

ENVIRONMENTAL LITERACY TEACHER GUIDE SERIES

Energy Potential

A Guide for Teaching Energy in Grades 3 to 8



1

Energy Comes in Many Forms

by Ivan Salinas

Energy is responsible for the world as we know it. It runs our homes, our cars, our bodies, and is virtually changing forms every moment of every single day. The sun is our constant supply of energy, as solar radiation allows plants to grow, water to evaporate, and wind to move. Today, our human communities are so intimately tied to energy resources we could hardly imagine a world without them. What was life like just a few hundred years ago when most relied only on wood for fuel and a few luxuries of charcoal and wax? What was the world like just a few thousand years ago, when only the wood was available?

Energy resources have become the cornerstone of our society. Almost everything we do in our daily lives depends upon energy. Even the water we drink from our faucets and the plastic and glass containers used to store our leftover foods, require energy. While plant-based energy resources dominated the energy landscape just hundreds to thousands of years ago, we now have a myriad of energy options. The potential for our energy future is great. The time for discovering new and innovative energy technologies is now.

We talk about energy every day. Some people are said to spend energy in their work, to recover energy after a night's sleep, or to conserve energy by turning

off lights. The pros and cons of all energy sources, renewable and nonrenewable, are debated by politicians and citizens alike and are often the subject of discussion on news networks. But what does *energy* mean to scientists, the people who define and study energy?

This chapter takes a closer look at what *energy* means and how this meaning is similar and different from our everyday use of the word. Basic concepts of energy and energy forms are reviewed as well as the laws that govern the way energy flows through our world. Lastly, energy resources will be classified as renewable and nonrenewable, a common concept taught in schools. In fact, many of the basic concepts discussed in this chapter

GRADE	STANDARD	EEI UNIT
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receive repeated attention in our schools and, therefore, deserve special attention in any study of energy. These concepts are the foundation for additional study on energy resources in our human communities.

What Is Energy?

Think about a magazine that describes an artist as focusing her “creative energy” from one activity, such as painting, to another, such as a sculpture. This use of the word *energy* implies that energy is stored in a person’s mind. We commonly

refer to energy as something we have stored inside our bodies. We say, “I don’t have any more energy to finish this test,” or “I’ll have more energy tomorrow to finish my homework.” Such a view of energy depicts it as something we gain or lose. Think about all the meanings of the word *energy* that your students encounter in a single school day!

Saying that someone or something “has” energy is a metaphor. It is the everyday meaning we give to the word *energy*. This metaphor is particularly problematic for science, because while

scientists look at energy as a “capacity,” they do not describe energy as something that can be “shared,” “used,” “spent,” or “possessed.” A very important concept to remember is that energy is not created; rather, energy is just transformed, from one form to another. Our experiences of energy are simply us witnessing energy flowing from form to form, happening every day in almost everything we do.

When we describe energy in this way, it is different from the scientifically accepted definition, which says that *energy* is the “capacity of doing work” (*work* being defined as “the force exerted through a distance”). The science definition of *energy*, while sometimes easy for students to remember in science class, does not readily give meaning to their everyday experiences. Students must relearn everyday words such as *work*, *force*, and *energy*, for science class that do not match the way they commonly use these words outside of school. As a consequence, teaching the concept of energy can be a challenge for many teachers.

In the scientific definition of *energy*, there are four concepts that need to

CHAPTER OVERVIEW

Energy is a difficult concept to define but one that we experience every moment of every day. Energy comes in several basic forms, and most of our experiences of energy can point to one of these forms—movement, light, heat, electricity, and so on.

Energy forms can be classed into two basic types: kinetic or potential. Potential energy may be chemical energy or gravitational energy. Kinetic energy is the energy of motion, such as the movement of wind or water or a person running. One interesting form of energy is heat. Heat, while sometimes useful, is not a useable energy resource. Oftentimes heat is considered a waste product. In science we use several laws—laws of thermodynamics—to help us understand the dynamics of energy in our world.

In this chapter we review forms of energy and how energy transforms following laws of thermodynamics.

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Kicking a soccer ball is a change from potential energy to kinetic energy.

be clarified: energy, work, force, and distance (or position). Let's take a closer look at these concepts in an example. Think of a soccer ball standing on a field or a playground. If someone kicks the ball, the ball will move. The ball is no longer standing on the field, but rather moving through the air. Thus, the position of the ball is not the same before and after someone kicked it. The change in the position happened because a person exerted a force on the ball when kicking it. Even though the force was exerted over a small distance (the kick), it was enough to change the ball's position.

Kicking the soccer ball is actually a change in energy—a change from **potential energy to kinetic energy** in the kicker, then to kinetic energy of the ball moving. **Heat** was probably given off along the way.

Another illustration of energy can be seen when shopping in a supermarket and using a shopping cart. When you get to the supermarket, you grab a cart

and move it along the aisles while you shop. If it were not for you pushing the cart, the cart would not move. You exert a force on the cart so it changes its position. You have the capacity to do work. As an option for people with disabilities, supermarkets may have

electric carts, which do the same thing; they move along the aisles while a person shops. The difference is that the person is not exerting the force. The cart has an electric motor that has the capacity to do work.

In both of these examples, energy is changing forms. We call this energy transformation. While your students may remember the definition of *energy* in science class, *energy transformations* will be what helps students connect the scientific definition to their real-world experience.

Energy changing forms is so common that we can find these transformations anywhere at any time, including when reading these pages! There is an energy transformation in your brain that helps your eyes move to scan the pages. There may be a lamp that illuminates your environment, changing electrical energy into light and heat energy. When we start looking at events happening in the world through the lens of energy transformations, it becomes easier to help students find meaning and connections between energy in science class and energy in their world outside of school.

Teaching Tip

Help your students better understand the basics behind energy transformation by trying the following activity. Have each student put a pencil at the edge of his or her desk so it is not moving. Explain how the pencil is exhibiting one type of energy as it is not moving (potential). Next, have students push their pencils off their desks and onto the floor. Ask students if the type of energy has changed from when it was still. This moving pencil now exhibits kinetic energy. Also discuss the role of students prior to pushing the pencil off of the desk. Where do students get energy from? Students should respond that they get energy to do everyday activities from food they consume. Discuss with students how the energy changed, or transformed, from one type (potential) to another (kinetic) during this exercise.

Student Thinking

Explaining Energy

Numerous studies have looked at student ideas about energy. Educators know that students describe energy in countless ways, but that some interpretations of energy are more common than others. Following are a few examples of the most common conceptions about energy.

	Common Student Ideas	Scientific Concepts
Energy as an agent	Energy causes things to happen. It makes an activity happen and can be stored inside a person or an object.	Energy does not cause events to happen. However, when events happen such as a ball rolling down a hill, there is always a change of energy to another form.
Energy as an action	Energy is an action or activity like burning, bubbling, running, and bouncing.	Actions are visible experiences that energy is changing forms. Running, for example, is the change of chemical energy (food) into kinetic energy (movement).
Energy as an ingredient or a product	Energy is an ingredient to help plants grow, people move, and cars run.	At the beginning of a chemical reaction, energy starts in one form; however, during the reaction, energy changes into another form.
Energy as a technical appliance	Energy is <i>electricity</i> or something that relates to electrical appliances and power lines.	There are many different forms of energy and electrical energy is an example of one of these forms. Electrical energy is the form of energy that powers many of our appliances by causing positive and negative charges to move.
Energy as a property of life	Energy is useful for humans or other living things. For example, we need energy to grow and live. Only living things have energy, but dead things do not.	Sunlight is necessary to power plant photosynthesis . Chemical energy is necessary to power other metabolic processes. During these processes, we do not “use up” energy but rather change energy forms. For example humans change chemical energy (food) into kinetic energy (motion). All “things,” living and nonliving, have some energy associated with them.

Ask Your Students

- 1 What is the first word you think of when you hear *energy*?
- 2 How would you define *energy*? How does this compare to the way scientists define *energy*?
- 3 How are electricity and energy different?



The word *energy* has many different meanings to students. To some students, it means “power.” Other students may think energy means “movement,” and still other students equate energy with “electricity.” All of these meanings have legitimacy, but none of them match the way scientists define *energy*. Yet, unless students are given an opportunity to confront these differences, they likely will never see a reason to revise their understanding of energy. The following activity has students compare their own definition of energy to a scientific definition.

Materials

- Chalkboard, whiteboard, or chart paper
- Writing materials

Directions

- 1 Gather students into an arrangement for productive classroom discussion. Ask students the following question: “What does the word *energy* mean to you?” Ask students to participate in a minute-long partner share of their ideas.
- 2 After the partner share, have pairs share their ideas with the whole class. Record a list of meanings for the word *energy* that represent the diversity of ideas from all students. Have students also record this list in their notebooks.
- 3 Share with students the scientific definition for the word *energy*: “Energy is the capacity to do work. It cannot be created or destroyed, but it can change form. Energy comes in many forms, such as light, heat, kinetic, electrical, and chemical.” Spend time discussing each part of this definition and what students think it means.
- 4 Ask one student to come to the front of the classroom to act as a class recorder. Have students compare the scientific definition of *energy* to the original class list. Which meanings from the original list match the scientific definition? What revisions could be made? Are there any contradictory meanings on the class list? Have the class recorder make notes on the class list regarding any changes.
- 5 Have students complete a quick journal activity responding to the following question: “How have my ideas about energy changed? What did I think *energy* meant before the activity, and now what do I think *energy* means?”



Discuss

- 1 What do you think the difference is between the words *energy* and *electricity*?
- 2 Explain how a lightbulb lighting is an example of energy. How does this activity match the scientific definition of *energy*?
- 3 Explain how riding a bike is an example of energy. How does this activity match the scientific definition of *energy*?
- 4 If someone says, “water gives you energy,” do you think this is true? Why or why not?

Pictures of Practice



What Is Energy?

Classroom activities on energy are numerous and diverse. One of the most iconic activities to do with students is to complete a comparison of student definitions of *energy* with scientific definitions. Like many words in science, people commonly use the word *energy* outside of the classroom; thus, most students have developed a meaning for the word *energy* that does not match what science teachers say in their classrooms. You can imagine how ingrained these everyday meanings for *energy* are compared to scientific definitions that students encounter intermittently in their science classrooms. Developing a shared meaning of the word that is directly related to how students commonly talk about it is a necessary step prior to engaging in a larger unit on energy.

Classroom Context

Lynn Howard is an elementary school science teacher. She teaches science to most students at Encanto Elementary in San Diego, California. The benefit of her position is that she can develop her curriculum across several years of instruction, as opposed to teaching within a single given year. Thus, her students have experienced several lessons on energy in school years prior to fifth grade, and Ms. Howard knows what was taught and how she taught it. Most students have learned about simple circuits, conducted experiments with circuits, and learned about compact fluorescent lightbulbs (CFLs). However, students are still using everyday definitions of energy, and before starting the fifth-grade energy unit, Ms. Howard decided that the first lesson would focus on developing a shared definition and understanding of the concept.

Video Analysis

Ms. Howard conducts a classroom lesson similar to **In the Classroom: Defining Energy**. Students generate a list of ideas about energy and then compare those to a scientific definition. In science, *energy* means “the capacity to do work,” and energy is governed by a set of principles, or laws. Energy is not created or destroyed but instead transforms between many different forms. There is always a loss of heat during energy transformations. This is not considered a loss of energy, because the heat is actually released into space. In the video, you will see students describe their ideas about energy prior to the classroom activity. Their ideas focus on power and movement. The video then shows segments from a classroom activity in which students generate a class list of meanings for the word *energy* and then compare that list to scientific ideas about energy. At the end of the video, Ms. Howard shares that she believes students still lack a strong understanding of energy that is aligned to scientific definitions, but students definitely seem to make progress on what they know about energy.

Reflect

How would you teach the concept of energy?

Given that students bring incorrect ideas about energy to your class prior to instruction on the topic, how would you construct a set of lessons to directly address these incorrect ideas? What everyday misconception would you target, and how would you work with students to improve their understanding?



Students: Grade 5

Location: San Diego, California
(an urban school)

Goal of video: The purpose of watching this video is to hear student ideas about *energy* before and during a classroom activity defining *energy*.

Forms of Energy

A regular car cannot move without gasoline, an electric fan cannot work without electricity, and it is hard to move our bodies without food. Yet, there are some cars that do not use gasoline and fans that spin using the wind. The same is true for heating: There are electrical as well as gas heaters, and we can also heat our bodies by exposing them to sunlight or when covering our bodies with electric blankets. While each of these are sometimes trying to accomplish the same goals, they may be transforming energy in different ways. Helping students to see patterns in energy transformations is one step toward a better understanding.

For example, how is an electric fan more similar to a toaster than to a wind turbine? How is using gasoline in cars more similar to people eating food, than to the workings of an electric car? Sometimes these similarities and differences are not immediately obvious.

There are two overarching categories of energy that are common concepts taught in schools. These are kinetic energy and potential energy. Kinetic energy is the energy of movement. It is visible and easy for students to identify in many situations. When a yo-yo moves up and down, it is exhibiting kinetic energy. Potential energy is a form of “accumulated” energy that is transformed when an object can move. There are different sources of potential energy. Before the yo-yo is released from the hand, when it is still, it has potential energy.

Additionally, kinetic energy and potential energy have an interesting relationship. An object that is at the top of a mountain, such as a bicycle, has more possibilities of increasing its kinetic energy than the same object does at sea level. Scientists refer to the object on the mountaintop as having more potential gravitational energy than the object at sea level. The kinetic energy of



A wind turbine harnesses kinetic energy of wind into electrical energy, while an electric fan uses electrical energy to get kinetic energy in the air it blows.

an object becomes increasingly greater as the potential energy of the object diminishes.

Light Energy. The presence of light is what allows us to see things in our daily lives. Additionally, plants transform light from the sun into chemical energy in glucose. In doing this, a complex mechanism of energy absorption and storage works in the leaves of most plants. Theories about

the nature of light say that light is a phenomenon of particles and also a phenomenon of waves. If we consider light as particles (**photons**), we may think of these particles as “hitting” the plant leaves to move “things” inside the plant, in the same way objects could be used to move others by a physical contact (e.g., the balls on a billiard table). If we look at light from the perspective of waves, we might envision

Teaching Tip

Ask students to illustrate potential and kinetic energy using their own experiences. For example, students might draw a sled or skateboard at the top of a hill and then sliding down the hill. Students should indicate that the sled has more potential energy at the top of the hill, but more kinetic energy while in motion. As an alternative, ask students to spend a week journaling examples of any energy in their everyday life at school or at home. Have students compare their list to lists generated by classmates. Identify the most common experiences of energy that everyone in the class shares as well as interesting or unique examples that students brainstormed.



An incandescent lightbulb (left) uses more energy than other bulbs that produce the same amount of light. A light-emitting diode (LED) bulb (middle) is the most efficient bulb, but it is more expensive than the compact fluorescent lightbulb (CFL) shown on the right.

a wave starting at one end (the source) of a long slinky and traveling to the other end (the receptor of the wave). The energy is transferred from one side to the other by “traveling” through a medium, in this case the slinky. The sunlight ultimately drives metabolic processes in plants to help them build energy-rich glucose molecules.

Another iconic example of light energy happens in a lightbulb, which is a change of electrical energy running through the lightbulb into light energy and heat. Have you ever touched an incandescent lightbulb after it’s been on for a long time? These lightbulbs can become incredibly hot. New compact fluorescent lightbulbs (CFLs) are said to be energy efficient because less of the original electrical energy is lost as heat. These bulbs use less electrical energy to give off the same amount of light.

Chemical Energy. One type of potential energy is chemical energy. Humans and other living things use chemical energy stored in plants for different purposes. Recall that plants transform light energy from the sun to

make chemical energy found in glucose and other complex carbohydrates. When living things eat plants, they obtain the chemical energy. Animals eat plants and other animals in order to obtain energy for growing and moving. Energy is then transformed in an animal’s body from chemical energy in the food to motion, or kinetic energy. Also, chemical energy is transformed into heat in order to maintain our

bodies at a constant temperature, which averages 98.6° Fahrenheit.

Another example of chemical energy is that found in fuels. When we burn wood, which used to be part of a plant, energy is transformed from the chemical energy to heat and light energy. When ancient plants and animals were trapped underneath Earth’s surface, given enough time, pressure, and heat, the materials were transformed into **fossil fuels**, such as coal, oil, and natural gas. Like burning wood, burning fossil fuels changes chemical energy into heat, light, kinetic energy, or ultimately, into electrical energy in power plants.

Engineered devices, including **combustion** engines, are one way people have learned to use the energy in fossil fuels. For example, most of today’s vehicles use fossil fuel (gas or diesel) by mixing it with oxygen and having the fuel explode under controlled conditions that make vehicles move. During this chemical reaction, chemical energy changes to kinetic energy. In addition, heat energy is always a product of this process, which is why car engines become so hot after running for awhile. Some scientist consider heat from cars, or other lost heat, as waste because the energy “is lost,” or dissipated.

Wood has chemical energy that changes to light and heat when burned.



Electrical Energy. The easiest way to think about electrical energy is to think of electricity we use every day, whether we plug electric cords into power computers or hair dryers. Electrical energy is probably the most widely used form of energy in our societies today. One common mistake made by students is to equate energy with electricity. Be particularly attentive when you hear students talking about electrical energy to make sure they understand that this is just one of many forms of energy. *Electricity* is referred to as any flow of electrical power or charge.

The use of the word *electricity* comes from the Greek *elektron*, which means “materials that are ‘amber-like.’” The Greek people discovered that rubbing some fabrics over amber or glass had attractive and repulsive effects on some objects. Scientists now explain this as electrostatic phenomena, or **static electricity**. Students will be familiar with static electricity if they have ever felt a shock when touching something or someone. Static electricity occurs

when attractive forces are the result of interactions between different types of charge, whereas **repulsive forces** are interactions between charges of the same type. Rubbing two objects together causes charge exchange, and both the objects become charged with one of the two types of charges (positive or negative). The flow of charge goes from a positively charged object to a negatively charged object.

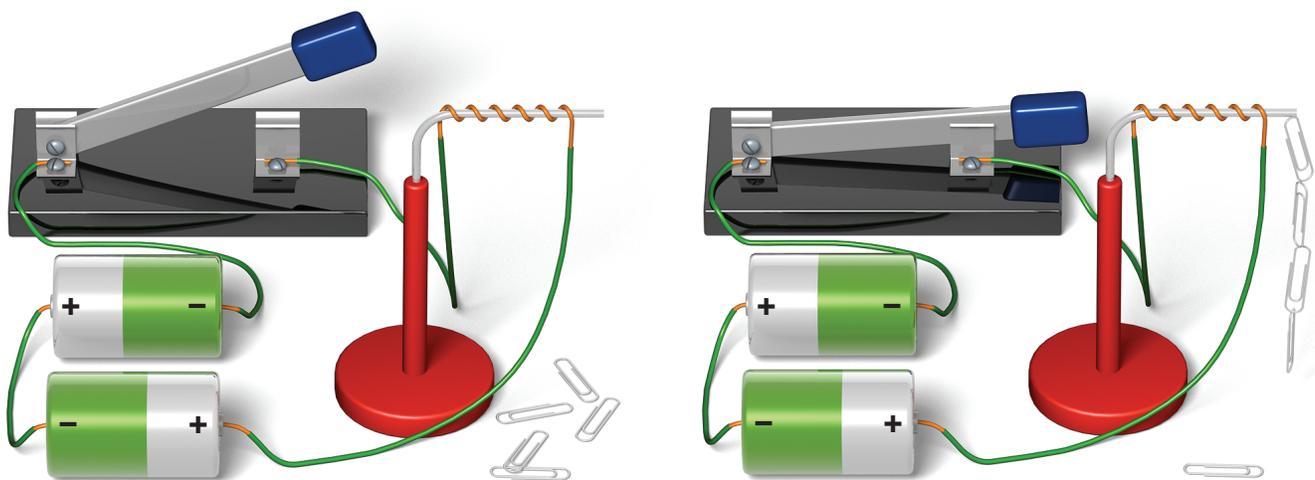
Electrical energy provokes the movement of charges. When that movement flows using engineered devices, we can transform this electrical energy into other kinetic forms, such as when we use appliances at home that move (e.g., fans), illuminate (lightbulbs), make sound (kinetic energy in radio speakers), or toast a slice of bread (heat energy in a toaster), just to name a few devices.

Scientists have discovered that various types of materials are able to facilitate the flow of electrical energy, while other materials are not good facilitators. Students likely know that metals allow

electrical energy to flow well, but that rubber (such as the rubber encircling a power cord) does not allow electricity to flow. Materials that facilitate electric flow are called **conductors**, whereas the ones that do not are called **insulators**. Electrical lines in our homes are metallic cables (conductors) covered with a rubber film (insulator).

Another important concept related to electrical energy is **electromagnets**. Scientists have discovered that magnets spinning inside a spiral made with an insulated conductor can create an electric flow. This is one of the principles that govern the construction of power plants. Different sources of energy can be used to make the magnets spin, such as chemical sources (coal or fossil fuels), gravitational potential sources (water falling in engineered dams), and nuclear energy, among others. These sources can be used to ultimately generate electrical energy for our homes using an electromagnet at the core of the power plant, which will be discussed in more detail in Chapter 2.

ELECTROMAGNETS



An electromagnet can be made using an iron or steel object (e.g., nail) and a coil of wire. This creates a magnetic field when electricity flows through the coil. Building electromagnets in class can be fun for students and help explain the concept in a hands-on way. See an example activity by the California Energy Commission at Energy Quest: <http://www.energyquest.ca.gov/projects/electromagnet.html>.

Nuclear Energy. Nuclear energy is one of the most mysterious forms of energy, as well as one of the most powerful sources. Students may believe nuclear energy is bad because they associated the word *nuclear* with nuclear weapons, bombs, or disasters. Yet, nuclear energy is an important form of energy we depend upon to meet our energy needs.

Nuclear energy is generated through the **nuclear fusion** or **nuclear fission** of atoms. Fusion involves combining atoms, while fission refers to the splitting of atoms. Atoms that have a heavy nucleus (more protons and neutrons) present are said to be **radioactive**.

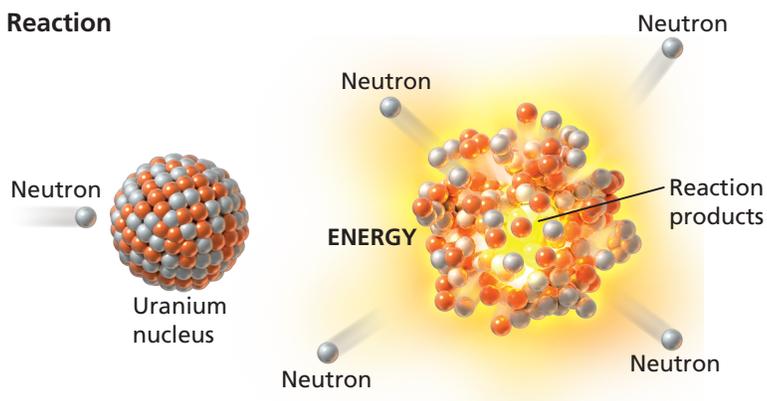
A radioactive atomic nucleus, or a radioactive substance, emits different forms of **radiation**, which are beams of high-energy that can have charged particles as well as neutral ones and also energetic beams that are not particles but waves.

Scientists have found that heavier nuclei are more prone to becoming radioactive, especially when they are unstable. Nuclei are unstable because the number of protons and neutrons are in higher quantities than nonradioactive or stable elements. In “searching for stability,” a nucleus will emit a radiation wave or particle, changing the number of protons and neutrons until reaching a quantity that characterizes stability. The concentration of unstable radioactive atoms can trigger a powerful reaction that releases huge amounts of energy. In controlled facilities, the energy released by radioactive nuclei can be transformed into electrical energy, which is what occurs in nuclear power plants. In uncontrolled settings, atomic energy can have disastrous consequences.

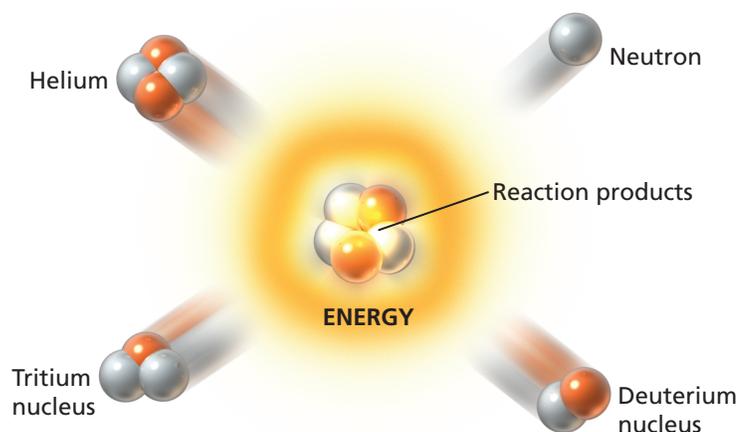
Nuclear radiation phenomena are not just related to heavy nuclei. Small nuclei can collide to form more heavy ones, also releasing radiation, or nuclear energy. That can happen when nuclei

FISSION AND FUSION

Fission Reaction



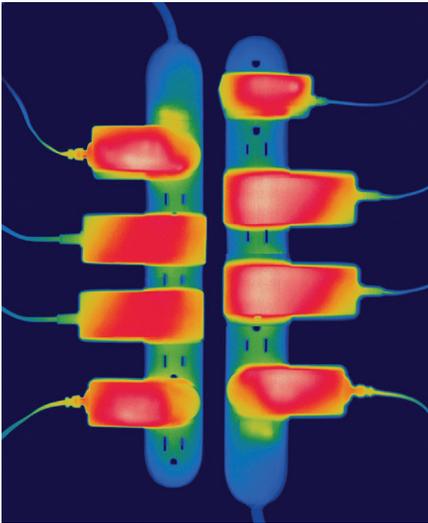
Fusion Reaction



Nuclear fission is the splitting of atoms, while nuclear fusion is the combining of atoms. In a controlled facility, these reactions can produce great amounts of energy that we can harness for electricity production. However, once fission or fusion has occurred, the waste products from the reactions are radioactive and must be stored in a place that will minimize harmful radiation from these materials. Because of the by-products of nuclear reactions and the difficulty of storing waste materials, nuclear energy use is still debated.

have enough kinetic energy to collide. For example, the sun is a host for those processes in which heat triggers the movement of small atoms, such as

hydrogen and helium, and their collision gives rise to radiation waves that travel in the form of light and heat to all places, including Earth's surface.



A thermal image shows plugs for hard drives and cell phones in a power strip giving off heat.

Heat Energy. We receive many forms of energy from the sun, a small percentage of which is within the visible spectrum and is what we typically refer to as light. When incoming visible light and infrared radiation interact with molecules in our atmosphere and the land surface, the radiation is absorbed and then gives off infrared radiation, also known as heat energy. It is this incoming and outgoing radiation that is responsible for heating our planet.

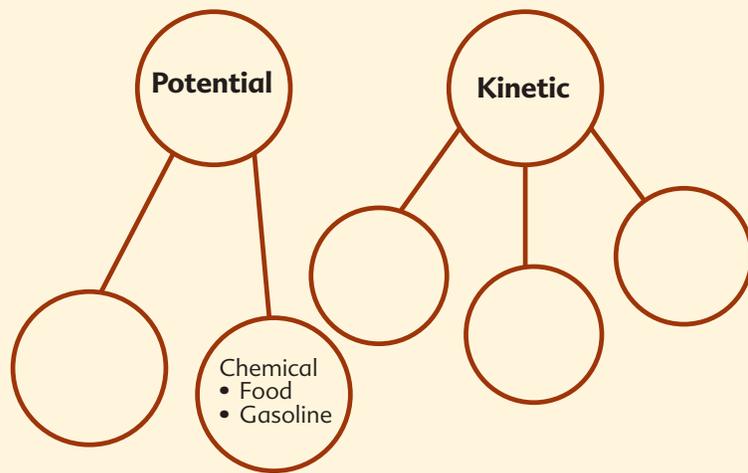
In our human systems today, heat energy is often considered a waste product, and energy engineers are looking for ways to reduce heat lost to make energy more efficient. The reason heat is considered a waste is because it is often an unusable form of energy that dissipates and is eventually lost into space.

Thermodynamics

Energy simply does not flow around our world in chaotic, unpredictable patterns. While energy is changing forms around us all the time, there are patterns in the way this happens. **Thermodynamics** is the name of the discipline that has come to govern much of what we know about energy and the physical sciences.

Teaching Tip

After you have finished discussing the various types of kinetic and potential energy, now may be a good time to have students place all of this information into a graphic organizer, such as a double-bubble map. Have students create their own organizer, starting out with two different bubbles, each that contains one type of energy, either potential or kinetic. Next, students will add bubbles below each type of energy that will include examples. You can also have students use a Venn diagram to show differences and similarities between the two types of energy. The following link provides a variety of different organizers or thinking maps: http://www.ascd.org/ASCD/images/publications/books/fisher2007_fig5.5.gif.



From this discipline comes the **laws of thermodynamics**. The first law of thermodynamics states that energy cannot be created or destroyed but can change forms. This law is also known as the conservation of energy principle.

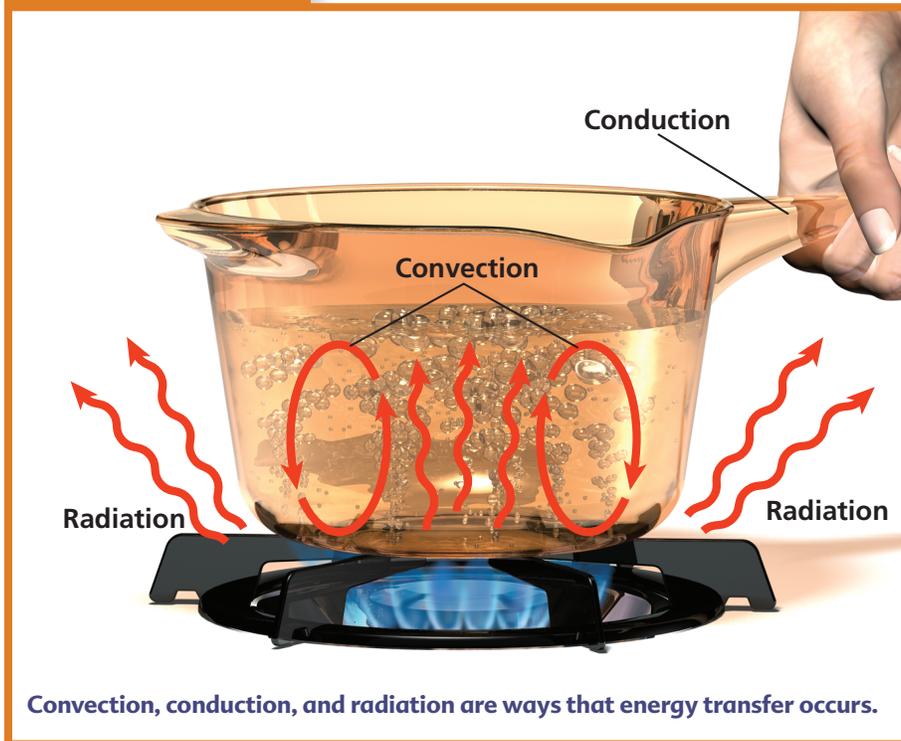
In addition to the principle of conservation of energy, there are additional laws that describe how energy flows. One of the laws is known as the zero law of thermodynamics. This law establishes that heat will always transfer from a body of high temperature to a body of lower relative temperature, until reaching the **thermodynamic equilibrium**, or the same temperature. As heat is energy, it is possible to say that energy transfers from hot bodies to cooler bodies. This

energy transfer happens through three different mechanisms: **conduction**, **convection**, and radiation.

Conduction. When a body conducts heat, it requires direct contact. For example, if a person with warm hands rubs the cold hands of another person, the cold hands will be warmed. Warm body heat is transferred to colder body heat. Another common example is when someone touches the hot metal handle of a pot on a stove. The heat from the pot is transferred to the person's hand, burning it.

Convection. In convection, heat is transferred within a fluid, such as a liquid or gas, by the motion of its molecules. The light of a flame is also an example of convection, in which most

ENERGY TRANSFER



of the heat is directed to the top of the flame and provokes the motion of air. Another example is placing a pinwheel over the flame, and the pinwheel starts to spin because of the movement of air around the flame. A liquid convection example would be a pot of water heated by placing it over a flame. The water molecules move from the warmer bottom of the pot toward the top, where the water is relatively cooler.

Radiation. Finally, radiation is another form of heat transfer. In radiation, hot and cooler bodies do not need to be in contact for heat to be transferred. **Electromagnetic waves** (infrared spectrum) are released from the body of highest temperature into the surroundings in all directions. An example of radiation is the heat we receive when sitting next to a fire in a fireplace. We are not in contact with the fireplace, but we still warm up through radiation of heat.

These three forms of energy transfer (conduction, convection, and radiation) occur mostly at the same time, and it is

difficult to isolate them from each other. Thus, when heating water in a pot on an electric stove, there is conduction from the stovetop to the metal pot, convection in the water receiving heat from the heated metal and the air receiving heat from the whole system,

and radiation is also present all around the pot.

Another law of thermodynamics that governs energy states that in any energy transformation, the total amount of energy being transformed into useful forms (e.g., kinetic, chemical, light, and so on) will not equal the original energy input because heat will always be released. For example, a lightbulb connected to a power line will transform electrical energy into light energy, but heat will be released and “lost” during this process. So the electrical energy made available to the lightbulb turns into both light energy and heat. As mentioned before, efficient lightbulbs are ones that reduce the amount of heat lost, so less electricity is needed to get the same amount of light energy.

When heat is given off it does not mean that energy is destroyed. Energy is simply lost into space in a form of energy that we can no longer use. Energy is always conserved, but this is why we use the common saying in schools, “Matter cycles, while energy flows” because ultimately all energy turns to heat and dissipates out into space.

Teaching Tip

Have students “experience” conduction for themselves by taking them outside the classroom on a warm day when the sun is shining brightly. When you are outside, first have the student press the palm of their hand against their cheek to notice the temperature. Next, have students place one of their palms against a surface, such as a school wall or pavement, that receives direct heat from the sun. Keep the palms on this surface until they start to feel warmer, and then remove them. Finally, place the palm against the cheek again and notice the difference in temperature from before the hand was placed against the warm surface.

Questions to ask your students after this activity:

1. How does the temperature of your palm compare with the first time you touched your cheek?
2. What process is taking place to warm your palm?



**In the
Classroom**

Watching Energy Flow

Energy changes all around us. Almost everything we experience, from reading a page to walking in the school hallway to turning on a light, involves energy changing forms. Training students to be more observant about these forms of energy provides a new lens for students to see energy in their everyday life. This involves teaching students about different forms of energy and then identifying everyday energy transformation. The following activity uses everyday energy transformations to demonstrate these changes (adapted from Environmental Literacy Project materials).

Materials

- Notebooks
- Labels
- Crank flashlight or radio
- Solar powered model car

Directions

- 1 Prior to the lesson, identify at least 8 to 10 energy transformations in your own classroom. These might be a lightbulb, overhead projector, computer, fan, plant, class pet, lighter or candle, and so on.
- 2 Label each object with a number to represent a “station.” If possible, add a crank flashlight and/or solar-powered model car to the list of stations to visit. These objects are fun for students to play with and also represent interesting examples of energy transformations.
- 3 Prepare a worksheet for students or have students use their science notebooks when they visit each station. If students use their notebooks, have students label the page with the number of stations and construct simple diagrams like the one shown in number 5.
- 4 In groups of two or three, have students visit each station to record the energy transformation. Ask students to discuss each situation and make note of areas in which they disagree.
- 5 When students visit a station, they should record the energy input and output for the station. Students can use the following diagram as one way to record their ideas.



- 6 After students visit each station, conduct a whole-class discussion in which students share their results.
- 7 In almost every situation, heat should be an energy output. After the class has generated a class list of results, ask students if they notice a pattern. Circle all the “heat” outputs. With older students this is an opportunity to connect to energy laws or other energy concepts, such as energy pyramids.

Discuss

- 1 Can you think of other instances in your everyday life that show energy transformations?
- 2 How do energy transformations show that energy is not created or destroyed? Thinking back to each station, do any of these situations show energy being created or destroyed?

Confusing Energy Concepts

Energy is an abstract concept that in everyday language becomes confused with other ideas. The meanings given to words in everyday speech are the product of social exchanges. Common ideas about certain words can be problematic for students learning science, a subject in which certain terms, such as *energy* or *evolution*, have very specific definitions. The following table contrasts some conceptions that are problematic as students understand the scientific concept of energy.

	Common Student Ideas	Scientific Concepts
Water and air are sources of energy to living organisms.	Water and air provide energy for people and plants to stay alive.	Water and air do not “have” chemical energy. Organisms cannot use these materials to meet their energy needs, because water and air cannot be chemically changed to supply energy. Food has chemical energy that is transformed when people consume it. Water and air are necessities for life but not as an energy source.
Heat and temperature are the same thing.	Heat rises. Temperature is related to objects’ materials and is not measurable but is qualitatively expressed as hotness or coldness.	Temperature is measurable and gives information about the amount of internal energy a body has. Heat is a form of energy and can be sensed when there is a temperature difference between two bodies.
Energy is the same as power.	Appliances connected to electrical outlets, or bulbs connected to batteries, are connected to power lines.	Electricity is the manifested phenomenon of electrical energy. Power is the amount of energy that is transformed in a given amount of time. Appliances that use more power “spend” more energy in less time.
Energy can be replenished by resting.	People have energy to act on things, and when they get tired, they recover energies by resting.	Energy is transformed by people to move and to maintain a constant body temperature. To transform energy into usable forms, a potential source of energy is needed, which—in the case of animals and people—is given by chemical energy “stored” in food.
Energy cycles.	Energy cannot be created or destroyed, so it cycles on Earth between living things.	Matter cycles and energy flows. While energy cannot be destroyed, it does dissipate as heat and is lost into space. We cannot recapture that lost energy.

Ask Your Students

- 1 Why are these ideas so confusing to students? Can you think of some examples of ways in which erroneous ideas are perpetuated in everyday life?
- 2 What activities could you plan to help students see differences among the terms contrasted in the table?

Pictures of Practice



Making Sense of Nuclear Energy

Nuclear energy, especially fission and fusion reactions, are difficult to understand for people of any age but can be especially hard for students. The idea that microscopic atoms are either combined (fusion) or split (fission) to make energy sounds almost like science fiction. Nuclear energy may also be associated with the atomic bomb, nuclear wastes, and incidents such as the Chernobyl accident. These associations can leave students believing that nuclear energy is a negative energy solution. Discussing how nuclear energy is produced is essential for students to develop a more accurate and complete understanding of this energy resource.

Classroom Context

During the middle of Ms. Howard’s energy unit, students learn about **renewable** and **nonrenewable** resources. Prior to classifying energy resources into these categories, Ms. Howard has students identify the resources we get from Earth. One resource—nuclear energy—is discussed in some detail because students have a negative image of this energy resource.

Video Analysis

At the beginning of the video, two of Ms. Howard’s students reveal they do not know much about nuclear energy, although Martinez says he thinks that nuclear energy is bad because he has heard of nuclear waste. While nuclear waste is a critical issue to consider with nuclear energy, the United States has waste disposal procedures to protect people from radiation. Martinez’s ideas represent beliefs that a lot of students (and the general public) have toward nuclear energy. When the class discusses nuclear energy, Ms. Howard explains that uranium is used, and one student describes the process of splitting the atoms. During the discussion students liken this to an “explosion” or “atomic bomb,” and Ms. Howard corrects them by using the term chain reaction. As the discussion progresses, students share their ideas about words such as *radioactive* and talk about how people dispose of waste. In the end, Ezequiel explains that the uranium is radioactive and that it is often buried after use. This is the common way to store used uranium rods, because there is no safe way to destroy the product after it has been used. During the post interviews, Andrea admits that she still does not understand nuclear energy, while Ezequiel describes the idea of fission but visualizes the process as putting “the atom on a cutting board, and they (scientists) use special tools to get to the inside of the atom.” In reality, the process is much more complicated than that and cannot be seen with the naked eye. Scientists use other matter—neutrons—to split atoms, not tools or knives.

Reflect

How would you respond to student ideas about nuclear energy?

There are many misconceptions that can arise when students discuss nuclear energy. How would you respond to the ideas brought up in Ms. Howard’s class discussion and during the pre- and post interviews?



Students: Grades 4 and 5

Location: San Diego, California
(a coastal community)

Goal of Video: The purpose of watching this video is to listen to students’ ideas about nuclear energy.

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- Watts, D. M. "Some alternative views of energy." *Physics Education* 18 (1983): 213–217.

Teaching Resources

- California Education and the Environment Initiative: <http://www.calepa.ca.gov/education/eei/>
- Jason Project Infinite Potential curriculum: <http://www.jason.org/public/WhatIs/CurrOIPIndex.aspx>
- National Geographic My Wonderful World energy resources: http://www.mywonderfulworld.org/educators_welcome.html
- U.S. Department of Energy lesson plans: <http://www1.eere.energy.gov/education/lessonplans/>
- U.S. Energy Information Administration resources for kids: <http://www.eia.doe.gov/kids/index.cfm>
- U.S. Energy Information Administration energy laws for kids:
http://www.eia.doe.gov/kids/energy.cfm?page=about_laws_of_energy-basics
- NOAA's energy resources from the ocean: <http://oceanexplorer.noaa.gov/oceanos/edu/lessonplans/media/09oceansofenergy.pdf>

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