ENVIRONMENTAL LITERACY TEACHER GUIDE SERIES

# Energy Potential

## A Guide for Teaching Energy in Grades 3 to 8

NATIONAL GEOGRAPHIC

# 6 Solutions for Our Energy Future

by Jose Marcos-Iga and Tania T. Hinojosa

**"We are like tenant farmers chopping down the fence around our house for fuel when we should be using Natures inexhaustible sources of energy—sun, wind and tide."**

*Thomas Edison, 1931 (qtd. in Gaworecki 2010)*

By now it is clear that energy is essential for not only progress, but also the basic functioning of our society. Many would agree that we are in the middle of an energy crisis. The International Union of the Conservation of Nature and other respected groups link this time of crisis with the pollution of our air, water and soil as well as with our changing climate. This energy crisis is not only impacting our environment and the survival of precious plants and animals, but it is also creating or exacerbating conflict and inequalities in our own communities. Yet, humans are resourceful and innovative, and we have the power to change our energy future. Changing our energy future will involve the following areas:

- Energy Policy: Who regulates energy resources within the United States and around the world? What are some of the current laws in place? What are some examples of current energy reform?
- Energy Innovations: Why do we need to rework our energy portfolios? Which alternatives to fossil fuels exist? What are the benefits and trade-offs of these cleaner sources of energy?
- Energy Action: What can each of us do to make a difference? Why should individuals conserve energy? How can we make choices that are more energy efficient?

All of these areas relate to two concepts that are key for understanding energy solutions. Both concepts are ones that your students have likely heard over and over, and both work in tandem to address our energy problems: e**nergy conservation** and **energy efficiency.**

| GRADE | STANDARD | EEI UNIT |
|---|---|---|
| Grade 3 | 3.1.2<br>3.3.3<br>3.4.1-2<br>3.5.1-3 | The Geography of Where We Live<br><br>California Economy—Natural Choices |
| Grade 4 | 4.1.5<br>4.4.6<br>4.5.3-4 | Reflections of Where We Live |
| Grade 5 | 5.7.3 | |
| Grade 6 | 6.4.a<br>6.6.a-c | <br>Energy: It's Not All the Same to You!<br>Energy and Material Resources: Renewable or Not?<br>Made From Earth |
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*Energy conservation* means "reducing energy consumption and waste." Examples include turning off lights when we leave a room and wearing a sweater indoors during the winter to keep the thermostat a few degrees lower. *Energy efficiency* involves the use of technology and strategies that allow for reduced energy use without reduced benefit (Alliance to Save Energy 2007). This can include weatherizing your home to conserve heat (insulation, for example) and using a programmable thermostat. Both conservation and efficiency are important as part of a successful approach to solving the energy crisis.

## Energy Policy

International agencies, countries, states, cities, and towns, as well as private-sector businesses, develop energy policies to describe their energy resource extraction, trade, and consumption practices. They

## CHAPTER OVERVIEW

**As fossil-fuel abundance wanes, the need to integrate renewable energy into the U.S. and world's energy portfolios increases. The need for consumers to conserve energy is also an important piece of the energy puzzle.**

**Government policy will play a critical part in reaching both conservation and efficiency goals. International organizations, such as the United Nations, are setting the tone for energy policy, and the U.S. government is also making strides to decrease our dependence upon fossil fuels. Learning about new technologies in renewable energy resources can also be a step toward student understanding of how efficiency is improving every day. In addition, learning small, practical changes they can make in their everyday lives can make a difference in how your students actively participate in reducing their energy use.**

**In this chapter we investigate energy policy at multiple levels, strides in renewable-resource technology and practical steps students can take to reduce their energy consumption.**

do this through the use of legislation, treaties, and protocols aimed at defining emissions standards, incentives, and security measures that relate to energy. When students are asked who regulates or controls energy, they often point to their utility companies, but know little about how our government—at different levels—actively participates in energy policies and planning. Knowing the people involved not only improves student understanding of the issues, but also can empower them as citizens to become more engaged as voters and community members.

In the United States, at the federal level, the Department of Energy (DOE) oversees energy policy. DOE's mission is to "advance the national, economic, and energy security of the United States; to promote scientific and technological innovation in support of that mission; and to ensure the environmental cleanup of the national nuclear weapons complex" (U.S. Department of Energy 2010). Interestingly, the DOE was not created until 1977 and only after the United States experienced several energy crises. Some may be surprised to learn that the DOE has only been around for a little more than 30 years. Who was in charge of American energy plans before that time?

Before the DOE existed, other federal entities served several of the energy-related needs of the country, which began in earnest around World War II. The Manhattan Project was created under the U.S. Army Corps of Engineers to lead the development of the atomic bomb. After the war, the Atomic Energy Act of 1946 was enacted to create the Atomic Energy Commission, which took over the Manhattan Project, putting the field of atomic research under civilian-government control. Later, in 1954, the Atomic Energy Act opened the development of nuclear power to the private sector and gave the Atomic Energy Commission the authority to regulate the new industry.

Two decades later, in response to changing needs, the Energy Reorganization Act of 1974 abolished the Atomic Energy Commission and created two new agencies: the Energy Research and Development Administration and the Nuclear Regulatory Commission. The former intended to manage the energy development, naval reactor, and nuclear weapons programs; and the latter to regulate the nuclear-power industry. Shortly thereafter, in response to oil embargoes described in Chapter 5,

## Teaching Tip

Energy conservation and energy efficiency are concepts that may be used interchangeably by the media or by adults. Students might have difficulty understanding the difference, but using examples and comparing the two would be a great way to help students differentiate between both concepts. For example, give students a list of actions such as those following and have them sort the actions into one of two groups: *Efficiency* or *Conservation*. Then discuss where students disagree and generate working definitions for each word that make sense to your students:

- Using Compact Fluorescent Lightbulbs (CFLs) (efficiency)
- Turning off lights when leaving a room (conservation)
- Unplugging electronics when not in use (conservation)
- Applying weather stripping to windows and doors (efficiency)
- Buying Energy Star appliances (efficiency)
- Riding your bike to school (conservation)

**Since the middle of the 20th century energy has been a top agenda item for U.S. Presidents. In this photo President Obama tours the DeSoto Next Generation Solar Energy Center in Florida. Renewable energies will play an important role in solving our energy problems.**

President Jimmy Carter signed the Department of Energy Organization Act of 1977. The legislation called for the creation of the Department of Energy to help end the U.S. dependence on foreign oil and unify energy organization and planning—goals the United States has been working toward since that time. The key point to make for students is that when energy legislation is passed, it is often the DOE that actually carries out the mandates in the legislation.

States also have their own departments of energy that create policy and state-level energy plans. For example, California has the California Energy Commission that was created in 1974, three years before the DOE was created. State commissions such as the California Energy Commission oversee energy-efficiency standards in building/development, provide incentives for using renewable energies, funding for innovative research and programs, and general energy planning for the state, just to name a few responsibilities. When energy legislation is passed at the state and federal levels, it is often the state's energy department or commission that sees the legislation carried out.

Energy policy varies widely from state to state, typically in response to that state's resources and needs. Some states, for example, must include regulations regarding hydropower, while others are more concerned with coal power or offshore drilling. To make state-level policies more accessible to students, consider discussing resources—major rivers, deserts, coastal areas, or biofuel crops—that could be used for energy generation, and then compare that with the future direction of your own state's energy plan.

Cities and towns have departments that oversee the energy policies within the municipality. These departments carry out legislation passed at the state or federal levels, but based on their city's energy needs and current energy system. For example, Los Angeles has the Department of Water and Power, the largest municipal utility in the United States. The agency's role is to provide residents of Los Angeles with power. The revenues paid by customers cover the cost of operations, often with surplus to put back into the city's budget.

**Los Angeles, California, is the second most populous city in the United States (after New York City). The L.A. Department of Water and Power faces the challenge of supplying this urban area with clean and reliable water and energy, day and night.**

While city-level departments implement state and federal energy mandates, they typically have their own set of commissioners that can enact citywide energy policies, as long as these policies do not contradict legislation. For example, in 2001 the city of San Diego created the Energy Conservation & Management Division (under the Environmental Services Department) with the main goal of overseeing San Diego's movement toward renewable energy resources, energy conservation, and energy efficiency—these goals were in line with California's overall energy plans. Think about how your local energy commissioners come into office. Are they appointed? What does this mean for our role as voters? Exploring the local energy commission or department makes this complex—and often distant—process much more real for students and gives them a specific way they can become involved in their community's energy plans.

At all levels—national, state, and municipal—government-run offices develop and enact energy policy. Most of these departments answer to voters in some way or another—through the election of city officials or state and national congress members—so that voters have a voice about the energy policies they believe will meet the needs of their communities.

## Important Energy Legislation

Energy-related legislation is often being passed at national and state levels. Sometimes the laws do not appear to relate directly to energy. For example, the speed limits on highways were not only implemented for safety reasons, but also imposed to control fuel consumption. Many nations worldwide have used Daylight Savings Time as

## Teaching Tip

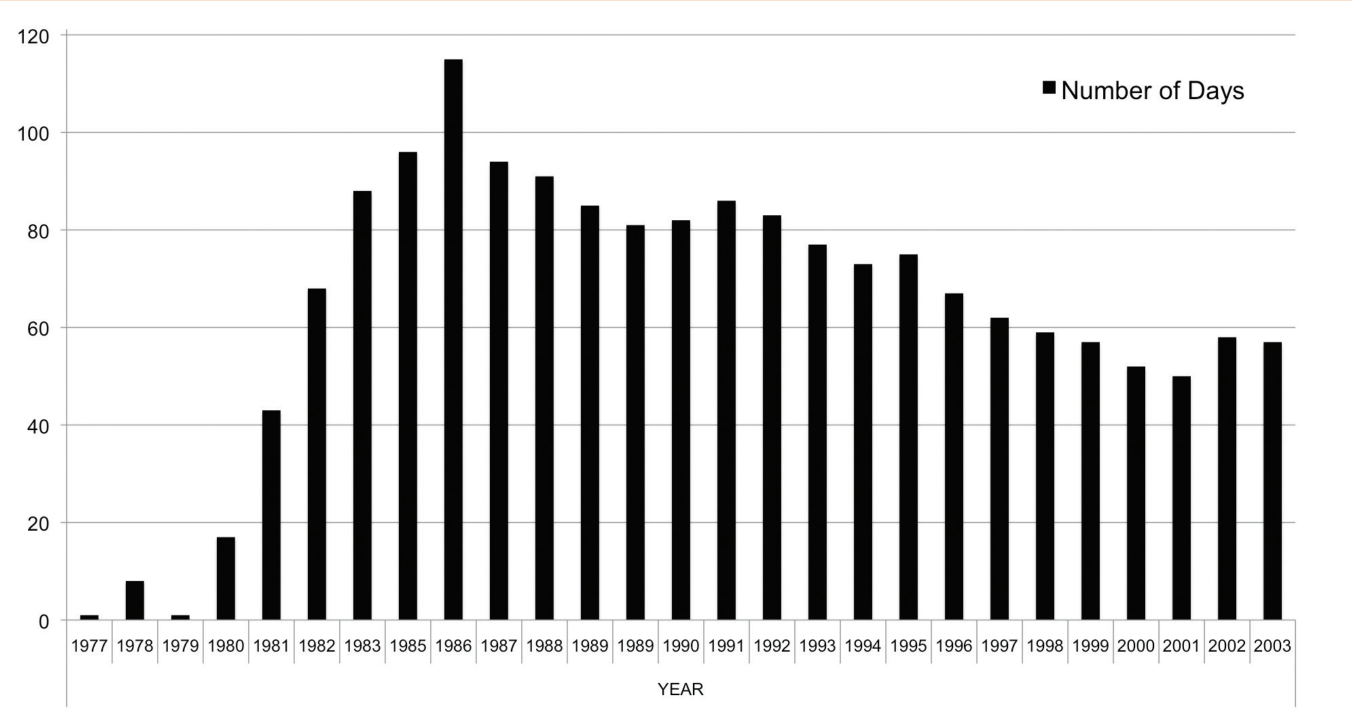
This may be a good time to have your students create a small poster that shows the time line of the important legislative actions pertaining to energy described above. As an extension for older students, you may have them research local energy legislation that has taken place over the past 50 years and add local legislation and events to the time line as well. Have students differentiate between federal legislation (in one color) and local legislation (in a second color), and then compare how the two match. Also have students note the special features of the local legislation that may tell them something about their local community.

a strategy to conserve fuel resources, especially in times of increased energy use (e.g., war), increased energy demand (e.g., rising prices), or reduced access to energy (e.g., embargoes). If your students live in an area that follows Daylight Savings Time, ask them a few questions regarding this time: What time of year does it take place? Is there more or less daylight during this time of year? As a result, do you use more or less light/energy at home? Why?

Other legislation is specifically designed to change our energy policies and programs. This legislation could seem distant to your students. They may even ask why it is important or how it will affect them. But much of this legislation has immediate impacts on citizens—from changes to appliance and lightbulb standards, to incentives to homeowners using renewable energies, to rising costs of gas at the pump. The following pieces of legislation are notable ones that altered America's energy policy, and ones that students should learn.

**Strategic Petroleum Reserve.** Two years before the Department of Energy was established, President Gerald Ford signed the Energy Policy and Conservation Act in 1975. The legislation called for the establishment of a reserve of up to 1 billion barrels of oil, later called the Strategic Petroleum Reserve. This need had been recognized for more than half a century, but it was the dramatic economic impact of the oil

**STRATEGIC OIL RESERVE**




**How many days' worth of oil imports are stored in the Strategic Petroleum Reserve? The maximum number of days of import protection ever held in the reserve was 115 days in 1985. Almost 20 years later, as oil consumption and imports have increased, that length of time has dropped to 57 days' worth of petroleum that could be met in an emergency. Learn more at http://www1.eere.energy.gov/vehiclesandfuels/facts/2004/fcvt_fotw321.html**


**A security guard stands near an oil-reserve pipeline at the Strategic Petroleum Reserve in Bryan Mound, Texas.**

embargo of the 1970s that emphasized the urgency of an oil reserve (as described in Chapter 5). The act also required “the President to prescribe one or more energy conservation contingency plans,” which needed to include rationing and prioritizing use of the energy resources available (U.S. Library of Congress 1975).

**Energy Policy Acts.** Since the 1990s, the U.S. government has passed three pieces of energy-policy legislation—referred to as the Energy Policy Acts of 1992 and 2005 and the Energy Independence and Security Act of 2007—each with their own focus and purpose.

The Energy Policy Act of 1992 addressed several key issues related to energy efficiency and conservation (e.g., establishing standards for efficient building and appliances and more efficient motors). The act included regulations on trading of natural gas across borders as well as establishing programs to support alternative-fuel vehicles and electric vehicles. In addition, it included a section on radioactive waste and called for the Environmental Protection Agency to outline standards for protecting against radiation at the Yucca Mountain nuclear-waste repository, which was the chosen site for disposing of nuclear waste from America’s nuclear power plants.

President George W. Bush signed the Energy Policy Act of 2005 to address growing energy problems. Importantly, this policy provided new tax incentives and loan guarantees for various forms of energy production. For example, certain companies received tax incentives if they agreed to drill offshore in the Gulf of Mexico as opposed to importing oil from another country. Other companies received loan guarantees or **subsidies** if they were investing in clean coal or renewable energies. Another feature of this legislation was the promotion of biofuels, and protecting the Great Lakes from oil drilling. While the act included incentives for both fossil-fuel industry and renewable industry, many critics argued that the subsidies mostly benefited the traditional energy industry, particularly oil, coal, and nuclear (Grunwald and Eilperin 2005).

After negotiations between the House and Senate, the Energy Independence and Security Act was signed into law (Freeman, 2007). This act focused on increasing the fuel standards for automobiles so that by 2020 there is a fleet-wide average gas mileage of 35 miles per gallon. The bill also included efficiency standards for lightbulbs and appliances, increases in biofuel use, new standards for energy efficiency of federal office buildings, and money to create a more efficient “smart” energy grid.

**The Vincent substation is expanded and modernized to bring solar and wind power to the Los Angeles Basin.**

**American Recovery and Reinvestment Act.** In response to an economic crisis, Congress passed the American Recovery and Reinvestment Act of 2009 to help create jobs and stimulate investment in American industries. President Barack Obama signed the bill, also known as the stimulus package, into law in February 2009 (U.S. Government 2010). Even though this was not an energy bill, it included several provisions related to improving and expanding energy infrastructure and supporting renewable clean sources of energy. The stimulus package included $21.5 billion for energy infrastructure, including renewable energy, electric transmission, and **smart-grid technologies** It also included $27.2 billion for energy-efficiency and renewable-energy research and investment, including research, development, and demonstration projects in biofuels, geothermal, wind, hydroelectric, and solar technologies, as well as electric-vehicle technology development.

**State Legislation.** Each state in the United States has opinions on energy resources and energy solutions. For example, while California is considered one of the largest users of energy because of the population and industry, it actually has one of the lowest per capita energy uses when compared to other states! That is partly because of California's mild climate, but also partly due to innovative energy-efficient appliance and building standards. New York State, the third most populous state in the country, actually has the very lowest energy use per capita, even given its geographic location. Interestingly, Wyoming, the least populous state (with a population less than that of the District of Columbia), uses more energy per capita than any other state. Ask your students to brainstorm reasons why New York and Wyoming use energy in the manner in which they do. Explore more comparisons at the Energy Information Administration (http://www.eia.doe.gov/states/sep_sum/plain_html/rank_use_per_cap.html).

## Teaching Tip

For students, and even adults, following the entire process of enactment of a law by Congress—from its preliminary versions to amendments by the House of Representatives and the Senate to the final signage by the President—can be an overwhelming task. Guiding your students through the entire process by dividing the class into groups representing the different positions of power can be a great way to get them familiar with this process. This can help them answer important questions that arise when analyzing the energy bills described in this chapter as well as any other law they may study in the future. Some important questions include:

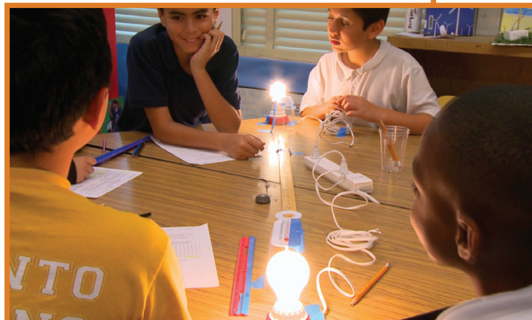
- What are the different roles played in Congress?
- Who drafts the initial bill?
- What is an amendment, and why are there so many of them?
- Why does the bill that is passed and signed look so different from the one that was initially drafted?
- What are the implications of this when studying the energy laws described here?

**Our government is continuously looking for ways to improve our energy system. This photo shows President Obama meeting with a bipartisan group of senators in the Cabinet Room of the White House, to discuss passing comprehensive energy and climate legislation, June 29, 2010. (Official White House Photo by Pete Souza)**

Pictures of Practice

# Energy Efficiency of Lightbulbs

Lightbulbs offer one of the most basic examples of energy efficiency. CFL lightbulbs may use up to 75 percent less energy and last 10 times longer than an incandescent lightbulb. Many students already know that CFL lightbulbs are more environmentally friendly compared to incandescent bulbs, but they may not realize why there is a difference. Conducting a hands-on investigation with both types of bulbs can provide students with a memorable experience that allows them to see firsthand the efficiency difference—through the measurement of temperature change—between the two bulbs.



**Students: Grades 4 and 5**

**Location: San Diego, California (working-class community)**

**Goal of Video: The purpose of watching this video is to see students investigate lightbulbs and describe what they learn about efficiency.**

## Classroom Context

Ms. Howard introduces energy efficiency to students through a lab investigation in which students compare the efficiency of an incandescent bulb to a CFL bulb. This lesson occurred early in the energy lessons, just after students completed an activity in which they tried to identify the most efficient way to move a stack of books from one location to the next. The lesson also occurred after students had already talked about different forms of energy and how energy changes between these forms. Prior to beginning the investigation, students took a closer look at different bulbs, comparing the writing (i.e., watts) marked on different bulbs and discussing the words *watt, lumens,* and *heat* (i.e., *waste heat*).

## Video Analysis

Ms. Howard starts the investigation with reviewing the word *efficiency*—doing the same amount of work with less energy. Students compare the watts of different lightbulbs, connecting the word *watt* to energy used by the bulb. Students learn that some incandescent bulbs use 60 watts, while others use 100 watts. Students also learn that a 60-watt incandescent bulb gives off the same lumens as a 14-watt CFL bulb. After reviewing the lightbulbs, Ms. Howard tasks students with finding the different amounts of heat given off by the bulbs. Students take temperature measurements using a thermometer located near the bulbs. They measure the temperature change after the bulb stays lit for 10 minutes, recording a temperature reading every minute. Students tangibly feel that the incandescent bulb gives off more heat than the CFL bulb. Andrea shares that the CFL is more energy efficient and mentions that it gives off less waste, or heat. Henry piggybacks onto Andrea's idea, saying that heat is a waste product because it is not being used. In post interviews, Esmerelda questions why incandescent bulbs give off so much heat, while Ezequiel seems confused about what *energy efficiency* means. When Ezequiel hears the word *efficiency* he thinks of "more power" and "better," rather than doing the same work with less energy.

## Reflect

### How would you teach energy efficiency?

What ways would you approach the concept of energy efficiency? How does the lightbulb activity support student learning of the concept? How would you respond to Ezequiel's post interview explanation of efficiency? What would you do next with Ezequiel?

Case Study

# What's So Cool About California?

California is at the helm of climate-change mitigation initiatives. The government of the state of California decided the debate on climate change was over by passing the Global Warming Solutions Act of 2006, an environmental law, signed by former Governor Arnold Schwarzenegger on September 27 of that year. The bill established a timetable and the measures necessary to bring California closer to the goals of the Kyoto Protocol. This bill was the first approved legislation by any U.S. state to cap emissions across all economic sectors. California, where one out of eight Americans live, now requires major industrial producers to reduce emissions 25 percent by 2020. In other words, California has to cut its annual release of carbon dioxide by 174 million metric tons. The reductions are so significant that it would take a forest twice the size of New Jersey to process all those emissions (California Energy Commission 2008).

In order to achieve these goals, California has set a series of key strategies in six areas. The strategies are taken from the California's Climate Plan Fact Sheet (California Energy Commission, 2008). Visit http://www.climatechange.ca.gov/ to see complete versions of each strategy and learn more about California's climate plan.


**Santa Rosa CityBus uses diesel-electric hybrid buses.**

**Solar panels transform light energy into forms of energy we can use.**

**Cap-and-Trade Program.** By setting a limit on the quantity of greenhouse gases emitted, a well-designed **cap-and-trade** program will complement other measures in California. The program provides a firm cap on 85 percent of the state's greenhouse-gas emissions.

**Transportation.** California will reduce 30 percent of its vehicle greenhouse-gas emissions by 2016. By 2020, California will decrease by 10 percent carbon-intensive vehicle fuels through its low-carbon fuel standard. Other transportation measures include using more efficient delivery trucks, heavy-duty trucks, and goods movement.

**Electricity and Energy.** California continues to improve appliance and building standards. By 2020, a total of 33 percent of the energy used in the state will come from renewable sources. Other efforts include the following programs: Million Solar Roofs; Solar Hot Water Heating; Green Buildings; and water efficiency.

**High Global Warming Potential Gases.** In order to minimize gases that potentially influence global warming, the state is making an effort to capture high global-warming-potential gases already in use. California is also reducing future impact by encouraging the use of leak-resistant equipment, putting restrictions upon use of products that release these gases, and imposing additional fees.

A former industrial site is replanted with trees.

**Forestry.** California is making an effort to preserve forest sequestration by minimizing the cutting down of forested areas so the protected trees will continue to take up, or sequester, carbon dioxide from the atmosphere. Additionally, California is reducing atmospheric carbon dioxide by encouraging forestry projects in which new trees are planted.

**Agriculture.** The agriculture industry in California contributes to production of carbon-dioxide emissions, as well as the release of other GHGs. In order to reduce the impact of agriculture on climate change, California is promoting the use of more efficient agricultural equipment and by minimizing fuel and water use through transportation and energy measures.

**Changing Energy Portfolio.** In early 2011, the state of California voted to increase its Renewable Portfolio Standard (RPS) to 33 percent by 2020. This legislation means that renewable energies must comprise 33 percent of utility companies' retail sales by that time.

## Explore More

Cool California is a great resource created as part of the efforts under the Global Warming Solutions Act. This website, created through a partnership between government, universities, and nongovernmental organizations, offers a toolkit for schools, as well as success stories that can inspire your students to act in their school and community (California Air Resources Board 2010). Examples include:

- The city of San Diego reduced its GHG emissions by 3,814,000 tons between 1999 and 2003. Between 2003 and 2010, the city had a target to reduce an additional 5,488,000 tons to accomplish its goal (California Air Resources Board). Explore more at http://www.coolcalifornia.org/case-study/city-of-san-diego.
- Solar capacity in the city of Santa Monica has doubled since the launch of its solar program (Solar Santa Monica). To date, there are 139 grid-connected solar projects in the city, representing 926 kilowatts of solar capacity. Explore more at www.coolcalifornia.org/case-study/sustainable-santa-monica.
- In 2001, Marin County became the first local government to calculate its ecological footprint. Marin County has set a target to reduce GHG emissions 15—20 percent below 1990 levels by the year 2020 for internal government and 15 percent countywide. Explore more at www.coolcalifornia.org/case-study/reducing-residents-ecological-footprint.
- Reforest California is a million-tree challenge to help raise funds to replant trees in Southern California State Parks that have been impacted by wildfires (The Coca Cola Company 2009). Explore more at www.reforestcalifornia.com.

# Case Study: Is Cap-and-Trade in Our Future?

To slow global warming, people will need to emit fewer greenhouse gases. Many scientists agree that to avoid "dangerous" climate change by about 2050, the world would have to cut greenhouse-gas emissions to a small fraction of what they are today (Stern 2009).

Use of renewable energy from wind turbines and solar panels is growing, as are energy-efficiency measures in homes and in more efficient cars. Nonetheless, greenhouse-gas emissions have continued to rise decade after decade, reaching an all-time high in 2010 (IEA 2011).

To try to ensure that people will quickly cut back greenhouse-gas emissions, one of the most popular approaches has been to build programs known as "cap-and-trade." These programs include a legal limit on the amount of greenhouse gases people are allowed to emit in a year—that is the "cap." Over decades, this cap could be continually lowered, so that eventually people would be emitting only very small amounts of greenhouse gases. Such a cap on emissions is similar to limits on fishing that governments have in place, that allows people to catch a certain amount of fish each year.

Under a cap-and-trade system, governments issue permits that allow businesses or individuals to release a certain amount of greenhouse gases into the air each year. To help make it easier for people to adjust to the emissions cap, then they are allowed to trade these permits between each other—that is the "trade" part of "cap-and-trade."

Some industries will probably find it easier to cut their emissions than others. For example, there are many ways of producing clean energy, using wind and solar energies instead of fossil fuels are two ways. Other industries—such as transportation and agriculture—may find it harder to cut their emissions. As a result some industries may have to cut their emissions to near-zero, so that other industries may emit more greenhouse gases (Stern 2009).

Under a trading system, then businesses or individuals that have leftover permitted emissions can sell what is left of their permits to others who have run out. The permits could be traded within countries and between countries. This trade in permits is meant to make it cheaper for people to cut greenhouse-gas emissions. It also gives people an incentive to cut their emissions more than required, because they can sell any leftover permits. Finally, it also allows people to choose how to cut emissions—for example, they could either cut how much energy they use, or they could use cleaner energy (Stern 2009).

Cap-and-trade has worked for cutting some kinds of pollution. The first such market was for sulfur-dioxide emissions, which come primarily from coal-burning power plants and which can cause acid rain and smog. Starting in the United States in 1990, the cap-and-trade system has been successful at cutting sulfur-dioxide emissions at a relatively low cost (Coniff 2009).

Today there is no one cap on greenhouse-gas emissions worldwide, but some countries have created cap-and-trade systems to fight global warming. The first such system—and still the world's largest—is in the European Union (European Commission 2010). Another cap-and-trade system was created by the Kyoto Protocol, an international agreement forged through the United Nations, which put caps on emissions from the richer countries that signed the agreement and allows countries around the world to trade emissions permits. California's Global Warming Solutions Act of 2006 also established a cap-and-trade system that went into effect in 2012 (California Air Resources Board).

There are other approaches to cut greenhouse-gas emissions, such as a simple tax on emissions or an encouragement of cleaner or more efficient technologies. If countries take further action to fight global warming, they are likely to use various combinations of these three approaches (Stern 2009).

## Energy Innovations

**"So we stimulate 100,000 innovators in 100,000 garages, trying 100,000 things; 1,000 of which will be promising, 100 of which will be way cool… and two of which will be the next green Google and green Microsoft."**
*Thomas L. Friedman*

Our current rate of development requires immense amounts of energy. For more than a century—since the Industrial Revolution—we have turned primarily to fossil fuels to obtain the energy we need. We have studied in previous chapters the social and environmental impacts of our dependence upon fossil fuels for our energy needs. Foreign-oil dependency has brought political and social instability around the world and along with coal—the primary source of electricity in the United States—has considerably increased the amount of greenhouse gases we put into the atmosphere. We know there are alternatives to fossil fuels—cleaner, more sustainable alternatives. Cheaper? Maybe not, at least not in the short term. But when we look at the long term and take into account the environmental and sociopolitical costs of harvesting and burning oil and coal, it can start to make more economic sense. But, how do we make the big turn to these energy innovations? Do your students think this is going to be an easy or difficult process? Do they have any ideas on how we are going to make this switch? One way is to reconsider energy portfolios, making adjustments each year toward more renewable energies.

According to the U.S. Department of Energy's Energy Efficiency and Renewable Energy Program, a **Renewable Portfolio Standard** (RPS) is "a state policy that requires electricity providers to obtain a minimum percentage of their power from renewable energy resources by a certain date" (U.S. Department of Energy 2009). By 2009, 24 states plus the District of Columbia had in place RPS policies, accounting for more than half of the electricity use in the United States. Nonetheless, the state average for renewable energies is less than 20 percent, with only Maine and California pledging for a goal of more than a third of their energy to be from renewable resources. The earliest deadlines to achieve the targeted goals are for Vermont and New York State in 2013. The latest is California in 2030 (U.S. Department of Energy 2009).

The Department of Energy website developed an interactive map of the United States, showcasing the different RPS programs by state. You can consult the map by visiting the following link: http://apps1.eere.energy.gov/states/maps/renewable_portfolio_states.cfm. Show this map to your students and start a discussion on the various RPS's by state. What do the percentages on the map refer to? Is one state more dedicated to increasing renewable energy resources than others? How can you tell? Find the state where you live on the map and discuss that particular RPS.

One piece of the energy-solution puzzle involves more investment in developing the innovative ideas and technologies that can move us toward renewable energies. We need solar power, but also a cheaper, more efficient way to harvest solar energy, with minimal environmental impact. We need hydropower that incorporates lower impact techniques that take into consideration the watershed and its inhabitants. We need nuclear power, but also a safe way to dispose of nuclear waste. In the following pages, we will review some of the most promising energy innovations and their potential as the next best thing for our energy future. Students often classify these energy resources as either "good" or "bad," but the issues are much more complicated than that. For each, we consider the benefits and trade-offs, because no one solution is the right solution for everyone and every place.

**Workers install solar panels in California. These panels use photovoltaics.**

**Wind.** Perhaps one of the most environmentally friendly sources of electricity, wind is a virtually never-ending source of kinetic energy. Wind energy occurs when different surfaces of Earth absorb heat from the sun at different rates, generating a variation in temperature in different portions of the atmosphere. When this happens, hot air rises, atmospheric pressure at Earth's surface is reduced, and cool air is pulled down to replace it. The result is air movement, or wind. The kinetic energy generated by the movement of air mass is harvested and transformed into electricity through the use of a turbine. Turbines rotate when wind flows over their blades, which moves the electric generator inside the turbine to generate the electricity.

**The Altamont Pass wind farm was commissioned in 1981 in response to energy crises in the 1970s. Since that time, wind technologies have advanced greatly. The turbines at Altamont Pass are being upgraded to reduce impacts on local wildlife.**

Some estimates predict that we could supply close to 20 percent of our electricity using wind energy (American Wind Energy Association 2010). Wind energy is considered to have the lowest external costs when compared other renewable sources (European Commission 2003). Electricity generated through the harvesting of wind power emits no greenhouse gases. The only carbon footprint generated is during the production of parts and assembly and during the transportation and installation of the windmills. Various studies have calculated that the energy invested in this process is paid back within a few months to a year (Lenzen and Munksgaard 2002).

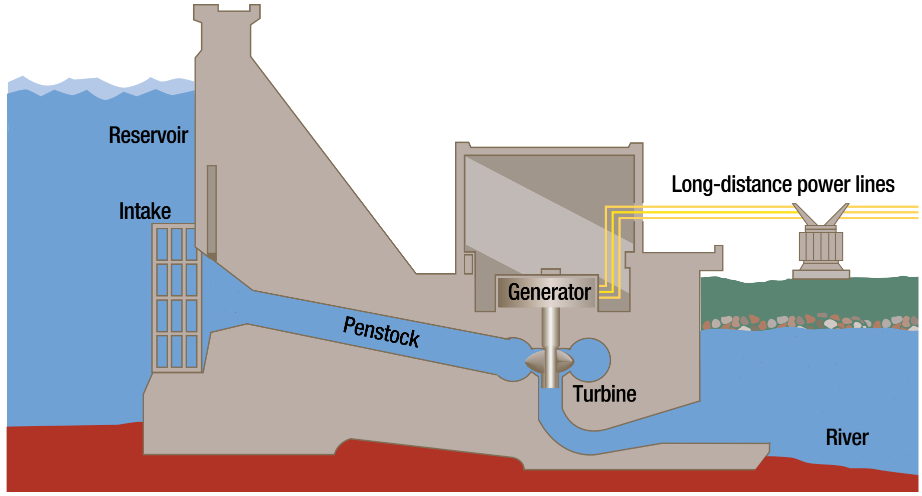
Perhaps the most important environmental impact of wind power is bird and bat mortality caused by wind turbines. A study conducted in Pennsylvania and West Virginia in 2004 by Bat Conservation International reported more than 2,200 fatalities by 63 turbines in a six-week period (Arnett et al. 2005). Risk varies by species of bat and migration period. Bat fatalities caused by wind turbines can be reduced by two-thirds with simple-but-consistent practices. Two of the most effective practices include stopping or slowing wind-farm operations during times of high bat activity, such as low wind conditions (Arnett et al. 2009), and placing microwave transmitters on the wind turbines, to deter bats (Aron 2009).

Interestingly, wind turbines kill relatively few birds when compared to other human practices. Would you believe that feral and domestic cats actually kill hundreds of millions of birds each year compared to only 10,000–40,000 killed by turbines? The power lines running from power plants are actually more of a concern, killing millions of birds annually. Yet, bird carcasses are often found in wind farms such as the Altamont Pass wind farm in California. But the Altamont Pass wind farm is not the usual story for most wind farms. This farm was built in the middle of a migratory bird route and used an older design that attracted birds. Most new turbines move slower because they have larger blades, and most new farms are built taking into account migratory routes. Newer turbine designs at this facility are significantly reducing the bird mortality observed in the past. Needless to say, wind energy is part of our future—it's an energy resource that is just too clean and reliable to pass up!

**Hydroelectric.** It is largest source of renewable-based electricity (World Energy Outlook 2010). Hydroelectric power uses the kinetic energy from flowing water to rotate a turbine, which in turn moves a generator that produces electricity. The rate of electricity generated by a hydroelectric plant depends on the quantity of water flowing at any given time (also called the flow rate) and the height from which the water falls (also known as the head), which directly relate to the pressure behind that water. The most common type of hydroelectric plant is a "high head" and generally uses a dam to store water at a higher elevation. In contrast, low-head plants use a fall only a few meters high. The benefit of low-head hydropower technology is that it can expand the opportunity to produce electricity from smaller waterways, such as washes, creeks, and irrigation canals (The Environmental Education Exchange 2004).

Hydroelectric power produces virtually no waste or pollution, but it does have other environmental impacts. The development of large-scale hydropower plants in the United States has declined in recent years because of environmental problems such as altered river flow and water quality, restriction of fish passage, and damage to upstream environments caused by inundation. Nonetheless, countries such as China continue to develop dams as a solution to their increasing need for electricity. Natural river systems are modified by the construction and operation of hydroelectric dams, and this affects fish and wildlife populations. The flooded area upstream affects the habitat condition for fish, because the bottom of the lake is much colder and oxygen levels are much lower than that in the flowing parts of the river. Species of fish adapted to survive in a flowing river cannot adapt to the changes fast enough, and entire populations tend to disappear over time. At the same time, some of these dams hold the water for long periods and release it all at once. This causes sudden floods downstream, erosion, and other impacts to the ecosystem and the water supply for human use.

Two of the most-affected fish populations are the salmon and steelhead trout of the Northwest, which depend on healthy river systems to reproduce successfully. Dams work as physical barriers, preventing fish from moving upstream to spawn and downstream to reach the ocean. Populations of salmon and steelhead trout have drastically decreased in the Northwest because of the extensive series of damns on major rivers such as the Columbia River (Environmental Protection Agency 2007). Many hydroelectric dams have now constructed fish ladders to assist salmon in returning upstream. Fish ladders create an alternative path around a dam that mimics the natural rapids a fish may normally navigate.



**Water from the reservoir rushes through the penstock into the powerhouse. The water spins the turbine, which drives the generator. Inside the generator is a large electromagnet that spins within a coil of wire, producing electricity (see http://www.tva.com/news/downloads.htm#diagrams).**

All this said about hydropower, many students actually do not realize the role of dams in energy generation. Students often believe that dams help to store water so that it's ready for use or that dams actually clean water to make it safe for drinking. For students, dams are related to water and not necessarily to energy, so showing students how dams work can change this perception. After you show the students how dams work, consider a discussion on the pros and cons of hydroelectric power. For older students, this may turn into a well-planned debate on both sides of the issue (consider having students do more research first).

**Nuclear Energy.** Nuclear, or atomic, energy is **potential energy** stored in the nucleus of an atom, and it is what holds the particles of the nucleus together. Inside the sun, nuclear energy is released when the nuclei of light atoms, such as hydrogen, join together to form heavier nuclei. Human-generated nuclear energy is released through fission, or the splitting of uranium atoms. This happens at a nuclear power plant, where initiating a fission chain-reaction in enriched uranium fuel rods inside reactors produces electricity. The heat released by the fission process is used to create steam, which rotates a turbine to activate a generator that produces the electricity.

Nuclear power is considered to be one potential power source for our energy future. It can supply millions of people with reliable power with virtually no greenhouse gas emissions. It can also be a reliable source of energy if other sources—wind, solar, or hydro—are not producing consistently. While it is presently very costly to construct and maintain a nuclear power plant, as the cost of fossil fuels rises, nuclear power may very well become an economically-competitive alternative.

Nuclear power plants have much lower emissions than fossil fuels and is comparable to many renewable choices. Some believe that nuclear power may be the most attainable choice for decreasing our dependence on foreign oil. When taken as a whole, nuclear power plants have few accidents as compared to the fossil-fuel industry. On the other hand, critics insist that nuclear power is dangerous and are worried about the radioactive waste generated by it. Another legitimate concern is accidents at nuclear power plants, which can result in radioactive materials leaking into the surrounding environment. For example, following a major earthquake and tsunami in 2011, radioactive materials contaminated areas near a Japanese power plant. They also argue that the main source of nuclear energy, uranium, is nonrenewable and will eventually be depleted. Nonetheless, 20 percent of the electricity produced in the United States comes from nuclear energy, and it is a reliable and clean source of energy that we depend upon.

Uranium, the chemical element used in nuclear energy, has to be extracted from underground and open-pit mines. Once extracted, the uranium ore is processed into a concentrated fuel through a process known as uranium enrichment. This process produces radioactive waste, which must be safely stored. The United States produces about 2,000 metric tons of radioactive waste per year, which is stored at the same nuclear plants that generate it, or sometimes at a designated disposal site. Although radioactivity decreases over time, all radioactive waste remains active for thousands of years. The areas where radioactive waste is stored can be contaminated, affecting the water and land with toxic by-products (Environmental Protection Agency 2008).

Unfortunately, most students view nuclear energy as negative, often because of its association with explosions, bombs, and toxic wastes. It is important to show students that nuclear energy is actually a viable energy option but that we still need to work on solutions for nuclear safety and waste disposal.

**Biofuels.** Biofuels are a form of bioenergy, which is energy made available from biomass. Biomass is any material from biological sources, including solid waste, animal waste, and plant matter such as trees, grasses, and agricultural crops. **Biogas,** such as methane, is the gas from the decomposition of organic matter, and is also considered a biofuel.

In some cases, biofuels offer a great way to reuse or take advantage of energy sources that were going to be wasted otherwise. Through bioenergy technology, waste and manure can be converted into fuel for transportation and power generation. One example of this is the methane gas that is generated as a by-product of **anaerobic decomposition** in a landfill. The methane generated is a powerful greenhouse gas. By trapping it and burning it to generate electricity, we are taking advantage of this resource. This way, we reduce the need for fossil fuels and lower the emission of methane into the atmosphere. Another example of reusing biomass to generate power is the use of waste vegetable oil (cooking oil from restaurants and households) to power converted diesel engines. This is different from biodiesel, which is also produced from the same source, but requires additional chemical processing. In general, burning biofuels emits fewer particulates than other energy sources.

On the other end, some biofuels use primary resources, such as crops, to generate a usable energy form. Ethanol from corn is the most well known and also the most controversial, because Its production is energy intensive. Opponents argue that it takes just as much energy to create the fuel as the ethanol produces. Current research by the National Renewable Energy Laboratory (2010) is concentrated in developing a technology to produce ethanol from cellulose, a form of carbohydrate that is not fit for human consumption but that is high in energy content. This would resolve part of the conflict generated by growing food crops for energy use. Furthermore, many scientists are investigating high-yield, but low-water-intensive crops—those that do not require large amounts of water to grow, such as switchgrass, as alternatives to growing corn or sugarcane for biofuel.

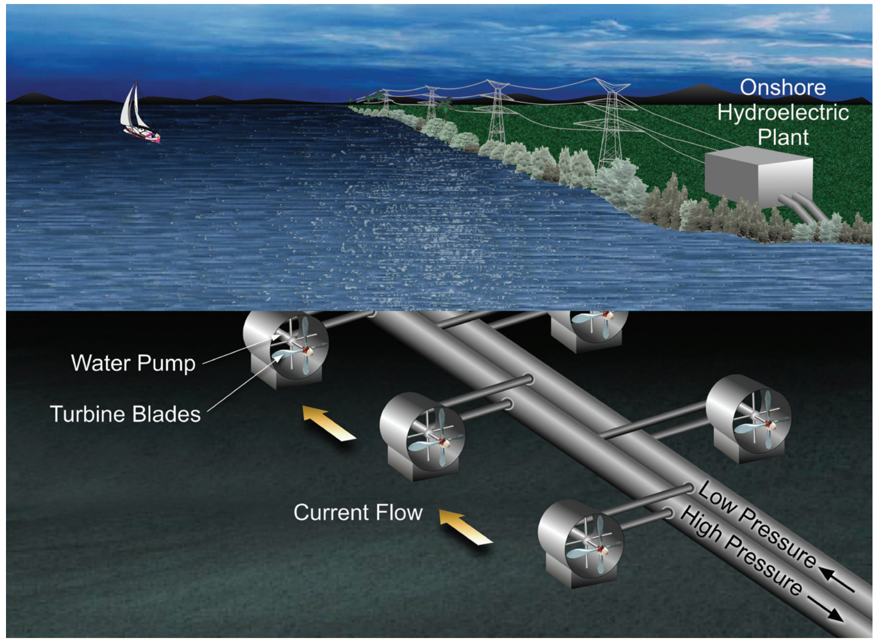
Some consider biofuels to be carbon-neutral sources of energy because the carbon released from using biofuels was originally taken in by the plants. However, the process of cultivating the plants and processing the fuels actually requires energy, which often comes from fossil-fuel-based power. In addition, creating bioenergy tends to be water-intensive, and there are concerns about food crops being diverted to fuel production, causing rising food prices that may leave people in some areas hungry. (The Environmental Education Exchange 2004).

Note that students may initially think that biofuels are good because they are plants. Plants are often viewed as 'good,' but when asked the question, "Is cutting down forests to grow biofuels okay?" students then reconsider the situation. Students still see burning plants as cleaner than burning fossil fuels, but they are ready to weigh other environmental impacts and trade-offs of biofuels to develop a more complete understanding of this energy option.

**Ocean Energy.** Wave and tidal power are two ways to harness the energy from the constant movement of the ocean. Neither of these technologies has been widely developed nor tested, but studies show potential because of their possibly low environmental impact. Wave power is the kinetic energy transported by ocean surface waves. There have been several attempts at developing commercial wave farms in the last few years; none of them have been widely successful. For example, in 2008, a British company created the Aguçadoura Wave Park off the shores of Portugal. The project intended to generate electricity for more than 1,500 homes but was cancelled after technical failure of the equipment just a few months later (Jha 2008). Ocean wave technology, because it is so young, is still under study. Companies are currently testing different designs to see which are most effective, and there is great promise that our ocean may be a viable energy source in our future.

Tidal power comes from the kinetic energy produced by the rise and fall of sea levels, and it is compared to wind energy in its reliability to generate electricity for prolonged periods. Just like with wind power, tidal power can be harvested through the use of turbines connected to an electrical generator. Another harvesting method for tidal power uses barrages, or dams, across the width of an estuary. Like clockwork, these systems would generate very predictable energy. Scientists are also looking at turbine systems that could take advantage of known ocean currents.

The downside of ocean energy sources—tidal, wave, or current—is the limited availability of sites that would be productive, as well as the high cost of generating electricity from them. Like all new technologies, ocean energy technologies are very expensive. Additionally, there is some concern that ocean energy systems may impact marine life, especially when built in known migratory routes. For example, currents are frequented by marine organisms for the same reason that we would build turbines in those locations—reliable, moving water.




**The movement of water causes the underwater turbine blades to rotate, which send high-pressured fluid to turn turbines in an onshore hydroelectric power plant.**

The ocean can also be a location for offshore wind and solar energy. With all these ocean energies, students may be concerned that water and energy don't mix. They learned from an early age that water is dangerous around electricity, so may question how we get electricity from objects sitting in water. It is important to reassure students that this type of energy is safe.

## Teaching Tip

Many of the energy innovations presented in this chapter might seem foreign to students. To make their learning significant, invite students to explore which of these are feasible in your region, state, city, community, and school. Start by having them research online and in the school's library more about the requirements for each of these innovations and then compare them to the features in your community. Pose a list of questions to guide their inquiry process:

- What type of renewable sources of energy do we have in abundance?
- Which of these innovations makes more sense in our community?
- What would be the cost of incorporating them?
- What would be the benefits?

For younger students, have them journal about the top three energy sources they think are best for their community. For older students, consider having students draft their own energy plan, using the research they found online as well as information they learned during class discussion.

Case Study

# Solar Energy

Adapted from *Powering Our Future: Renewable Energy Education* (The Environmental Education Exchange 2004)

The sun is the ultimate source of energy on Earth. The sun drives water cycling and wind and weather patterns and is the source of energy for all life on Earth. This means that solar energy is the ultimate source of many other energy sources on Earth, including fossil fuels, biomass, and wind. Of course, the term *solar energy* is commonly used to refer to the forms of energy that we obtain more directly from the sun. Sunlight, also called solar radiation, is the most inexhaustible, renewable source of energy known to humankind. The amount of energy that the sun radiates onto Earth every hour is greater than the amount of energy used worldwide in a full year.

In general, the ways we use the sun's energy can be described as passive or active. **Passive solar energy** involves using the sun's energy with no or minimal mechanical or electrical devices. Passive solar energy can involve using the sun's energy as a light or a heat source. Lighting buildings with natural light is called daylighting. Passive applications of solar thermal energy, or the heat energy of the sun, include heating water and buildings. Using passive solar techniques for heating is very efficient. Heat energy is considered low-quality energy. Electricity, for instance, is a high-quality energy because it is very concentrated. When electricity is converted to another form, heat, a low-quality energy, is given off. Using electric heat, for instance, is inefficient. You are using a high-quality energy source for a low-quality need. A lot of energy is "wasted." Passive thermal systems prevent this type of waste. This is because the energy is used in the same form (heat) rather than converted from one form to another.

**Active solar energy** is any type of solar application that uses electrical and/or mechanical equipment. Solar thermal power plants are an example of active solar thermal application. At such plants, sometimes called "power towers," the sun's rays are concentrated as a heat source to boil water or another fluid, producing steam. The steam is used to rotate a turbine, activating a generator that produces electricity. This is very different from photovoltaic energy.

**British Motor Car Distributors in San Francisco, California, installed solar panels on their carports to supply the dealership with enough power to meet its daily energy needs.**

Photovoltaic, or PV, energy is a form of active solar power that is created when light energy from the sun is converted on an atomic level directly into electrical energy. Photovoltaic technology actually produces electricity with no moving parts and without burning fuel. PV technology is based on an interesting fact of physics and chemistry that light energy can stimulate an electrical current in certain materials or semiconductors.

The basic building block of all photovoltaic systems is the photovoltaic cell. The PV cell is where the energy conversion process takes place. Although other materials can be used, today almost all photovoltaic cells are made of a very thin wafer of crystalline silicon. Silicon is the second most-abundant element in Earth's crust (the first being oxygen). The photovoltaic effect occurs when sunlight strikes silicon (or certain other semiconductors) and the light energy is absorbed, energizing electrons so that they become free from their atoms and move through the material. A PV cell is designed to enhance this natural process. By connecting the cell to a circuit along which the electrons can flow, we can harness the electricity and put it to use.

**More than 3,300 solar panels have been erected on a vacant five acres at NASA's Kennedy Space Center in Florida to create the Solar Energy Center.**

Sunlight is comprised of a range of wavelengths. It is light energy, per se, that causes the photovoltaic effect. The heat energy in sunlight is central to solar thermal applications, like passive solar buildings and water heaters, but plays no role whatsoever in photovoltaics.

The performance of a PV cell is measured in terms of its efficiency at converting light energy into electricity. Some types of PV cells available today reach efficiencies of about 15 percent. *Efficiency* refers to the amount of energy that is actually obtained from a process, as much energy is lost as heat when it is converted into electricity or other forms. As per the laws of physics, no conversion of energy can be 100 percent efficient. For comparison, use of fossil fuels to create electricity is about 30 percent efficient; that is, 70 percent of the energy is lost during conversion and transport.

Photovoltaic power has proven extremely reliable. A photovoltaic array has no mechanical (or moving) parts, and PV equipment can operate reliably for long periods with virtually no maintenance. No fuel or input is required other than sunlight. Because sunlight is free, there are no fuel costs (and no unpredictable variations in fuel costs over time). The cost of a PV system is almost entirely paid up front for equipment and installation, and operating costs are quite minimal. Developing PV plants, however, can be very expensive.

Producing PV cells does result in some pollution. However, in contrast to electricity generated by conventional energy sources, photovoltaic electricity does not involve the release of greenhouse gases and other air pollutants, production of toxic or radioactive waste, large PV projects can cover thousands of acres, which disrupts the natural ecosystem. The downside of using photovoltaic power is the high cost of the technology and the habitat loss when solar plants are built in pristine habitats. Of course, solar units cannot generate power at night and are less efficient during cloudy weather. Also the storage of energy from PV plants can be a challenge. Although solar panels are expensive, the price of PVs is decreasing and will continue to do so as the technology improves and more homes and businesses purchase it.

# Student Thinking

# Renewable Resources

Often, students are introduced to renewable energy resources as a “no harm” energy alternative to traditional fossil fuels such as oil, coal, and natural gas. While students are interested in learning about renewable energy, they often have misconceptions that may hinder their understanding of these resources. They may also be confused about how to determine whether an energy source is renewable or not.

| | Common Student Ideas | Scientific Concepts |
|---|---|---|
| **Impact on environment** | Renewable energy resources have no negative impacts on the environment. | In general, renewable energy resources emit fewer particulates and less carbon dioxide than fossil-fuel burning. Renewable resources still have negative effects on the environment. For instance, building any power plant disrupts ecosystems and can endanger wildlife. |
| **Biofuels** | It is only the heat produced by burning biomass that can be used for energy (such as burning firewood). | There are several different types of biofuels. Burning biomass is often used for heating and cooking. Biogas is produced when organic matter decomposes, such as in a landfill, and can be used to produce electricity. Some biofuels are produced from crops, which can be energy- and water-intensive and may cause food prices to rise. |
| **Efficiency** | Renewable energy resources are 100 percent efficient. | There are no energy resources that are 100 percent efficient. In fact, some renewable energy resources, such as solar power from PV cells (see **Case Study: Solar Energy,** page 116), are less efficient than fossil fuels. |
| **Nuclear energy** | Nuclear energy is renewable because it is considered a “clean” form of energy. | Nuclear energy emits virtually no greenhouse gases, so it is often lumped together with renewable resources. However, there is a finite amount of uranium on the planet, and therefore, it is not renewable. Additionally, nuclear waste disposal and potentially lethal accidents are concerns. |

## Ask Your Students

1. What kind of impact do renewable energy resources have on the environment?
2. How is biomass such as wood, agricultural crops, and so on, used to create energy? Are there any drawbacks to using biofuels?
3. How efficient are renewable energy resources?
4. Is nuclear energy renewable?

## Taking Action

The most effective way to make learning about energy significant is to discuss actions that are reasonable solutions for individual people, families, schools, and the local community. Students will often ask themselves, "What can I do about this?" The answer is that every individual, even our youth, can do a lot to help with energy solutions. There are many ways students can help with energy conservation at school or at home. Using energy wisely makes a lot of sense—even to young citizens. Two important strategies for taking action include energy conservation and energy efficiency, both of which can reduce energy use while simultaneously reducing a home's or school's cost for energy.

## What Can You and Your Family Do?

**Reduce Obvious Energy Use.** The first step is a simple one: turn off lights, even if they are energy-efficient bulbs. With just the flip of a switch, energy conservation is at everyone's fingertips. Use compact-florescent lightbulbs because they use roughly 75 percent less energy than incandescent bulbs and last up to 10 times longer. LED lightbulbs are more costly but even more efficient than CFL bulbs. In winter and summer months, adjust the thermostat just a few degrees. A large portion of home energy use goes to heating and cooling. In the winter, lowering the thermostat by as little as 1°F can reduce a heating bill by three percent. On milder days, such as in spring and fall, open windows instead of using air conditioning.

**Reduce Hidden Energy Use.** Turn off and/or unplug electrical appliances when they are not being used. Electronics use energy even when turned off. This is called "phantom power" because it's a hidden energy drainer. Using a power or surge strip with an on/off switch can make turning power off fairly easy. In some locations, weatherizing one's home is an important energy-efficiency strategy. Extra weather stripping around doors and windows reduces air leaking through the cracks. Also, conserving water conserves energy. It takes energy to move water into our homes and industries. Turning off faucets and using less water means conserving energy indirectly.

**Upgrade.** Investigate your appliances and more energy-efficient alternatives. When upgrading appliances, look at Energy Star appliances (http://www.energystar.gov/), which have better energy-efficiency ratings. This is particularly important for furnaces, hot water heaters, and refrigerators. In fact, the refrigerator is the biggest energy consumer in a home—improving its efficiency can mean both big savings and much better home energy efficiency.

**Reduce Transportation Costs.** Monitor your daily driving habits and consider replacing one day of driving with public transportation, carpooling, bike riding, or walking. Also, consider reducing the transportation (and fuel) costs for the food you purchase. When appropriate, choose food products that are locally grown and appropriate to your climate. For example, citrus fruits such oranges and grapefruits are grown in the mild climate of southern California. Choose these local products when in season rather than those from Florida or South America.

**Changing lightbulbs to energy-efficient bulbs can reduce energy use and save on electricity bills. A CFL bulb uses only 14 watts of energy compared to 60-watt or higher incandescent bulbs.**

**Simply turning off unused lights in your home is one of the easiest energy-conservation practices everyone can do.**

**Dryers use a lot of energy that could be conserved if people used the sun's energy to dry their clothes instead.**

## What Can Your Classroom and School Do?

**Create an Energy Challenge.** Develop a program at school to reduce energy use. Have each classroom develop an energy plan, and then monitor the school's energy use across the year. The energy plans might include reminding students to turn off lights when not in use, replacing school lightbulbs with energy-efficient alternatives, and adjusting classroom temperatures a few degrees to reduce energy use.

**Develop a List of Local Sustainable Vendors.** Have your students develop a list of vendors—shops, restaurants, grocery stores, and markets—that carry locally-grown or locally-made products or companies that have programs to conserve energy. Once your class has created a list, consider asking these vendors to visit your classroom to talk about what they are doing to reduce their use of energy or to make energy more efficient.

**Let Your Voice Be Heard.** Investigate ways to get involved in the community or the community issues being discussed. As a class, weigh-in on the issues. Write a class letter to your local newspaper, create a blog, or make a video about what's important to your classroom. As adults, we can sign petitions, vote for political leaders that promise to act, and contact our local and state representatives, but students can also let their voices be heard by contacting their representatives and informing them of the importance of energy conservation.

## What Can Your Community Do?

**Learn About Local Incentives.** Communities (and states) may offer incentives or subsidies for installation of alternative energy sources, such as solar or wind.

### Teaching Tip

Have your students make a pledge for one action they will take to conserve energy or become more efficient. Have students share their action with the class, justifying their choice with scientific evidence or explanation. As students share their pledges, maintain a class list. Make sure to follow up with students after several weeks' time to see how effectively they followed through on their pledge and to discuss any difficulties they encountered.

**Support Public Transportation.** Advocate for public transportation in your community, as well as well-developed and safe bike trails. If these systems are in place, make sure to support them by riding the public transportation system when possible and biking to work or for fun with family and friends. Also, support your community in replacing government and public automobiles with fuel-efficient or hybrid alternatives.

**Get Connected.** Know your community's energy plan. What are the important goals, and how can you support these in happening? Get connected to local parks, businesses, and community groups so that you can be part of the programs happening in your local community. Become aware of these options and learn about what partnerships might be appropriate for your students or for other community groups.


**Public transportation, such as subways and buses, are one way to reduce energy used on transportation.**

## In the Classroom

# Measuring Your Energy Use

Auditing energy use is an important step for identifying actions for conservation. In this activity, students will audit their home energy use—lightbulbs, appliances, thermostat temperatures, and so on, to determine where they believe their highest energy use is and what they can do about it.

## Materials

- Use an online energy meter or audit such as http://environment.nationalgeographic.com/environment/energy/great-energy-challenge/personal-energy-meter/ or print an energy audit questionnaire for students to complete at home. Even if using an online energy audit, students will need a worksheet that includes information about home energy use. See Your Energy Audit worksheet at http://www.pbs.org/wgbh/nova/teachers/activities/3519_energy.html for an example.

## Directions

1. For more information prior to starting the lesson, please review http://www.eia.doe.gov/kids/energy.cfm?page=us_energy_homes-basics.
2. Explain or review the concepts of energy efficiency and energy conservation.
3. Engage in a discussion about their energy sources. Ask students, “Do you know where the energy you use every day comes from?”
4. Show the class several electricity-bill samples, and ask students to brainstorm what things they do at home that contribute to the bill.
5. Depending upon whether students are doing an online energy audit, give the class a worksheet to gather information about home energy use. Have students complete these worksheets overnight. Make sure students record number and types of lightbulbs, thermostat settings, and so on. If possible, students can also ask parents if they have a record of monthly energy use. If using an online audit, give students time to enter their information into the online program.
6. Start a class discussion about students’ findings. Have students share their findings about what uses the most energy in their households. Are they already doing something that is right?
7. After all students have shared, discuss with them how the energy audit has helped them think about their own energy use. Have students design a plan to increase energy conservation and efficiency. As students develop these plans, generate a class lists of some of the most common actions that students can take.

## Discuss

1. What was something that surprised you during your energy audit? Why was this surprising?
2. What patterns exist across all of our energy audits?
3. What is the number one solution that will reduce your energy use? Why do you feel this is the best solution for your home?

# Case Study: The Energy-Water Nexus

Two of the biggest challenges of the 21st century include meeting the energy and water needs of an ever-growing population. These two critical resources are inextricably linked. All energy produced with fossil fuels and nuclear energy uses water. Our water distribution and treatment system also requires a great deal of energy. The connection between these two resources is known as the energy-water nexus. Our lives would not be the same without abundant supplies of both.

**Energy Needs Water.** Generating electricity requires water. In fact, electricity generation is one of the largest industries to withdraw freshwater resources (irrigated agriculture also withdraws a significant amount of water). Electricity that comes from fossil fuel or nuclear power plants requires up to 190,000 million gallons of water per day. That's equivalent to filling almost 300,000 Olympic-sized swimming pools per day! Electricity generation accounts for up to 39 percent of the freshwater taken from the environment. Consider this: Coal, the most common fossil fuel used for electricity generation, requires 25 gallons of water to generate a kWh (kilowatt-hour) of power. With every flip of a switch, U.S. citizens indirectly use water when they use energy.

**Water Needs Energy.** Our water system also requires a great amount of energy for treating and transporting water. The energy used accounts for close to 75 percent of the financial cost of water. Actually, up to 4 percent of the electricity generated for our power grid goes to our water supply-and-distribution system. In some states such as California, this amount is even higher (up to 5 percent) because California pumps water across long distances and over mountains, using a vast aqueduct system. Other factors that affect the amount of energy needed include 1) depth at which groundwater is pumped; 2) distance from surface waters that are used; and 3) the quality of the water before treatment. For example, groundwater pumped from low depths (e.g., 120 feet) that is fairly clean requires minimal energy, while groundwater that is brackish and pumped from deeper underground (e.g., 500 feet or more) can be energy-intensive to access and treat.

As the population continues to grow, demands for both of these resources will increase. As water resources become harder to access, we will have to pump from greater depths and transport water across longer distances, as well as use more energy to treat water. All of this will affect the cost of water for consumers, and the amount of energy required. Everyone will have to cut back on water use, including our energy industry. The capacity of some power plants may be affected if they cannot get the water they need. This means that consumers may be affected by how much their local power plants can supply.

As a consumer, one might ask what can be done. Obviously, conserving both water and energy is a key to solving shortages of these critical resources. A study in California found that activities at home, such as heating water, washing clothes, and using clothes dryers, use 14 percent of the electricity consumed by people. All three of these activities have alternatives that allow people to conserve both water and energy. Consider hanging clothes on a clothesline, adjusting settings on hot water heaters to 120 degrees F, and only washing clothes when necessary, using full loads and cool water.

For more information, read about the Energy-Water Nexus at http://www.sandia.gov/energy-water/.

Pictures of Practice

# Conserving Water, Conserving Energy

When you ask students about conserving energy, they may mention actions such as turning off lights, turning off electronics, and driving less. Students are less aware of complex energy relationships, such as the relationship between energy and water use. In order to pump clean water into homes and businesses, we require energy for pumping and processing. The water-energy nexus, as it is called, is a term used to describe how our use of water is intimately connected to our use of energy. Conserving one—water—is also conserving the other—energy.


**Students: Grades 4 and 5**

**Location: San Diego, California (working class community)**

**Goal of Video: The purpose of watching this video is to hear students make connections between water and energy use.**

## Classroom Context

Ms. Howard addresses energy concepts with her elementary students across several grade levels. The lesson on energy conservation occurred at the end of her energy unit and at the very last discussion of the day. Ms. Howard asks her students to describe ways they could conserve energy.

## Video Analysis

Ms. Howard asks students what they can do about energy today. Henry mentions that people can conserve energy, and Ms. Howard asks him what he means by conserve. Henry says "turning off the lights" or changing incandescent lightbulbs to CFL bulbs. But conserving energy is about more than turning off lightbulbs. Many of our actions use energy but in ways that may not seem apparent on the surface. Andrea immediately mentions that people can conserve water, and Ms. Howard asks her to elaborate. Andrea says you need electricity to pump the water. Rubysella adds to the idea of conserving water, and Ms. Howard draws comparisons between energy and water. Angel then mentions that water prices go higher and explains that prices go up to make people conserve water. In fact, energy costs may account for up to 80 percent of the costs on our water bills (Taylor, Philpot, & Ruppert 2009), so all three students share ideas that indicate they are starting to connect the two resources. Read more in **Case Study: Water-Energy Nexus,** page 122.

## Reflect

### How would you connect energy conservation with water conservation?

These students show they are making the connection between energy and water. Where would you go next with these students? What concepts should they know more about? If you were teaching energy conservation to your own students, how would you introduce students to water conservation and other "hidden" energy costs?

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## Teaching Resources

California Education and the Environment Initiative: http://www.calepa.ca.gov/education/eei/

U.S. Energy Information Administration resources: http://www.eia.doe.gov/kids/energy.cfm?page=3

National Geographic energy meter:
http://environment.nationalgeographic.com/environment/energy/great-energy-challenge/personal-energy-meter/

National Geographic energy diet:
http://environment.nationalgeographic.com/environment/energy/great-energy-challenge/energy-diet/

National Geographic energy conservation video:
http://video.nationalgeographic.com/video/player/environment/energy-environment/energy-conservation.html

National Geographic's Action Atlas: http://www.actionatlas.org/map

National Geographic's wind energy interactive:
http://environment.nationalgeographic.com/environment/global-warming/wind-power-interactive/

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