Introduction to Energy

What is Energy?

Energy does things for us. It moves cars along the road and boats on the water. It bakes a cake in the oven and keeps ice frozen in the freezer. It plays our favorite songs and lights our homes at night so that we can read good books. Energy helps our bodies grow and our minds think. Energy is a changing, doing, moving, working thing.

Energy is defined as the ability to produce change or do work, and that work can be divided into several main tasks we easily recognize:

- Energy produces light.
- Energy produces heat.
- Energy produces motion.
- Energy produces sound.
- Energy produces growth.
- Energy powers technology.

Energy at a Glance, 2009

	2008*	2009
World Population	6,682,639,000	6,776,917,000
U.S. Population	304,060,000	307,007,000
World Energy Production	491.66 Q	n/a
U.S. Energy Production	73.42 Q	72.97 Q
• Renewables	7.38 Q	7.76 Q
• Nonrenewables	66.04 Q	65.21 Q
World Energy Consumption	491.83 Q	n/a
U.S. Energy Consumption	99.29 Q	94.57 Q
• Renewables	7.37 Q	7.74 Q
• Nonrenewables	91.92 Q	86.83 Q

Q = Quad (1016 Btu) see Measuring Energy on page 10.

*The latest year for which final data for World and U.S. is available from EIA.

Note: 2009 data for World Energy Production and World Energy Consumption is not available at time of printing.

Forms of Energy

There are many forms of energy, but they all fall into two categories–potential or kinetic.

POTENTIAL ENERGY

Potential Energy is stored energy and the energy of position, or gravitational energy. There are several forms of potential energy, including:

- **Chemical Energy** is energy stored in the bonds of atoms and molecules. It is the energy that holds these particles together. Biomass, petroleum, natural gas, and propane are examples of stored chemical energy.

  During photosynthesis, sunlight gives plants the energy they need to build complex chemical compounds. When these compounds are later broken down, the stored chemical energy is released as heat, light, motion, and sound.

- **Stored Mechanical Energy** is energy stored in objects by the application of a force. Compressed springs and stretched rubber bands are examples of stored mechanical energy.

- **Nuclear Energy** is energy stored in the nucleus of an atom—the energy that holds the nucleus together. The energy can be released when the nuclei are combined or split apart. Nuclear power plants split the nuclei of uranium atoms in a process called **fission**. The sun combines the nuclei of hydrogen atoms into helium atoms in a process called **fusion**. In both fission and fusion, mass is converted into energy, according to Einstein's Theory, $E = mc^2$.

- **Gravitational Energy** is the energy of position or place. A rock resting at the top of a hill contains gravitational potential energy. Hydropower, such as water in a reservoir behind a dam, is an example of gravitational potential energy.

KINETIC ENERGY

Kinetic Energy is motion—the motion of waves, electrons, atoms, molecules, substances, and objects.

- **Electrical Energy** is the movement of electrons. Everything is made of tiny particles called atoms. Atoms are made of even smaller particles called electrons, protons, and neutrons. Applying a force can make some of the electrons move. Electrons moving through a wire are called **electricity**. Lightning is another example of electrical energy.

- **Radiant Energy** is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays, and radio waves. Light is one type of radiant energy. Solar energy is an example of radiant energy.

- **Thermal Energy**, or **heat**, is the internal energy in substances—the vibration and movement of atoms and molecules within substances. The faster molecules and atoms vibrate and move within substances, the more energy they possess and the hotter they become. Geothermal energy is an example of thermal energy.

- **Motion Energy** is the movement of objects and substances from one place to another. According to **Newton's Laws of Motion**, objects and substances move when a force is applied. Wind is an example of motion energy.

- **Sound Energy** is the movement of energy through substances in longitudinal (compression/rarefaction) waves. Sound is produced when a force causes an object or substance to vibrate. The energy is transferred through the substance in a wave.

Conservation of Energy

Your parents may tell you to conserve energy. "Turn out the lights," they say. But to scientists, conservation of energy means something quite different. The law of conservation of energy says energy is neither created nor destroyed.

When we use energy, we do not use it up—we just change its form. That's really what we mean when we say we are using energy. We change one form of energy into another. A car engine burns gasoline, converting the chemical energy in the gasoline into mechanical energy that makes the car move. Old-fashioned windmills changed the kinetic energy of the wind into mechanical energy to grind grain. Solar cells change radiant energy into electrical energy.

Energy can change form, but the total quantity of energy in the universe remains the same. The only exception to this law is when a small amount of matter is converted into energy during nuclear fusion and fission.

Efficiency

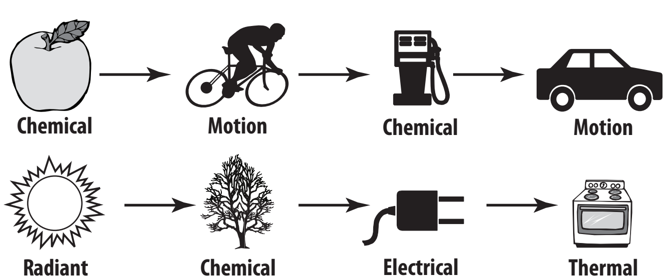
Efficiency is how much useful energy you can get out of a system. In theory, a 100 percent energy efficient machine would change all of the energy put in it into useful work. Converting one form of energy into another form always involves a loss of usable energy, usually in the form of heat.

In fact, most energy transformations are not very efficient. The human body is no exception. Your body is like a machine, and the fuel for your "machine" is food. Food gives us the energy to move, breathe, and think. But your body isn't very efficient at converting food into useful work. Your body's overall efficiency is about 15 percent. The rest of the energy is used as heat.

An incandescent light bulb isn't efficient either. A light bulb converts ten percent of the electrical energy into light and the rest (90 percent) is converted into thermal energy (heat). That's why a light bulb is so hot to the touch.

Most electric power plants are about 35 percent efficient. It takes three units of fuel to make one unit of electricity. Most of the other energy is lost as waste heat. The heat dissipates into the environment where we can no longer use it as a practical source of energy.

Energy Transformations



Forms of Energy

POTENTIAL

Stored energy and the energy of position (gravitational).

CHEMICAL ENERGY is the energy stored in the bonds of atoms and molecules. Biomass, petroleum, natural gas, propane and coal are examples.

STORED MECHANICAL ENERGY is energy stored in objects by the application of force. Compressed springs and stretched rubber bands are examples.

NUCLEAR ENERGY is the energy stored in the nucleus of an atom—the energy that holds the nucleus together. The nucleus of a uranium atom is an example.

GRAVITATIONAL ENERGY is the energy of place or position. Water in a reservoir behind a hydropower dam is an example.

KINETIC

Motion: the motion of waves, electrons, atoms, molecules and substances.

ELECTRICAL ENERGY is the movement of electrons. Lightning and electricity are examples.

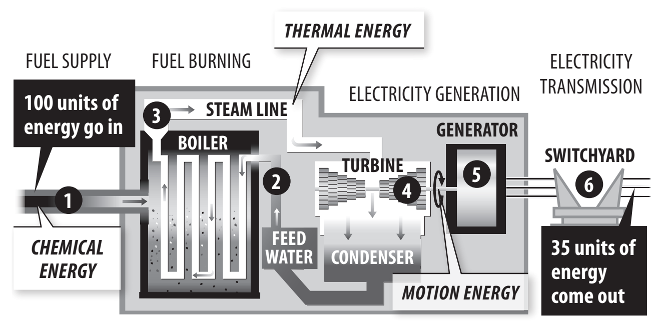
RADIANT ENERGY is electromagnetic energy that travels in transverse waves. Solar energy is an example.

THERMAL ENERGY or heat is the internal energy in substances—the vibration or movement of atoms and molecules in substances. Geothermal is an example.

MOTION is the movement of a substance from one place to another. Wind and hydropower are examples.

SOUND is the movement of energy through substances in longitudinal waves.

Efficiency of a Thermal Power Plant



How a Thermal Power Plant Works

1. Fuel is fed into a boiler, where it is burned to release thermal energy.
2. Water is piped into the boiler and heated, turning it into steam.
3. The steam travels at high pressure through a steam line.
4. The high pressure steam turns a turbine, which spins a shaft.
5. Inside the generator, the shaft spins coils of copper wire inside a ring of magnets. This creates an electric field, producing electricity.
6. Electricity is sent to a switchyard, where a transformer increases the voltage, allowing it to travel through the electric grid.

Introduction to Energy

Sources of Energy

People have always used energy to do work for them. Thousands of years ago, early humans burned wood to provide light, heat their living spaces, and cook their food. Later, people used the wind to move their boats from place to place. A hundred years ago, people began using falling water to make electricity.

Today, people use more energy than ever from a variety of sources for a multitude of tasks and our lives are undoubtedly better for it. Our homes are comfortable and full of useful and entertaining electrical devices. We communicate instantaneously in many ways. We live longer, healthier lives. We travel the world, or at least see it on television and the internet.

The ten major energy sources we use today are classified into two broad groups—nonrenewable and renewable.

Nonrenewable energy sources include coal, petroleum, natural gas, propane, and uranium. They are used to generate electricity, to heat our homes, to move our cars, and to manufacture products from candy bars to MP3 players.

These energy sources are called nonrenewable because they cannot be replenished in a short period of time. Petroleum, for example, was formed millions of years ago from the remains of ancient sea life, so we can't make more quickly. We could run out of economically recoverable nonrenewable resources some day.

Renewable energy sources include biomass, geothermal, hydropower, solar, and wind. They are called renewable energy sources because their supplies are replenished in a short time. Day after day, the sun shines, the wind blows, and the rivers flow. We use renewable energy sources mainly to make electricity.

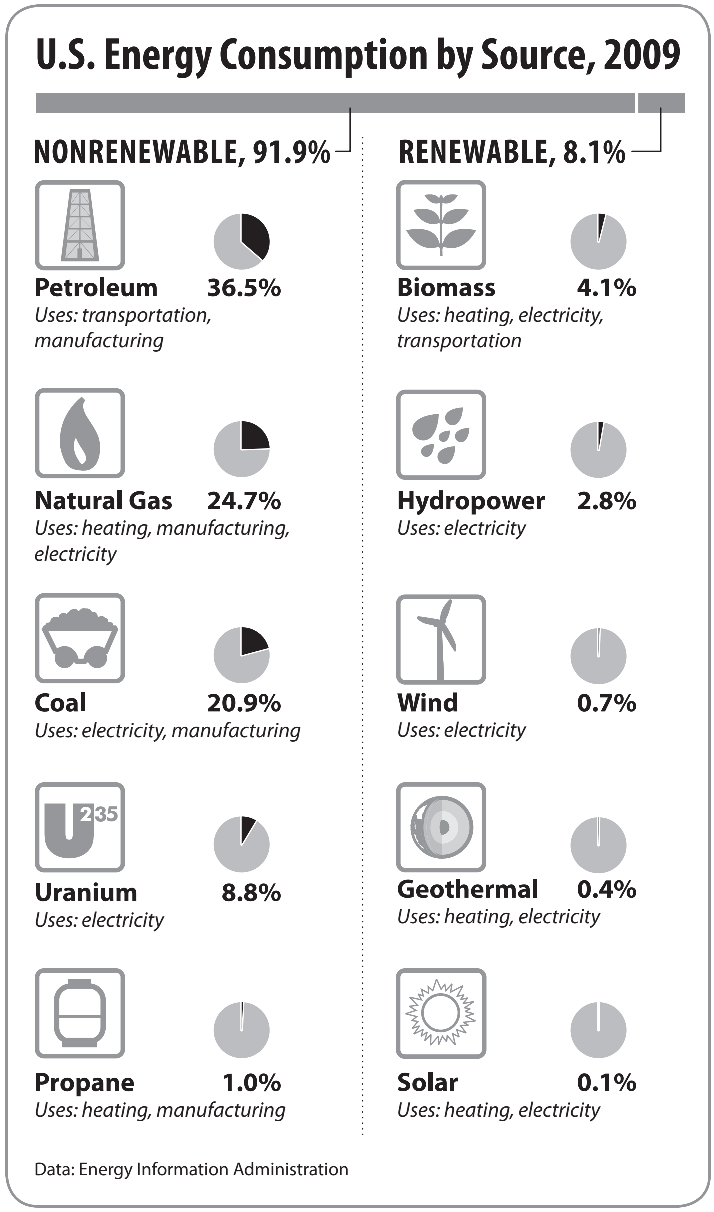
Measuring Energy

"You can't compare apples and oranges," the old saying goes. That holds true for energy sources. We buy gasoline in gallons, wood in cords, and natural gas in cubic feet. How can we compare them? With British thermal units (Btu), that's how. The energy contained in gasoline, wood, or other energy sources can be measured by the amount of heat in Btu it can produce.

One Btu is the amount of thermal energy needed to raise the temperature of one pound of water one degree Fahrenheit. A single Btu is quite small. A wooden kitchen match, if allowed to burn completely, would give off about one Btu of energy. One ounce of gasoline contains almost 1,000 Btu of energy.

Every day the average American uses about 844,000 Btu. We use the term quad to measure very large quantities of energy. A quad is one quadrillion (1,000,000,000,000,000) Btu. The United States uses about one quad of energy every 3.6 days. In 2007, the U.S. consumed 101.53 quads of energy, an all-time high.

Is electricity a renewable or nonrenewable source of energy? The answer is neither. Electricity is different from the other energy sources because it is a **secondary source of energy**. That means we have to use another energy source to make it. In the United States, coal is the number one fuel for generating electricity.



Energy Use

Imagine how much energy you use every day. You wake up to an electric alarm clock. You take a shower with water warmed by a hot water heater using electricity or natural gas.

You listen to music on your MP3 player as you dress. You catch the bus to school. And that's just some of the energy you use to get you through the first part of your day!

Every day, the average American uses about as much energy as is stored in seven gallons of gasoline. That's every person, every day. Over a course of one year, the sum of this energy is equal to about 2,500 gallons of gasoline per person. This use of energy is called **energy consumption**.

Energy Users

The U.S. Department of Energy uses three categories to classify energy users—residential and commercial, industrial, and transportation. These categories are called the sectors of the economy.

▪ Residential/Commercial

Residences are people's homes. Commercial buildings include office buildings, hospitals, stores, restaurants, and schools. Residential and commercial energy use are lumped together because homes and businesses use energy in the same ways—for heating, air conditioning, water heating, lighting, and operating appliances.

The residential/commercial sector of the economy consumed 41.6 percent of the total energy supply in 2009, more energy than either of the other sectors, with a total of 39.3 quads. The residential sector consumed 21.2 quads and the commercial sector consumed 18.1 quads.

▪ Industrial

The industrial sector includes manufacturing, construction, mining, farming, fishing, and forestry. This sector consumed 28.2 quads of energy in 2009, which accounted for 29.8 percent of total consumption.

▪ Transportation

The transportation sector refers to energy consumption by cars, buses, trucks, trains, ships, and airplanes. In 2009, the U.S. consumed 27.0 quads of energy for transportation. More than 96 percent of this energy was from petroleum products such as gasoline, diesel, and jet fuel.

Energy Use and Prices

In 1973, when Americans faced their first oil price shock, people didn't know how the country would react. How would Americans adjust to skyrocketing energy prices? How would manufacturers and industries respond? We didn't know the answers.

Now we know that Americans tend to use less energy when energy prices are high. We have the statistics to prove it. When energy prices increased sharply in the early 1970s, energy use dropped, creating a gap between actual energy use and how much the experts had thought Americans would be using.

The same thing happened when energy prices shot up again in 1979, 1980, and 2008—people used less energy. When prices started to drop, energy use began to increase.

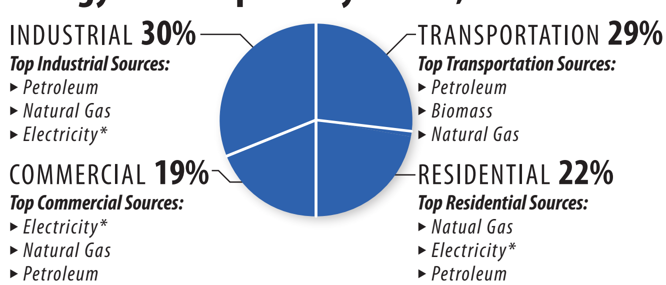
We don't want to simplify energy demand too much. The price of energy is not the only factor in the equation. Other factors that affect how much energy we use include the public's concern for the environment and new technologies that can improve the efficiency and performance of automobiles and appliances.

Most reductions in energy consumption in recent years are the result of improved technologies in industry, vehicles, and appliances. Without these energy conservation and efficiency technologies, we would be using much more energy today.

In 2009, the United States used 27 percent more energy than it did in the 1970s. That might sound like a lot, but the population increased by over 43 percent and the nation's **gross domestic product** (the total value of all the goods and services produced by a nation in one year) was 2.6 times that of the 1970s.

If every person in the United States today consumed energy at the rate we did in the 1970s, we would be using much more energy than we are—perhaps as much as double the amount. Energy efficiency technologies have made a huge impact on overall consumption since the energy crisis of 1973.

Energy Consumption by Sector, 2009



*Electricity is an energy carrier, not a primary energy source
Note: Figures are rounded.
Data: Energy Information Administration