

# 57 The Conservation of Energy



**E**nergy is involved in everything that happens. We are aware of energy when it is released or absorbed. Examining the changes of energy in action has led to one of the most important scientific ideas central to all science disciplines.

**CHALLENGE**



What is the guiding principle behind the behavior of energy?



*Energy, light, and sound are released when fireworks explode.*

## MATERIALS



For each student

- 1 Student Sheet 53.1, “Anticipation Guide: Ideas About Energy,” from Activity 53, “Home Energy Use”
- 1 Student Sheet 57.1, “Three-Level Reading Guide: Conservation of Energy”

## READING

Use Student Sheet 57.1, “Three-Level Reading Guide: Conservation of Energy” to guide you through the following reading.

## ENERGY ACTION

### Releasing Energy, Absorbing Energy

From our everyday experiences, energy seems to us like it is something that people consume. It often appears that energy is “used up” when, actually, it has not disappeared. Instead, energy is transferred and/or transformed into another energy type. For example, the energy in the food we eat provides thermal energy for our bodies. Or the chemical energy in gasoline is released and transformed into the motion of the car. Everyday energy “consumptions” are really energy transformations in which energy is released.

Following energy as it is transferred and transformed shows us a chain of interactions that both release and absorb energy. Take oil, for example. Oil formed in the



*Oil was formed over millions of years deep inside the earth from decayed plants and animals. The plants and animals absorbed energy from other sources such as food and sunlight.*

ground over millions of years from the decay of dead plants and small animals. The energy in the plants originally came from sunlight, which the plants transformed into chemical energy through the process of photosynthesis. The energy in the animals came from the food they ate. When oil in a furnace burns, the chemical potential energy in the oil is released as thermal energy which we feel as warmth.

## The Law of Conservation of Energy

If you compared the amount of chemical potential energy of the oil in the furnace before it was burned to the amount of thermal energy coming out of the furnace, you would find they were different. There is less energy released from burning oil than there was chemical potential energy stored in it. What happened to the other energy? Not all of the chemical energy in the oil is transformed into thermal energy during the burning. Some was transformed into an energy type that's easy to overlook. In the case of the burner, a small amount of the chemical potential energy in the oil was transformed into light and some into sound, and some remained in the ash and was not released. Sometimes the "missing" energy from a process is called "lost energy." This lost energy has turned into another energy type that is not recognized or used. Sound and light may not be energy useful for heating in this example, but it must be considered part of the total energy released by the burning oil.

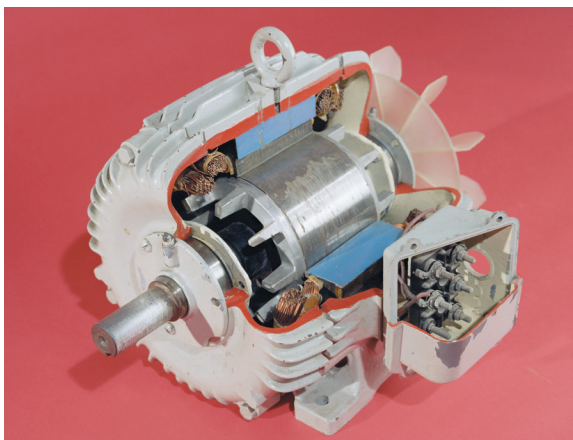
The total amount of energy in a system is the same before and after a transformation. Energy can be transferred or transformed, but cannot be lost or destroyed. This idea is known as the **Law of Conservation of Energy**. This means that the total amount of energy before something happens must be equal to the amount afterward, regardless of the process or energy types involved. The Law of Conservation of Energy doesn't say which kind of energy must be present before and after an event, just that the total energy doesn't change.

The Law of Conservation of Energy is one of the central principles in science and applies to many disciplines. For example, a biologist can apply this law when examining a food web. Biologists have tracked the amount of chemical energy in a producer, such as grass, through several consumers, such as a cow and a person. It appears that some of the chemical potential energy in all of the grass eaten by the cow is "lost" before the person drinks milk from the cow. However, a closer look reveals that this chemical energy was transformed into a variety of energy types, including the mechanical energy used by the cow to move around and the energy released by the cow's metabolism.

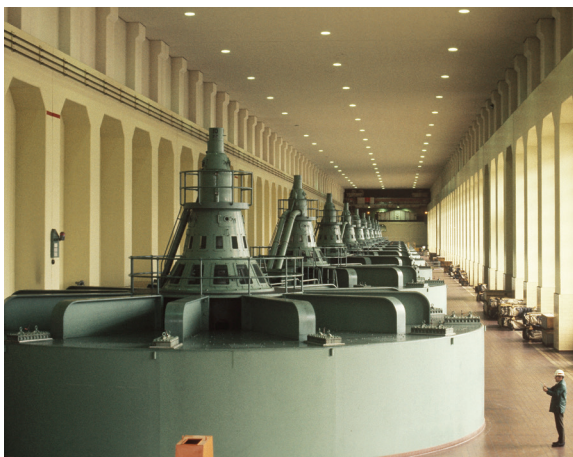
## The Process of Heating

Thermal energy is almost always released during an energy transformation. For example, a lightbulb transforms electrical energy into light, but the system loses energy by heating. A hot lightbulb is evidence of this. When you drive a nail into a block, the nail becomes warm, indicating that some of the mechanical energy hitting the nail was turned into thermal energy. The process of heating, although useful in many situations and critical to life, is not always desirable. With the lightbulb, usually the desirable energy type is light, not thermal energy.





*The interior of a motor.*



*Large generators at a hydroelectric power plant.*



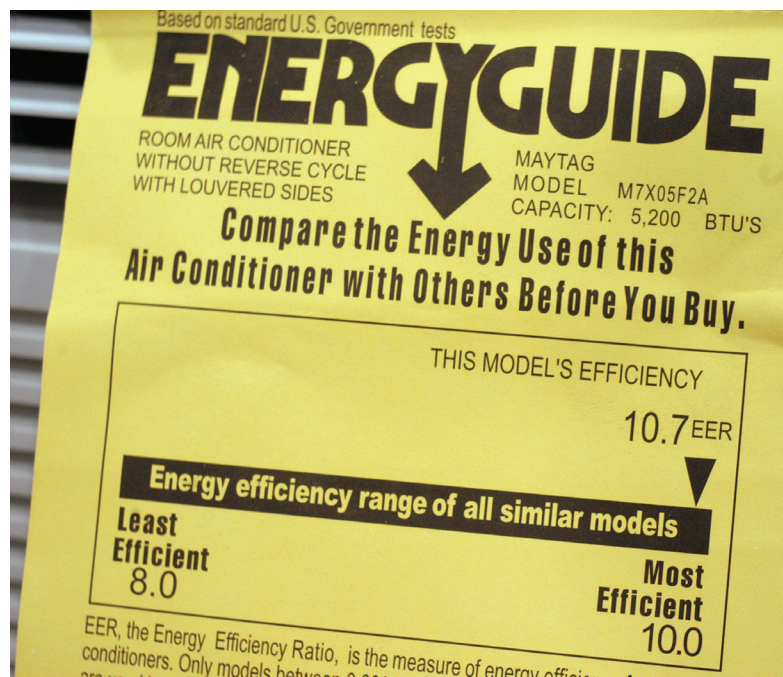
*A combustion engine is assembled.*

Thermal energy that is released during a transformation is not lost or destroyed but is dissipated, or spread out, which makes it hard to harness. Therefore, transforming thermal energy into other types of energy is more difficult than many other transformations. Even with the most innovative technology, only about 40% of thermal energy can be converted into useful mechanical energy. Similarly, it is difficult to convert thermal energy into chemical or electrical energy. Although many transformations release thermal energy, it can be a challenge to capture and use it.

### Energy Efficiency

No energy transformations result in 100% useful energy, and people who are concerned with energy evaluate energy transformations by efficiency. **Efficiency** is the ratio of useful energy that is released to the total energy absorbed by the process. For example, a car's engine transforms the chemical potential energy of gasoline into other types of energy. About 74% of the energy in the gasoline is released by heating, but only the remaining 26% is transformed into motion from the engine. Although no energy is created or destroyed, the engine's efficiency is only 26%, or the portion of useful energy that was released. Interestingly enough, since the engine has to overcome air, road, and transmission resistance, it turns out that only about 3% of the original chemical potential energy actually moves the car.

Appliances and other devices are rated by the government for their energy efficiency. When a certain model of an appliance is described as "energy efficient," it usually means that it uses less energy than comparable models that produce the same result. For example, a newer refrigerator that has an "Energy Star" consumes less energy than older models of refrigerators consume to cool the same volume of food at the same temperature. By consuming less energy to do the same work, an Energy Star appliance increases efficiency.

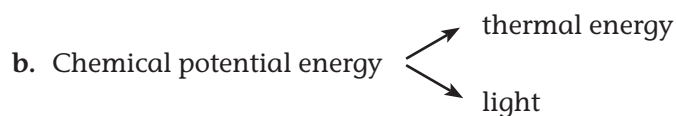


*New appliances come with a tag that provides an energy efficiency rating.*

An important idea that is related to efficiency is the term conservation. **Energy conservation** (not to be confused with the Law of Conservation of Energy) means to reduce, or “save,” the total energy transformed in the first place. For example, someone who turns out lights when not using them is conserving energy. Keeping a lightbulb off when not in use is related to conservation because it will use less energy, or conserve energy. Another way to conserve energy is to use an energy-efficient device that uses less energy when it is on. Using energy efficiently saves energy resources, reduces environmental pollutants, and reduces cost. For these reasons, learning how to convert energy more efficiently is a major goal of technology and engineering.

## ANALYSIS

- Which of the following diagrams accurately applies the Law of Conservation of Energy to a toaster in use? Explain your choice.



- Your friend tells you that a “generator makes electricity.” Do you agree or disagree with her statement? Explain why in terms of the Law of Conservation of Energy.



- Your friend says that when he measured how much electricity was provided by a battery, it was less than the potential energy in the battery. He concluded that the transformation violated the Law of Conservation of Energy. Do you agree? Explain, using the ideas of the Conservation of Energy.



- Which energy is often called the “graveyard of kinetic energy” and why?
- What is the efficiency of an engine that gives off 70% thermal energy?



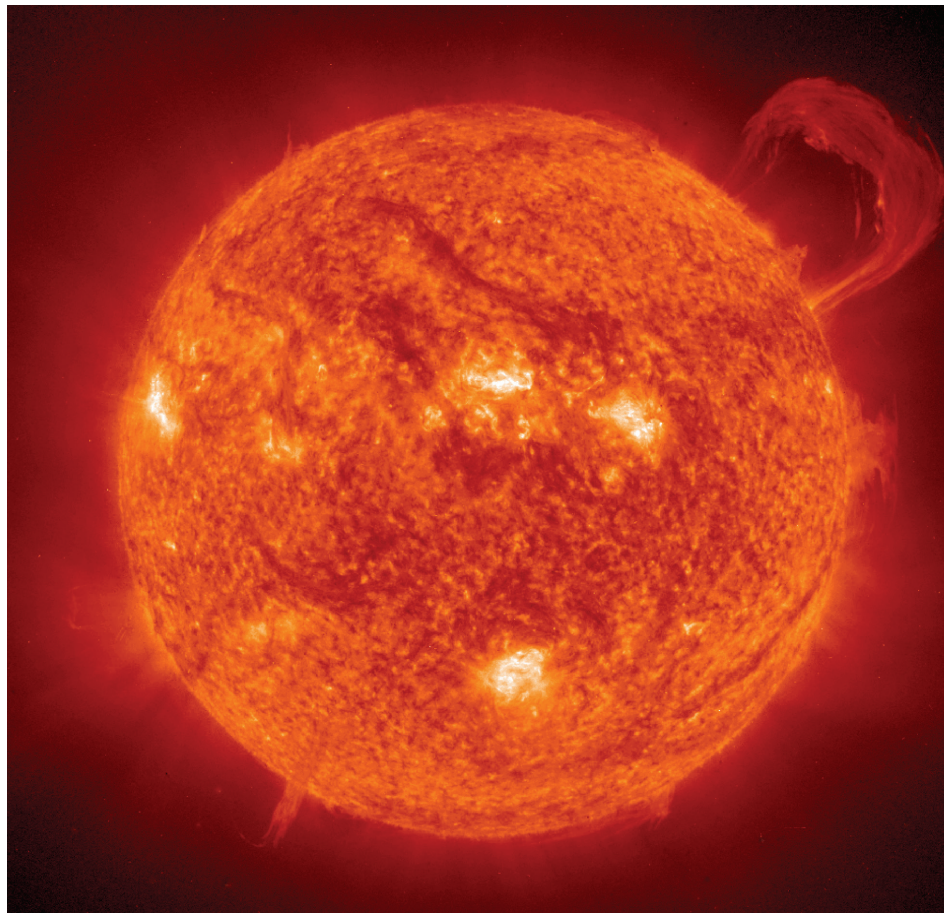
# 58 Follow the Energy



**S**ince energy is never created or destroyed, it is possible to follow energy transfer through many transformations. If you follow energy transformations far enough, you will find something interesting: most of the energy here on earth can be traced all the way back to the Sun. The Sun emits electromagnetic energy, or light, which is produced from nuclear reactions occurring in its center. When the Sun's energy reaches us here on Earth, it is transformed into many types of energy that sustain life.



**Can you follow the transforming energy?**



*Most of the energy found here on Earth can be traced all the way back to the Sun.*

## MATERIALS



*For each group of four students*

**8 Energy Event Cards**



*For each student*

**1 Student Sheet 58.1, “Follow the Energy”**

## PROCEDURE

1. Look at the table “A Summary of Energy Types” on the next page that describes different types of energy found in nature or human inventions.
2. With your group, examine the eight Energy Event Cards, and compare them to the table.
3. Chose an Energy Event Card, and identify all the energy types involved in the transformation shown. Use Student Sheet 58.1, “Follow the Energy,” to record the energy types before and after the transformation.
4. In the last column on Student Sheet 58.1, “Follow the Energy,” write a complete sentence or two that describes the energy transformation shown on the Energy Event Card. Include all the energy types you listed.
5. Repeat Steps 3–4 for the other seven Energy Event Cards.

## ANALYSIS

1. Copy the lists of words shown below.

**List 1:**

kinetic energy  
potential energy  
light  
sound

**List 2:**

chemical energy  
potential energy  
nuclear energy  
thermal energy

**List 3:**

fossil fuels  
stored energy  
chemical energy  
absorb energy  
release energy

- a. Look for a relationship among the words in each list. Cross out the word in each list that does not belong with the others.
- b. Circle the word in each list that is a category that includes the others.
- c. Explain how the word you circled relates to the other words in the list, and how the word you crossed out does not fit in the list.



A Summary of Energy Types				
Energy Type	Name	Depends on	Description	Example
Potential Energy	Chemical	Type of substance	Energy stored in the bonds of atoms	Energy stored in fossil fuels and food
	Elastic	Springiness of object	Energy stored by stretching or compressing	Energy stored in a stretched rubber band or compressed foam
	Electric (static)	Electron-charge buildup	Energy stored by the buildup of charges (electrons or ions)	Charge building up on person walking on a rug or combing fine hair
	Gravitational	Height and mass	Energy stored due to an object's mass and height	Energy stored due to the mass and position of a train on the top of a roller coaster or water at the top of a waterfall
	Nuclear	Stability of atom	Energy that is stored in the nucleus of atoms	Energy stored in uranium-238 atoms, energy stored in the nucleus of hydrogen atoms in the center of the Sun
Kinetic Energy	Electric (current)	Charge, conductivity	Movement of charge and energy from one place to another	Lightning, electricity through wires
	Light	Intensity and frequency	Energy transferred by the rapid movement of electromagnetic fields	Sunlight or X rays
	Motion (kinetic)	Mass, speed	Movement of an object from one place to another	Wind or a moving train
	Sound	Loudness	Energy transferred by the vibration of an object	Music in air or voices under water
	Thermal	Mass, material, and temperature	Energy transferred in transit from a hot to a cold object	Hot plate heating up water, or hot water cooling to room temperature

2. The diagram below shows the transfer of energy from the Sun all the way to a student using a computer. Using the table on the previous page, decide on the type of energy at each of the situations. There may be more than one energy type at each place.

