Unit 10

Energy Challenges

Background

Introduction

We all rely on energy in our daily lives, from the foods that we eat to transportation to lighting and heating our homes. As our human population continues to grow exponentially, our consumption of coal, oil, and natural gas rises with it—along with global temperatures. The energy that we currently use comes from non-renewable sources, which produce the greenhouse gas carbon dioxide. This unit explores the consequences of our current energy consumption habits. It addresses renewable energy sources such as biomass, biofuels, solar, wind, and hydrogen technologies. Carbon sequestration is also discussed as a potential solution for removing carbon dioxide from the atmosphere and storing it in the ground.

Essential Questions

What forms of energy are available?

What are the benefits and drawbacks of current energy sources?

How can we provide the energy we need while maintaining ecological balance?

Content

Unit 10 focuses on resources that are used to produce energy. The Unit 10 text examines forms of non-renewable and renewable energy supplies for their benefits and limitations. Currently coal, oil, and natural gas supply the majority of our energy, while producing the greenhouse gas carbon dioxide and many other pollutants. The text looks at renewable forms of energy including nuclear power, biomass energy, hydropower, geothermal energy, wind power, solar energy, and hydrogen power.

Part One of the video discusses carbon capture and sequestration and the use of biofuels for transportation. You will meet scientist Dr. Neeraj Gupta, who is working on ways to purify carbon dioxide emissions from coal producing plants and then to store this CO_2 as a liquid deep underground. The video briefly describes the importance of solar energy and wind power in our need for clean renewable energy. Part Two of the video describes the research being done at the National Renewable Energy Laboratories (NREL) by scientists such as Andy Aden. A goal of NREL is to produce enough biofuels to meet one-third of the gasoline needs in the United States by the year 2030. A major concern with ethanol is that in its current production it uses corn kernels to produce fuel, which competes with people's need for food. Scientists at NREL are therefore trying to find an efficient way to use cellulosic material to avoid taking crops away from the food supply.

Background

Learning Goals

During this session you will have an opportunity to build understandings of the following.

a. Knowledge

i. Conservation is a necessary first step toward meeting today's energy needs.

ii. Current coal, oil, and natural gas deposits were formed over millions of years as a result of the accumulation of prehistoric plant and animal matter.

iii. A number of clean, productive renewable energy technologies are available and necessary to meet today's energy needs.

iv. Both non-renewable and renewable energies have limitations.

v. There are important benefits to using renewable energies.

b. Skills

i. Science is a descriptive process.

ii. Science is an experimental process.

c. Dispositions

i. Energy has a direct impact on social, economic, political, environmental, and economic systems.

ii. Science helps explain current events.

Key Concepts

Non-renewable energy
Renewable energy
Fossil fuels
Nuclear power
Biomass
Biofuels
Carbon sequestration
Hydropower
Geothermal energy
Wind energy
Solar energy
Photovoltaic
Hydrogen power

FACILITATOR: These concepts correspond roughly to the sections of the unit. There are a number of other concepts that could be included. It is best to start with the author's major ideas and then ask for input from the study group for other concepts they would include.

Misconceptions about Energy

Renewable energy is a second rate form of energy.
Renewable energy is non-polluting and produces energy of the same quality as that from non-renewable sources.

Renewable energy systems are too expensive.
While scientists agree that there is a financial cost associated with renewable energy, people need to consider the environmental cost when they use non-renewable sources of energy.

Background

Wind turbines are noisy.

Modern wind turbines produce very little noise. The turbine blades produce a whooshing sound as they encounter turbulence in the air, but the noise tends to be masked by the background noise of the blowing wind. An operating modern wind farm at a distance of 750 to 1000 feet is no noisier then a kitchen refrigerator.

Solar energy only works well in warm, sunny climates.

Solar technologies can work efficiently anywhere as long as they're placed correctly. Photovoltaic cells (solar panels) actually become more efficient at colder temperatures. Solar thermal collectors for hot water can make adequate amounts of hot water, even at subzero temperatures. Passive solar heating works well in any climate as long as the building is well insulated.

Activity One: Assessing Prior Knowledge, Questions, and Related Experiences (20 minutes)

FACILITATOR: Distribute index cards to the study group. On the first card, participants should indicate something they know about energy production. On the second, they should write one question they have about energy production. And on the third card, they describe a direct experience that they have had that relates to energy use. For example an individual might write:

Gasoline is burned in cars to produce energy for them to run.

How does solar energy work?

Last summer, when it was really hot, we didn't have any electricity.

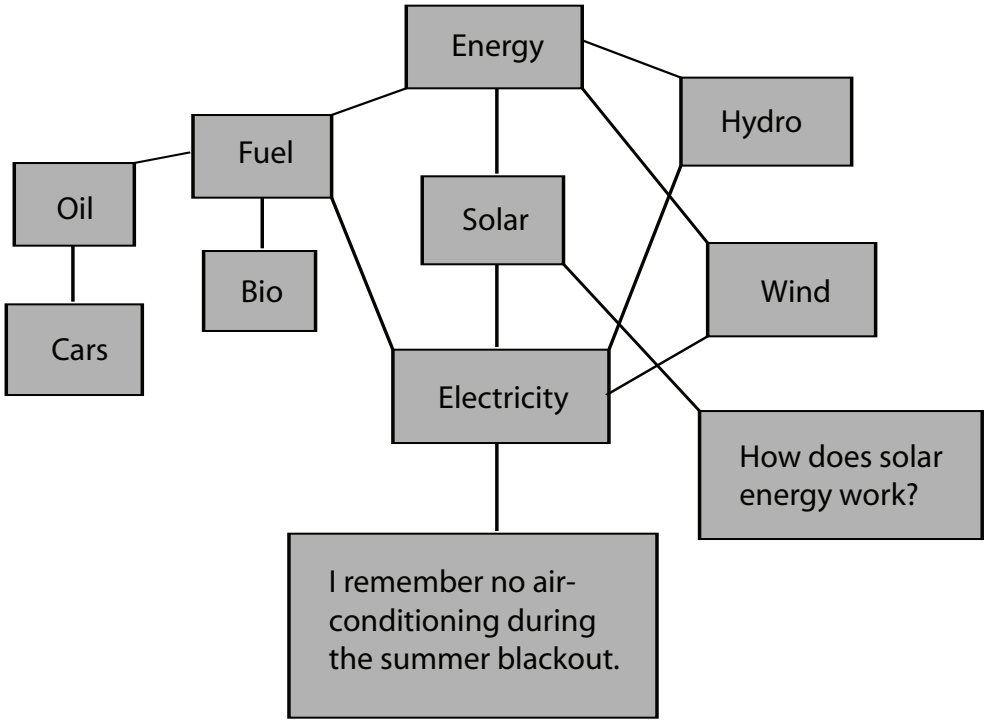

Figure 10.1 The study groups idea collection with major subjects identified and the addition of the major focus ideas of the video. This activity links individual pre-existing knowledge with that of other group members and the unit content.

Background

Activity Two: Current Events & Editorial Cartoons

Participants will share an article that they have found that relates to the week's topic. All members of the group will share their headlines for the articles. The leader should ask a few people to summarize their articles and ask for comments from others with related articles. As the group discusses the articles, a participant should record key concepts and make a list. (Participants may choose to bring in a cartoon or an editorial related to the week's topic instead of an article.)

Activity Three: Home Energy Quiz

Each participant should complete the following quiz. After participants have calculated their energy score, the facilitator should combine the results for each question and find the mean number of points for each question. In a large group, discuss where the greatest amounts of energy are used. Then break into smaller groups and ask participants to discuss ways to make their homes more energy efficient. After approximately 10 minutes, have each group share their ideas.

Background

Home Energy Quiz

How much insulation do you have in your attic?
- 6 inches or less (2 points)
- 7 to 11 inches (4 points)
- 12 inches or more (6 points)

How often were your furnace filters cleaned or changed in the last year?
- Not at all (0 points)
- 1 to 3 times (2 points)
- 4 or more times (4 points)

How many compact fluorescent light bulbs do you have in high-use areas of your house?
- No compact fluorescent bulbs (0 points)
- 1 to 4 compact fluorescent bulbs (2 points)
- 5 or more compact fluorescent bulbs (4 points)

What is the temperature on your thermostat in winter and summer?

Winter
- 74ºF or higher (2 points)
- 71ºF to 73oF (4 points)
- 70ºF or lower (6 points)

Summer
- 74ºF or lower (2 points)
- 75ºF to 77ºF (4 points)
- 78ºF or higher (6 points)

What is the size of your home?
- Small—less than 1000 ft^2 (6 points)
- Average—1000 ft2 to 2500 ft^2 (4 points)
- Large—2500 ft^2 or larger (2 points)

What type of vehicle does your family drive?
- Small compact car (6 points)
- Full size car (4 points)
- Van (2 points)
- SUV or truck (0 points)

When traveling in your vehicle, are you:
- Usually alone (0 points)
- Sometimes with someone else (2 points)
- Usually with someone else (4 points)
- Always with someone else (6 points)

Do you recycle?
- Always (6 points)
- Usually (4 points)
- Seldom (2 points)
- Never (0 points)

Add up your score and see where you fit in.
8–21: There are a lot of ways to improve the energy efficiency of your home that will help same energy, money, and the environment.
22–36: Your house could be more energy efficient and comfortable.
37–50: Congratulations! You are well on your way to becoming an energy super-star!

Video (45 minutes)

Activity Four: Watch the Video

As you watch the video, think about the following focus questions.

1. Why is burning oil, natural gas, and coal of concern to us?
2. What is the goal of carbon sequestration and how do scientists at Batelle Memorial plan to meet this goal?
3. Why do the holes for carbon sequestration have to be so deep?
4. What does the term "renewable" mean?
5. What are the benefits or using biofuels as energy for transportation?
6. What are the concerns about using biofuels as energy for transportation?
7. What is cellulosic material and why are scientists at the National Renewable Energy Laboratories researching it?
8. What are other possible energy sources for transportation?

Activity Five: Discuss the Video

Discuss the following questions about the video.

1. Discuss how scientists at Batelle Memorial and the National Renewable Energy Laboratories conduct their research. How does this reflect the nature of science?
2. What is the relationship between carbon sequestration and global climate change?
3. What are the advantages and disadvantages of using biofuels? Can you propose an alternative to fossil fuels and biofuels for transportation?
4. Based on what you learned from the video, discuss an energy plan for your school that minimizes the amount of carbon dioxide put into the atmosphere.

FACILITATOR: Refer back to the misconception section and Activity One: Assessing Prior Knowledge. Has the video contributed to the participants' new understanding of concepts? Are there any changes the participants would make about the arrangement of their cards from Activity One?

Going Further (60 minutes)

Activity Six: Online Energy Interactive Lab: Part 1

FACILITATOR: Participants will need access to the Internet and should be directed to http//:www.learner.org/channel/courses/envsci/interactives/energy.

Overview

In the world today, with populations and economies booming, the demand for energy is rising. A portfolio of different energy sources is used to meet this demand. In this lab, the challenge is to try to meet the world's projected energy demand by choosing from the available energy sources, while keeping atmospheric CO_2 under control and also avoiding the particular limits and pitfalls associated with each energy source.

Simulation 1

Before the industrial revolution, the world's atmospheric CO_2 levels were below 280 parts per million (ppm). Levels have now risen to ~380 ppm. In order to limit the worst effects of climate change, many scientists believe we must keep peak atmospheric CO_2 to no more than double the pre-industrial concentration, or about 550 ppm.

The goal of this lesson is to try to keep total atmospheric CO_2 under 550 ppm limit while staying within the tolerances defined for each specific fuel source. If you approach a limit on a particular fuel, you will be given a warning. The slider bar will change color and indicate that you cannot use more of that particular fuel. If you hit a hard limit, depleting the entire world's reserves of that fuel or power source, you will not be allowed to increase the use of that power source.

You should use the following chart to graph the changes in energy per year and the atmospheric carbon dioxide while also recording the changes you made.

Year	Changes Made	% Oil	% Coal	% Gas	% Biofuel	% Nuclear	% Hydro	% Solar	% Wind
2000									
2010									
2020									
2030									
2040									

Were you able to keep atmospheric CO_2 under 550 ppm from the year 2000 to 2100? What needs be done to help you meet this goal?

Going Further

Simulation 2

If people start conserving energy and if our technology becomes more energy efficient, less CO_2 will be emitted. In this simulation you can introduce improvements in energy efficiency by using the "advanced options" tab. When you click on this tab, you can decrease energy demand, increase energy efficiency, and increase carbon capture and storage. The goal again is to keep atmospheric CO_2 under 550 ppm or even lower by the end of the century.

Graph the changes in energy per year and the atmospheric carbon dioxide while also recording the changes you make in the following chart.

Year	Changes Made	% Oil	% Coal	% Gas	% Biofuel	% Nuclear	% Hydro	% Solar	% Wind
2000									
2010									
2020									
2030									
2040									
2050									
2060									
2070									
2080									
2090									
2100									

Were you able to keep atmospheric carbon below 550 ppm. If so, what made the difference this time?

Conclusion

The problem of meeting the world's energy needs while limiting dangerous atmospheric CO_2 concentrations is neither easily solved nor insurmountable. As you've seen in this lab, no energy source is a magic bullet. Energy efficiency will be key as well, because energy that isn't expended is the cleanest energy of all. There may also be technologies on the horizon that will help with some of our fuel sources.

Going Further

Activity Six: Online Energy Interactive Lab: Part 2

What are the advantages and disadvantages of our energy sources? In this activity, participants will use the information from Unit 10 to fill out the following table.

Energy Source	Renewable?	CO_2 emissions	Advantages	Disadvantages
Coal				
Oil				
Natural Gas				
Nuclear Power				
Biofuel				
Hydropower				
Geothermal				
Wind Energy				
Solar Energy				
Hydrogen				

Going Further

Discussion

With a partner, compare your results.

In a large group, discuss similarities and differences of the energy sources and respond to the following questions.

1. What energy sources are being used currently where you live?
2. What energy sources will be best for your future?
3. How do we get there from here?

Activity Seven: Return to Essential Questions

The facilitator should draw the attention of the participants back to the essential questions posed in the Background Section of this unit guide. Discuss how the participants' ideas may have changed in regard to the questions. Discuss the most logical and complete answers to the questions.

Activity Eight: Discuss Classroom Supplementary Activities

Following the Between Sessions section of each unit are Classroom Supplementary Activities. These activities are related to the unit topic and are suitable for middle and secondary science classrooms. If the participants in this study group are teachers, the facilitator should take the time to review these lessons. If participants are familiar with the lessons, they should describe how they have used them. Discuss how the classroom activities might be used in relation to a specific science topic and how the activities can help relate the unit topic to classroom lessons.

Between Sessions

Next Week's Topic Overview

Read Unit 11 before the next session. In Unit 11, the emphasis is on atmospheric pollution. When fossil fuels are burned, CO_2 is not the only pollutant that is a concern. Mercury, nitrogen dioxide, and sulfur dioxide are also emitted. This unit will examine: surface air pollution, ozone depletion, green house gases, acid rain, and mercury pollution.

Read for Next Session

For the next session be sure to read the Unit 11 Professional Development Guide background section. Consider the essential questions as you read the text. The misconceptions section will give you some insight into what misunderstandings people may have about atmospheric pollution. Consider discussing the topic with your friends or students and discussing common misconceptions.

Current Events

Bring in a current event article or cartoon related to atmospheric pollution.

Supplementary Classroom Activity 1

Renewable Energy Project

In this project students will investigate and present information on one form of renewable energy. The teacher should divide students into groups of four and assign (or let them choose) a form of renewable energy. The types of renewable energies to choose from are: solar, geothermal, wind, hydroelectric, hydrogen, biofuels, and methane. If you allow students to choose, be sure there is at least one group for each energy source so students will learn about all seven energy sources.

Student Handout

You may work with a team of up to four people to complete this task. Each person on the team will take on one of the following expert roles and have the responsibilities that go along with that role:

The Research

SCIENTIST: You are concerned with understanding and explaining how this energy source works. Here are some questions you will want to consider for your presentation.

1. What is the source of power or raw materials for this energy source?
2. How does the system harness and transfer energy?
3. What are the by-products from this energy source?
4. Is it possible to use this energy source in our area of the country?

ENVIRONMENTALIST: You are concerned with the effects of this technology on nature. You want to explain how this new project could impact the natural surroundings. You would ideally want to see technology that will not produce greenhouse gases and that will not consume natural resources in such a way that would adversely affect future generations of both humans and other species. Here are some questions you will want to consider for your presentation.

1. Are there any harmful wastes produced by this technology?
2. Will natural habitats be adversely affected by this technology?
3. Are there any concerns to public health and safety?
4. How will using these energy resources contribute to global warming?

ECONOMIST: You are concerned about how much the technologies will cost. You want an energy source that is both efficient and cost effective, something that will give a return on the initial investment to put the technology in place.

1. How does the cost of this energy source compare to the current cost of fossil fuels in this area?
2. How much money will it cost to start to use this technology?
3. How much money will be saved by using this technology over the long term?
4. Does this technology create any extra employment opportunities?

HISTORIAN/SOCIOLOGIST: You are concerned with how this energy source has been used around the world. Humans have always used energy to improve their quality of life. Many different types of energy have been used in different regions and at different times in history. Here are some questions you will have to answer in your presentation.

Supplementary Classroom Activity 1

1. When was this energy source first discovered or invented?
2. Where in the United States or other countries is this energy source currently used?
3. How easily do you think our community would accept using this new energy source?
4. How much energy is currently produced using this technology?
5. How has this technology affected the lives of the people who use it?

The Presentation

After completing your research, you will present your information to the group. Your presentation should include:

- An oral presentation with 2 to 3 minutes of information from each of your team member experts.
- A poster, PowerPoint presentation, or portfolio that includes pictures that show how your energy source is used.
- A written report with information from each of your team member experts. Each team member should prepare 2 to 3 pages typed, double-spaced. It should include a bibliography of all references used.
- A scale model or demonstration that will help the audience visualize how the energy source works.

Supplementary Classroom Activity 2

Electrolysis of Water

Note: It is recommended that the teacher try this activity before doing it with students.

Introduction

Hydrogen is a renewable source of energy as long as it is not harvested from fossil fuels. Hydrogen is non-polluting because when it burns it combines with oxygen in the air to produce water. In this lab students will see how hydrogen can be separated from water through the process of electrolysis, using electricity to separate the molecules. They will then see the amount of energy contained in a small amount of hydrogen when they burn it to form water.

Pre-Activity Discussion Questions

How is hydrogen produced?

What happens when hydrogen is burned?

Why is hydrogen considered a non-polluting, renewable energy resource?

Materials

electrodes, sodium hydroxide, 400 ml beaker, water, DC power supply, alligator clips, test tubes, graduated cylinder, stir rods, wood splints, matches, safety glasses

Set up

Students should work in pairs.

Supplementary Classroom Activity 2

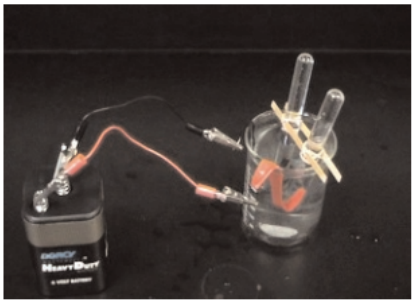

Figure 10.2 Experimental Set-Up

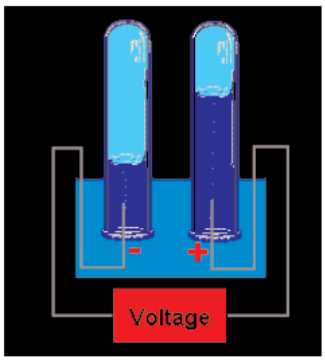

Figure 10.3 Experimental Results

Procedure

1. Wear safety glasses throughout the experiment.
2. Fill the beaker half full with water.
3. Fill each test tube with water so there is no air in the test tube. Using a small piece of plastic or cardboard, cover the test tube and invert it into the water in the beaker. There should be NO air bubbles in the test tubes.
4. Add 0.5 grams of sodium hydroxide to the water. Stir. The sodium hydroxide acts as a catalyst to speed up the reaction. The reaction would occur without this catalyst but at a much slower rate.
5. Place the electrodes as shown above. A section of the metal portion of the electrode should be outside of the test tube.
6. Attach the electrodes to the DC power supply. Observe.
7. When one of the beakers is filled with gas, disconnect the electrodes.
8. Using a rubber band, mark the test tube that is not completely full so you can measure the amount of gas collected later.
9. Carefully remove both test tubes from the beaker. DO NOT invert the test tube or you will lose the gases you've collected.
10. Place a flaming wood splint into the mouth of the test tube that was completely filled with gas (the test tube should still be upside down). Observe.
11. Insert a glowing splint up past the rubber band of the test tube that was half full (the test tube should still be upside down). Observe.
12. Measure the amount of gas collected in both test tubes.

Supplementary Classroom Activity 2

Data

Make observations while the test tubes are filling with gas. Record anything interesting that you notice.

Record the volume of gas in each test tube.

Write the chemical equation for electrolysis of water: (2H2O ------> $2H_2$ + O2)

Write the chemical equation for the burning of hydrogen: ($2H_2$ + O2 -------> $2H_2O$)

Conclusion

What gas was in each test tube? How did you determine this? Why is hydrogen a good source of energy?

Discussion

Through this activity students will see that hydrogen can be produced by the electrolysis of water. Twice as much hydrogen gas will be produced as oxygen gas. When hydrogen is burned, the only byproduct is water. Currently, the problem is finding an energy source that will carry out the electrolysis of water in order to produce the hydrogen renewably and efficiently. Discuss with participants ways that hydrogen could be produced from water without using fossil fuels.