

Supplemental Lesson

California Education and the Environment Initiative

EEl Supports
New Common
Core and Next
Generation Science
Standards

6

Science Standard
6.6.a.



Energy: It's Not All the Same to You!

California Education and the Environment Initiative

The Education and the Environment Initiative Curriculum is a cooperative endeavor of the following entities:

California Environmental Protection Agency
California Natural Resources Agency
California Department of Education
Department of Resources Recycling and Recovery (CalRecycle)

Key Partners:

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Office of Education and the Environment

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Supplemental Lesson



Los Angeles freeway traffic

Energy Conversions—Powering California’s Transportation

The unit, “Energy: It’s Not All the Same to You,” focuses on energy sources associated with the production of electricity in California. This supplemental lesson goes beyond electricity production and takes a more comprehensive view of how California uses energy. Students are introduced to four energy end-use categories common in our everyday lives: commercial, industrial, residential, and transportation. This supplemental lesson can be taught after the five regular 6.6.a lessons are completed.

The class analyzes a circle graph to discover that Californians consume 40% of their energy for transportation, more than the total amount of energy used for residential and commercial activities combined. They then discuss the energy sources that power transportation in California and learn that the vast majority of transportation within the state depends on petroleum products. Petroleum is not one of the energy sources students discussed in

“Energy: Its Not All the Same to You” because it is not used in electricity production in California. As part of this supplemental lesson students read the Supplemental Reader *Where Oil Comes From and How It Is Used*, a story that complements *The Energy Source Buffet* reader.

The readings and discussion during this lesson prepare students to consider differences in the effects of the sources and energy conversions that power transportation in

California. They participate in a class discussion about which energy sources for cars and trucks can minimize their adverse effects on air, land, water, and natural systems.

Background

For thousands of years humans have been using petroleum products for purposes ranging from religious rituals to medicines. It is only since the mid-1800s, however, that crude oil has been gathered in large quantities



Learning Objectives

Describe four major end-use categories of energy.

Identify the energy end-use category that consumes the greatest amount of California's energy.

Provide examples of the types and characteristics of the byproducts that result from the conversion of energy for use in transportation.



In many cases, there are alternative energy sources that result in fewer adverse effects on natural systems. Powering cars and small trucks with electricity, for example, does not directly produce any emissions into the air; however, it is important to recognize that the power plants that produce the electricity that is then used to charge the batteries to power the cars may themselves release byproducts and have other effects on natural systems.

and used as a major source of energy.

In the mid-1840s, experiments conducted by Samuel Kier, a landowner in northwestern Pennsylvania, started the process of changing what was an infrequently used natural material into the most important energy source of the industrial age and modern society. Credited with being the first person to refine crude oil into various products, Kier worked with a trained chemist to make refined products that could be burned to release heat, converted into kerosene to produce light, or made into other useable materials.

Today, the United States is the world's largest consumer of crude oil and petroleum products, about 18.8 million barrels per day, as of 2011. Approximately 55% of these petroleum products come from the U.S. with most of the remaining 45% imported from Canada, Saudi Arabia, Venezuela, Mexico, and Nigeria. Data from the federal Energy Information Administration demonstrate that U.S. dependence on imported oil peaked in 2005, and has been declining ever since.

It is important to consider the full "life-cycle" effects of using all sources of energy. The processes of exploration, drilling, extracting, transporting, and refining crude oil have both direct and indirect effects on the environment. Even

when well managed, all of these steps of producing petroleum products consume natural habitat, and release oil, gases, and chemicals into the soil, water, and air.

Using gasoline, diesel fuel, jet fuel, heating oil, and other products after they come out of the refineries can result in other significant environmental issues. Whether for commercial, industrial or residential uses, or for transportation, converting these petroleum-based fuels into useful energy and other products can have a range of measurable effects on Earth's climate as well as on human health.



Woman pumping gasoline

Key Vocabulary

Climate change: A long-term significant change in the weather patterns of an area.

Commercial: Connected with business, industry, or trade, and generally operated for a profit.

Extracting: The act of removing natural resources from their natural origin or separating a metal from ore.

Industrial: Related to the production of goods, such as manufacturing, mining, and processing ore, and chemicals.

Life-cycle assessment: A study of how extracting, processing, and using energy and other natural resources can affect the environment.

Petroleum products: The products derived from crude oil.

Residential: Related to places people live, such as houses, apartment buildings, motels, and other living areas.

Transportation: The act of carrying or moving people or things from one place to another.

Toolbox



Summary of Activities

Students are introduced to four energy end-use categories. They explore the use of petroleum in California's transportation systems and compare its effects to other energy sources used for transportation.



Instructional Support

See Extensions & Unit Resources, Unit 6.6.a. Teacher's Edition, pages 30–31.

Students can do research on alternative sources of energy that can be used for transportation.

Prerequisite Knowledge



Students should know:

- forms and uses of energy in students' communities.
- different methods of producing energy (including using fuel, converting solar energy to electricity, using hydro- or wind-power).
- that when fuel is used (consumed) most of the energy released becomes heat, a byproduct that transfers to the surrounding environment.
- that the “usefulness” of energy sources is determined by weighing the benefits against the conversion costs and release of byproducts.

Students should be able to:

- explain that the “usefulness” of energy sources is determined by weighing the benefits against the conversion costs and release of byproducts.
- describe other byproducts of energy production and consumption (for example, liquids, gases, and solids that may have varied effects).
- provide examples of how the byproducts of converting energy sources enter natural systems.
- describe how the quantities of energy consumed, and the amount and characteristics of resulting byproducts, affect natural systems.

Advanced Preparation



Gather and prepare Materials Needed:

- Gather from previous lessons:
 - **Energy Sources Chart** from Lesson 4 (6.6.a. Teacher's Edition) and post.

Gather and prepare A-V Materials.

Create a Ways We Use Energy Chart:

- On large paper, make a **Ways We Use Energy Chart** based on the sample on page 6. Make chart cells large enough to accommodate the sample answers.
- Chart should be visible and accessible to students.

Create an Energy Sources Used for Transportation Chart:

- On large paper, make an **Energy Sources Used for Transportation Chart** based on the sample on page 7. Make chart cells large enough to accommodate the sample answers. Note: Use paper to cover the “Energy Sources Used” and “Petroleum/Oil Products” headings.
- Chart should be visible and accessible to students.

Add new vocabulary to Word Wall.

Supplemental Student Workbook and Reader:

- Prepare one copy for each student.



Materials Needed



A-V Equipment:

- projection system, screen

Class Supplies:

- large paper
- colored markers
- drawing paper
- pencils or pens
- ruler
- tape or thumbtacks

Supplemental Student Workbook and Reader:

- *Where Oil Comes From and How It Is Used*, pages 2–6
- *Powering California's Transportation*, pages 7–8

Audio-Visual Materials



Supplemental Visual Aids

- **Energy Sources Used to Produce California's Electricity**, Supplemental Visual Aid #1
- **Energy End-Use Categories**, Supplemental Visual Aid #2
- **California's Energy End-Uses by Category**, Supplemental Visual Aid #3
- **Energy Sources for Cars 1 and 2**, Supplemental Visual Aids #4–5

Duration



Preparation time:

10 min.

Instructional time:

50 min.



Safety Notes

None

Procedures

Vocabulary Development

Use the **Dictionary** and the vocabulary **Word Wall Cards** to introduce new words to students as appropriate.

Step 1

Project **Energy Sources Used to Produce California’s Electricity** (Supplemental Visual Aid #1). Remind students that in the reader *The Energy Source Buffet* they learned about the many different energy sources that power plants in California convert to generate electricity. Point out the “Renewables” category on the circle graph. Remind students that “Renewables” include the energy sources: bioenergy, geothermal, “small” hydropower, solar, and wind.

Ask students, “What major energy source is missing from the circle graph?” (*Petroleum/oil*) Then ask, “Why do you think that oil is not included?” (*Oil is not used by power plants in California to generate electricity.*)

Mention that in some places outside of California, there are power companies that use oil to generate electricity. Some of these companies burn oil to heat water to create the steam they use to spin turbines in their generators. Other power companies burn oil under pressure to produce a stream of hot exhaust gases to spin their turbines.

Step 2

Ask students, “In addition to generating electricity, what are other ways humans use these different energy sources, including oil, in their daily lives?” Write their responses on the **Ways We Use Energy Chart**. (*Accept all reasonable answers.*)

Ways We Use Energy	
<i>Driving cars</i>	<i>Cooking</i>
<i>Heating and cooling homes</i>	<i>Manufacturing</i>
<i>Mining</i>	<i>Pushing sailboats</i>
<i>Flying airplanes and hot air balloons</i>	<i>Heating up swimming pools</i>

Step 3

Distribute a copy of **Supplemental Student Workbook and Reader** to each student.

Project **Energy End-Use Categories** (Supplemental Visual Aid #2). Explain that energy producers, environmental specialists, and economists group end-uses of energy into four different categories: commercial, industrial, residential, and transportation.

Ask students to volunteer definitions for each of the energy end-use categories: commercial, industrial, residential, and transportation.

- Commercial use (*related to business, industry, or trade and generally operated for a profit, such as operating stores, farms, restaurants, libraries, etc.*)
- Industrial use (*related to the production of goods, such as manufacturing, mining, and processing ore, chemicals, etc.*)
- Residential use (*related to places people live, such as houses, apartment buildings, motels, and other living areas*)
- Transportation (*related to moving people, goods, and equipment from one place to another*)



Step 4

Project **California’s Energy End-Uses by Category** (Supplemental Visual Aid #3).

Ask the students, “Which energy end-use category consumes the most energy in California?” (*Transportation consumes 40% of California’s energy.*)

Instruct students to record the name of the four energy end-use categories on the appropriate areas of the circle graph on the **Powering California’s Transportation** worksheet (**Supplemental Student Workbook and Reader**), based upon the percentage of energy use in each category. Explain to students that they will study energy used for transportation in California and the different fuel sources that are converted to power these transportation activities.

Give students time to answer the second question on **Powering California’s Transportation**.

Step 5

Call students’ attention to the **Energy Sources Used for Transportation Chart**. (*Note: Keep the “Energy Sources Used” and “Petroleum/Oil Products” column headings covered until Step 6.*)

Ask students, “How do humans move people and things from one place to another?” Tell them you only want answers related to external energy sources, for example, cars and trucks rather than humans and horses. Write students’ responses on the chart under the heading “Methods of Transportation.” (*Accept all reasonable answers, but consider limiting the number of responses due to time constraints.*)

Energy Sources Used for Transportation Chart

Methods of Transportation	Energy Sources Used	Petroleum/Oil Products
Airplanes	Jet fuel, gasoline	Yes
Gliders	Gasoline for the ones pulled by airplanes	Yes
Hot air balloons	Natural gas	No, however often found near petroleum deposits
Space vehicles	Rocket fuel, liquid hydrogen, liquid oxygen	Yes
Cars and small trucks	Gasoline, diesel fuel, biofuels, natural gas, electricity (battery and solar), hydrogen	Yes
Motorcycles	Gasoline, electricity	Yes
Large trucks	Gasoline, diesel fuel, biofuels, natural gas	Yes
Buses	Gasoline, diesel fuel, biofuels, natural gas, hydrogen	Yes
Trains	Coal, wood, diesel fuel, electricity	Yes
Cable cars	Electricity	No, unless the electricity is produced by an oil-fired power plant
Subways	Electricity	No, unless the electricity is produced by an oil-fired power plant
Boats and ships	Coal, wood, diesel fuel, wind, nuclear energy	Yes
Submarines	Diesel fuel, nuclear energy	Yes
Tractors	Gasoline, diesel fuel	Yes

Step 6

Uncover the “Energy Sources Used” column heading on the **Energy Sources Used for Transportation Chart** and ask students, “What energy sources are used for these different types of transportation?” Record their answers under the heading “Energy Sources Used.” (*Accept all reasonable answers.*)

Uncover the “Petroleum/Oil Products” column heading and ask students, “Which of these methods of transportation use energy sources that are products of petroleum/oil?” Record their answers under the heading “Petroleum/Oil Products.”

Point out that, as they can see on the **Energy Sources Used for Transportation Chart**, petroleum products are used for practically all methods of transportation. Mention that this is how California consumes 40% of its energy for transportation. (*Note: Even modes of transportation that do not use oil as an energy source often use it as a lubricant for various parts of the vehicles.*)

Step 7

Give students 10 minutes to read pages 2 and 3 of the **Supplemental Reader Where Oil Comes From and How It Is Used**.

Instruct students to answer questions 3 and 4 on **Powering California’s Transportation**. Briefly discuss their answers as a class to check for understanding.

Step 8

Give students 10 minutes to read the remainder of the **Supplemental Reader Where Oil Comes From and How It Is Used**.

Instruct students to answer questions 5–7 on **Powering California’s Transportation**. Briefly discuss their answers as a class to check for understanding.

Step 9

Refer students to the **Word Wall Card** with the term “Life-cycle assessment.” Ask students to share and discuss what they know about the importance of considering all phases of energy consumption including how different fuels are extracted, processed, and used in various human activities.

Explain that since 40% of California’s energy is used for transportation, it is especially important to consider which of the possible energy sources used for transportation are likely to cause the fewest effects on the environment. Ask students, “What factors should we take into consideration when choosing an energy source for powering cars, trucks, and other modes of transportation?”

- *We should compare the effects of extracting the different energy sources on natural systems.*
- *We should compare how the processing and byproducts of different energy sources affect natural systems.*
- *We should compare how using each of the energy sources affects natural habitat, the atmosphere, and human health.*

Have students answer question 8 on **Powering California’s Transportation**.

Step 10

Project **Energy Sources for Cars 1 and 2** (Supplemental Visual Aids #4–5). Tell the students that you are going to introduce them to alternative energy sources for cars.

Discuss each of the five major energy sources that humans currently use to power cars and small trucks. Point out that each of these energy sources has advantages and disadvantages (byproducts and effects on natural systems) that make some more feasible than others. Ask students to share their thoughts about the choices among the different energy sources. In the interest of stimulating a conversation about life-cycle assessment, ask students, “Are electric cars and trucks necessarily cleaner?”



(It depends. Not all electricity is “equal” in terms of the effects on the environment when it is produced. It depends on the energy source used to generate it. In addition, electric cars, like all modern vehicles, are manufactured using some plastic components, which are petroleum-based.)

Gather ***Supplemental Student Workbook and Reader*** for assessment.

Lesson Assessment

Description

Powering California's Transportation (Supplemental Student Workbook and Reader, pages 7–8) assesses students' achievement of the learning objectives: "Describe four major energy end-use categories of energy;" "Identify the energy end-use category that consumes the greatest amount of California's energy;" and "Provide examples of the types and characteristics of the byproducts that result from the conversion of energy for use in transportation."

To demonstrate what they have learned, students label a circle graph and provide written responses to questions.

Suggested Scoring

An Answer Key and Sample Answers for **Powering California's Transportation** are provided on pages 11–12. There are 50 total points possible.

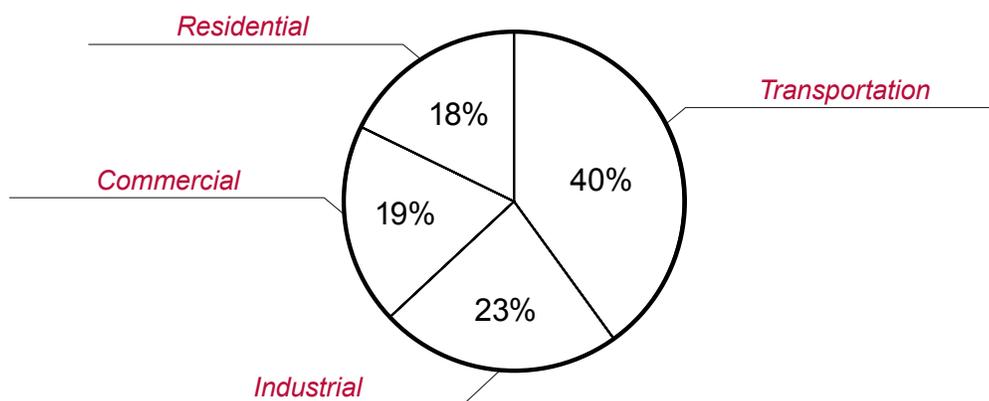
Answer Key and Sample Answers

Powering California's Transportation

Supplemental Lesson | page 1 of 2

Name: _____

- Record the names of the four energy end-use categories on the appropriate parts of the circle graph. (2 points each)



- Which energy end-use category consumes the greatest percentage of California's energy? (2 points)

Transportation

- What is petroleum and how is it formed? (5 points)

Petroleum is a fossil fuel that is also called crude oil. It is formed from plants and animals that died millions of years ago and were buried underground and transformed (by heat and pressure) over a long period of time.

- Describe an example of how petroleum products are converted for use in transportation? (5 points)

Internal combustion engines can burn petroleum products. The energy from these small explosions can be used to power cars, trucks, and buses.

Answer Key and Sample Answers

Powering California's Transportation

Supplemental Lesson | page 2 of 2

Name: _____

5. Where do we get crude oil and petroleum products? (5 points)

Crude oil comes from deep underground and beneath the oceans. Refineries distill the crude oil into gasoline, diesel fuel, and other products.

6. What are the byproducts of refining crude oil and using it in internal combustion engines? (5 points)

Refining petroleum products releases carbon dioxide, methane, and other byproducts. Internal combustion engines release five main gases: carbon dioxide, carbon monoxide, hydrocarbons, nitrogen oxides and water vapor, as well as very small particles called "particulate matter".

7. How do exploring, drilling, producing, transporting, and using petroleum products influence natural systems? (5 points)

Exploring, drilling, producing, transporting, and using petroleum products can affect the environment, including land, air, and water. Oil spills and other chemicals can pollute the soil and may get into the water. Refineries release methane and other byproducts into the atmosphere. When petroleum products are burned, release of greenhouse gases into the atmosphere contributes to global climate change.

8. Identify three of the factors considered during "life-cycle assessment" that should be discussed when choosing an energy source for powering cars, trucks, and other modes of transportation?" (5 points each)

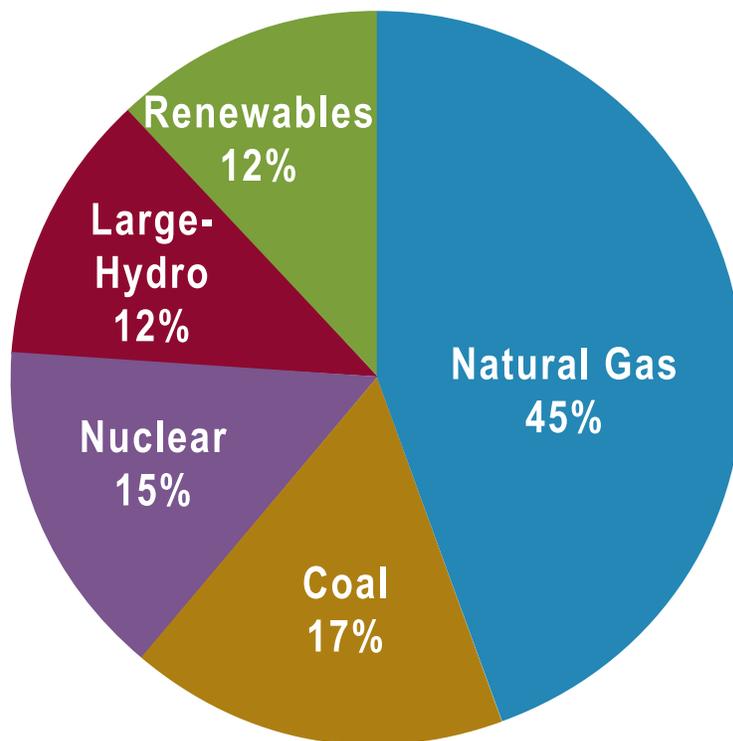
We should compare the effects of extracting the different energy sources on natural systems.

We should compare how the processing and byproducts of different energy sources affect natural systems.

We should compare how using each of the energy sources affects natural habitat, the atmosphere, and human health.



SVA #1 Energy Sources Used to Produce California's Electricity



California's Power Mix

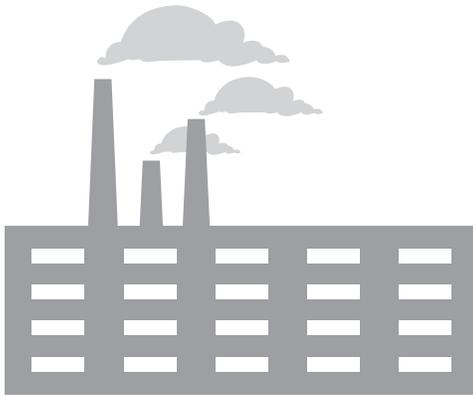
Energy Source	Percent of Total
Natural Gas	45%
Coal	17%
Nuclear	15%
Large Hydro	12%
Renewables	12%

Source: California Energy Commission, 2007

Note: Total Exceeds 100 percent due to rounding.

SVA #2 Energy End-Use Categories

Industrial



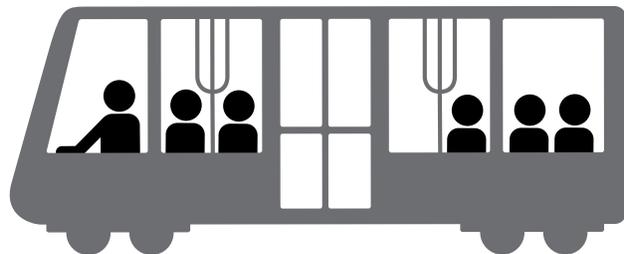
Commercial



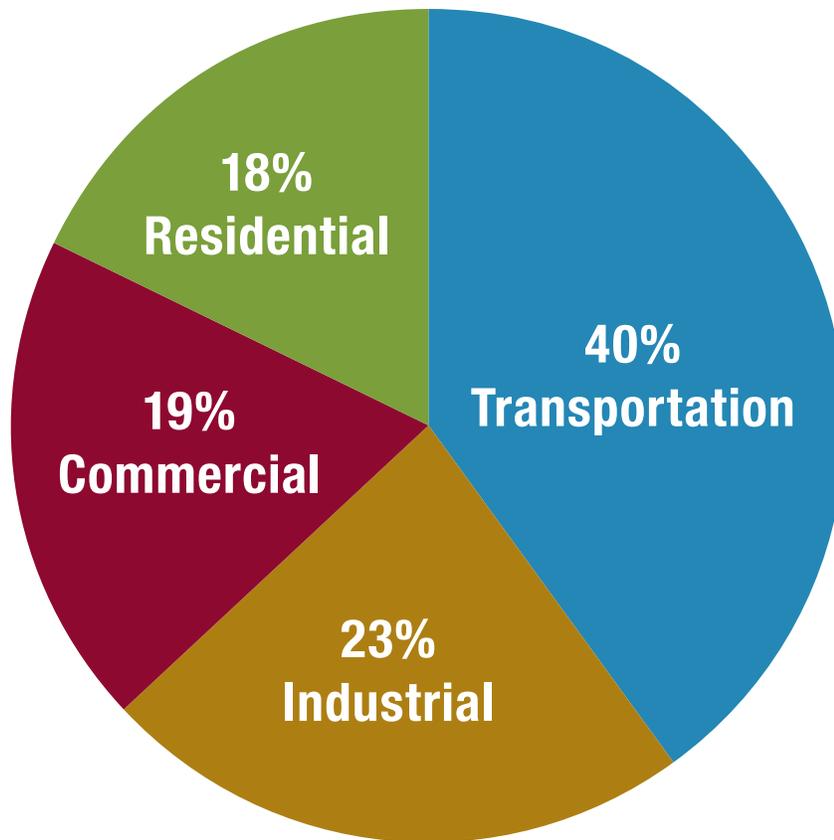
Residential



Transportation



SVA #3 California's Energy End-Uses by Category



Source: U.S. Department of Energy, Energy Information Administration, 2011
http://www.eia.gov/beta/state/seds/data.cfm?incfile=/state/seds/sep_sum/html/sum_btu_1.html&sid=US

SVA #4 Energy Sources for Cars 1

Energy Source	Advantages	Byproducts	Effects on Natural Systems	Limitations
Gasoline and Diesel fuel	Well developed industry exists to produce and distribute fuels. Existing fleet of vehicles can use it.	Releases large amounts of carbon dioxide, other gases, and soot (particulates).	Greenhouse gases can result in global climate change. Extraction, transportation, and processing can disrupt and/or damage natural habitat.	More expensive to buy than natural gas. Nonrenewable sources.
Natural gas	Produces fewer emissions than using gasoline and diesel fuel.	Releases carbon dioxide, hydrogen sulfide, and soot (particulates).	Greenhouse gases can result in global climate change. Drilling and transporting disrupt and/or damage natural habitat.	Few fuel stations and limited driving range without refueling. Nonrenewable sources.
Biofuels	Some are made from waste materials and save space in landfills. Can collect and use methane from decaying materials rather than releasing it into the atmosphere. Renewable sources.	Releases carbon dioxide, other gases, and smoke (particulates).	Greenhouse gases can result in global climate change. May use farmland which then can not be used to produce food. Land for growing fuel can consume natural habitat and affect wildlife populations. Fertilizers may have additional impacts.	Large amounts of energy needed to produce biofuels. Few fuel stations. A relatively new technology that is not fully developed.

SVA #4 Energy Sources for Cars 2

Energy Source	Advantages	Byproducts	Effects on Natural Systems	Limitations
Battery Electric	Zero emissions from the vehicles. Electricity may be generated from renewable sources.	No air pollution from the vehicles.	No direct effects from the vehicles, but the power plants that supply the electricity may affect natural systems (for example, releases of particulate matter and/or greenhouse gases that can result in climate change).	Few charging stations. Most vehicles take many hours to charge. Some sources of electricity are nonrenewable.
Hydrogen Fuel Cell Electric	Zero emissions from the vehicle. Can be made from renewable sources such as biomethane and electricity from solar or wind-power. Can be refueled in the same time as a gasoline vehicle.	Hydrogen fuel cell vehicles emit only water.	Depends on the source of energy used to make the hydrogen. For example, greenhouse gas emissions can be associated with making hydrogen from natural gas or using nonrenewable electricity.	Few refueling stations, but more are in development and will likely be available in the next few years. Some sources of hydrogen are nonrenewable.

Contributors

Contributors to the Development of this EEI Curriculum Supplemental Lesson

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Credits

Supplemental Dictionary

Photos

Climate change	Melting ice sheets – Colin Monteath/Minden Pictures/National Geographic Society
Commercial	Shopping Center – Marcus Lindstrom/iStockphoto.com
Extracting	Oil Pumpjack – David Gomez/iStockphoto.com
Industrial	Los Angeles Industrial Area – trekandshoot/iStockphoto.com
Life-cycle assessment	Balancing decisions – Henrik Jonsson/iStockphoto.com
Petroleum products	Gas station – Jeff Cleveland/BigStockPhoto.com
Residential	San Francisco neighborhood – Chuck Schug/iStockphoto.com
Transportation	Truck – Aaron Kohr/BigStockPhoto.com

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Illustrations

Page 15	Icons – Si Gal/iStockphoto.com
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Photos

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Page 2	Los Angeles freeway traffic – Tim McCaig/iStockphoto.com
Page 3	Automobile exhaust – Remedios/iStockphoto.com
	Woman pumping gasoline – Abejon Photography/iStockphoto.com
Page 13	California oil refinery at dusk – Hal Bergman/iStockphoto.com

Supplemental Student Workbook & Reader

Illustrations

Page 2	Petroleum and natural gas formation – Energy Information Administration
Page 4	Barrel of crude oil – Adapted by Rebecca Voorhees/Creative Services, California State University, Sacramento, from original by Energy Information Administration

Photos

Page 3	Internal combustion engine – Maciej Noskowski/iStockphoto.com
Page 5	Oil pipeline entering refinery – Wolverine Enterprises/iStockphoto.com
Page 6	Oil spill entering wetland – Foxtrot101/iStockphoto.com
Page 6	Oil refinery explosion – Jim Lopes/iStockphoto.com

Supplemental Word Wall Cards

Photos

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Commercial	Shopping Center – Marcus Lindstrom/iStockphoto.com
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