<tr>
<td>Stays on Topic</td>
<td>Stays on topic all (100%) of the time.</td>
<td>Stays on topic most (99-90%) of the time.</td>
<td>Stays on topic some (89%-75%) of the time.</td>
<td>It is difficult to tell what the topic was.</td>
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<tr>
<td>Content</td>
<td>Shows a full understanding of the topic.</td>
<td>Shows a good understanding of the topic.</td>
<td>Shows a good understanding of parts of the topic.</td>
<td>Does not seem to understand the topic very well.</td>
</tr>
<tr>
<td>Poster Attractiveness</td>
<td>The poster is exceptionally attractive in terms of design, layout, and neatness.</td>
<td>The poster is attractive in terms of design, layout, and neatness.</td>
<td>The poster is acceptably attractive, though it may be a bit messy.</td>
<td>The poster is distractingly messy or very poorly designed.</td>
</tr>
<tr>
<td>Poster Graphics</td>
<td>Several of the graphics used on the poster reflect an exceptional degree of student creativity in creation and/or display.</td>
<td>At least 1 or 2 of the graphics used on the poster reflect student creativity in creation and/or display.</td>
<td>The graphics are made by the student, but are based on the designs or ideas of others.</td>
<td>No graphics made by the student are included.</td>
</tr>
</tbody>
</table>

Resources

Your group has been asked to do research related to your assigned energy source. As you do the research, use the questions below as a guide for the type of information you should collect in order to complete your chart. You are not required to answer each of these questions, but these prompts help you think through the impacts of your energy source on the three components of sustainability: environment, economy, and society.

I. **First, think about the following questions related to how energy is obtained from your source.**

1. How is this energy source extracted? – Or – What technology is used to capture energy from this source (wind, solar)?

2. In what geographic location is this energy source typically found? How far away is this location from your region?

3. How is this energy source transported to the location where it is used to produce energy?

4. How is this energy source converted or processed so that it can be used to produce energy?

II. **Next, use the following questions to think about how your energy source affects the environment, economy, and society.**

**ENVIRONMENT**

1. How does this energy source affect air and water quality?

2. How does this energy source affect ecosystems or wildlife habitat?

3. How does this energy source affect vertebrate and invertebrate animals?

4. Does this energy source create waste byproducts? If so, how is the waste disposed of?

5. Is this energy source used at a rate that enables it to be replenished in a short period of time?
ECONOMY

1. Does this energy source create jobs and income flow for local economies?

2. Does this energy source create jobs and income flow for the U.S. economy or other countries?

3. Does the use and production of this energy source contribute to the economic development of communities? Explain your answer.

4. Is this energy source expensive or inexpensive to acquire in comparison to other sources?

5. How might new technologies make this energy source more economically feasible in the future? What other changes might affect this source?

SOCIETY

1. Does this energy source negatively affect some people? (Consider the people who live near and work at the energy production facility as well as the people who extract, process, and transport the energy source.)

2. Are individuals and communities able to be involved in making decisions about the use of this energy source? Is this a fair decision-making process?

3. Is this energy source affordable for varying income levels?

4. Do some groups of people benefit economically from the use and production of this energy source at the expense of others? Explain your answer.
1. Use the questions on the Group Handout to guide your research and fill in the table. Use this table to help you organize your research about the impacts of the energy source on the environment, economy, and society. Also, based on your research, decide whether you believe this energy source could be feasible for your community.

2. Using the information on this worksheet, create a poster to present information on this energy source to the class. Your poster should include pictures, photos, or original graphics, as well as research references. Your presentation should be 10 to 15 minutes long, and you will be graded on your presentation skills and the quality of your poster.

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Environment</th>
<th>Economy</th>
<th>Society</th>
<th>Is this energy source feasible to use or continue using in your region? Why or why not?</th>
</tr>
</thead>
</table>
As groups present information on energy sources, fill out the charts below, describing impacts on the environment, economy, and society.

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>ENVIRONMENT</th>
<th>ECONOMY</th>
<th>SOCIETY</th>
<th>Is this energy source feasible to use or continue using in your region? Why or why not?</th>
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