Energy Education Teaching Ideas for Homeschool

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Wisconsin K-12 Energy Education Program

What is the Wisconsin K-12 Energy Education Program?

The Wisconsin K-12 Energy Education Program (KEEP) was created to help promote energy education in Wisconsin. KEEP is administered by the Wisconsin Center for Environmental Education (WCEE) and receives its primary funding through Focus on Energy, a public-private partnership offering energy information and services to energy utility customers throughout Wisconsin. The goals of this program are to encourage energy efficiency and use of renewable energy, enhance the environment and ensure the future supply of energy for Wisconsin. For information about Focus on Energy services and programs, call 800.762.7077 or visit www.focusonenergy.com.

Mission Statement

The mission of KEEP is to initiate and facilitate the development, dissemination, implementation, and evaluation of energy education programs within Wisconsin Schools.

Goal

The goal of KEEP is to improve and increase energy education in Wisconsin.

Energy Education for Homeschool Teachers

Each year, KEEP hosts an Educator Tent at the Renewable Energy and Sustainable Living Fair. The fair, hosted by the Midwest Renewable Energy Association (www.the-mrea.org), is the largest and most successful venue of its kind in the world. The Educator Tent provides a haven for educators to network, explore resources in energy education, and participate in renewable energy workshops.

Homeschool teachers are among the participants who visit the Educator Tent and express interest in energy education. Because of this interest, the Wisconsin K-12 Energy Education Program submitted a grant to the Wisconsin Environmental Education Board (WEEB) requesting resources to fund its Energy Education at Home Project.

Through this project, KEEP conducted a workshop at the Energy Fair for homeschool teachers. During this workshop, educators received a kit of hands-on resources related to key renewable energy concepts. The participants were also asked to review existing KEEP activities and to provide advice on how they could be adapted for the homeschool setting. The participants recommended that a curriculum for homeschool should contain extensive background information and a list of complementary teaching ideas (or “Energy Sparks”). By providing “Energy Sparks” each parent can adapt the activity to meet the individual learning needs of his or her child. Educators are encouraged to visit the KEEP Web site, www.uwsp.edu/keep, for more extensive information and teaching ideas to further enrich their child’s energy education.

A Rationale for Energy Education

Ask people to talk about energy; what would they say? Some would talk about the cost of energy and mention the price of gasoline or the cost of heating their homes in winter. Some might wonder how utilities can keep enough energy on hand to satisfy the growing populations and if we'll need to build more power plants. Others might say that the widespread use of fossil fuels pollutes the air, causes acid rain, and leads to global warming, and that we should turn to cleaner, alternative energy resources to solve these problems. Some would recall the energy crisis of the 1970s, when the United States faced an oil embargo by the nations of the Middle East and a resulting sudden rise in the price of oil. They might say that if we continue to import oil, we must develop domestic energy resource to protect ourselves from future disruptions. Still others would have nothing to say—they simply take energy for granted and assume that it will always be there to maintain their health and lifestyles.

Energy is more than an individual economic, environmental, or political issue. It is the agent upon which all processes on Earth and throughout the universe depend. Without energy there would be no stars, no planets, no life. Every interaction among living and nonliving things is accompanied by the transfer and conversion of energy. Energy is the underlying "currency" that governs everything humans do with each other and with the natural environment that supports them.

If you understand energy and how it influences every aspect of our lives, you understand how issues like energy prices, the environment, utilities, imported oil, and a myriad others are interconnected. You might see how a solution to one issue could lead to the solution of another. If you drive a fuel-efficient car, for example, you might not only save yourself money on gasoline, you might help reduce pollution and even decrease this country's dependence on foreign oil.

Energy is certainly an important and complicated issue. The future of Wisconsin depends on people making wise energy policies and choices. That's why a comprehensive foundation in energy education is vital for Wisconsin.

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An Introduction to Energy Education

A common definition of energy is the ability to do work (or to organize or change matter). Work involves force and motion. You can see evidence of energy when something moves or changes (when work is done). Light, thermal energy, and sound are other ways we can detect energy. People might think of energy as a substance such as fuel or a force or power, but in scientific terms energy is a state or condition that can be quantified and measured. Scientists use energy to describe certain properties of an object or a series of objects. It is similar to how you can describe an object's weight or size, and you can assign a value to quantify an object's energy.

Energy is transferred from one object to another during work (when there is movement or change). The amount of energy that is present before and after work is the same (scientists say energy is conserved). For example, let's say you drop a ball. Scientists can measure the energy before, during, and after the fall. The amount of energy remains constant throughout the process—it is just in different states. Likewise, when an object is thrown, a spring released, or something burned, the energy can be measured and will remain constant. This is the reason behind the statement, "Energy can neither be created nor destroyed, it can only be converted from one form to another." Scientists have found that the amount of energy in a closed system remains constant.

Wherever you look, you can see examples of energy transfers. When you turn on a light, you see the result of energy being transferred from the sun to the plants to the coal to electricity and finally to the light you see. During each of these transfers, energy changes form. There are two main forms of energy—kinetic energy (motion) and potential energy (position). More specific forms of energy include thermal (heat), elastic, electromagnetic (light, electrical, magnetic), gravitational, chemical (food), and nuclear energy.

During energy transfers, it might seem that energy does go away or become reduced. For example, a bouncing ball stops bouncing, a battery dies, or a car runs out of fuel. The energy still exists but it has become so spread out that it is essentially unavailable. Burning a piece of wood releases light and thermal energy (commonly called heat). The light and heat become dispersed and less useful. Another way to describe this process is to say the energy is concentrated in the wood (chemical energy) and becomes less concentrated in the forms of thermal and light energy. Energy has been called the currency of life. It flows through Earth's processes, creating wind, providing light, and enabling plants to create food from water and air (carbon dioxide). Humans have tapped into this flow to generate electricity, fuel our cars, and heat our homes. The sun provides Earth with most of its energy. It is important for children to recognize and appreciate this source of energy and to explore the transformations that bring the sun's light into their home in the form of light, heat, food, and fuel. We are fortunate to have many "concentrated" sources of energy. Besides the sun, there is wind, chemical energy found in biomass and in fossil fuels such as coal and oil, and in nuclear resources.

While the amount of energy in our world remains constant, as we use it (transfer it to one form to another), it becomes spread out and less useful. Energy also gives us the ability to work. Through education and becoming aware of what energy is and how we use it, we can use our concentrated resources more wisely and ensure that they will be available for future generations.

Energy Conversions

Most of us don't realize just how important energy is in our lives. Every facet of our life involves energy. One of the reasons we tend to take energy for granted is that it is constantly changing from one form to another. When this happens it is called an energy conversion.

During these conversions, energy is changing between potential and kinetic forms of energy. Potential energy is the energy stored in matter because of its position or the arrangement of its parts. Kinetic energy is the energy of motion. For example, to operate a wind-up toy, kinetic energy from winding the toy is converted to elastic potential energy in the toy's spring mechanism. After the spring is released, the elastic potential energy is converted back to kinetic energy when the toy moves.

In all energy conversions, the useful energy output is less than the energy input. This is because some energy is used to do work, and some energy is converted into heat (which escapes into the environment). For example, the chemical energy in food is converted to mechanical energy (moving our muscles) by a process similar to burning called respiration. Energy is needed to break apart the food molecules, and during the process, heat energy is generated. Feel your arm; this warmth is the heat energy that is produced by respiration within your cells. Let's say you are using the energy you gained from food to operate a pair of scissors. Heat is lost during this activity, too. There is friction when the blades of the scissors slide against each other to cut paper. Friction is the resistance to sliding, rubbing, or rolling of one material against another, which requires extra work to overcome and results in energy loss through heat. This heat energy escapes into the environment.

So, everywhere you look there are energy conversions. As energy is being converted, heat is being generated all around you (and inside you). Both of these make life on Earth what it is, full of diverse and interesting creations and changes.

Potential and Kinetic Energy

Energy is classified into two main forms: kinetic energy and potential energy. Kinetic energy is defined as the energy of a moving object. A thrown football, a speeding automobile, or a rock falling from a cliff are examples of objects that have kinetic energy. Potential energy appears in many different forms, and is defined as the energy stored in matter due to its position or the arrangement of its parts.

Types of potential energy include gravitational potential energy, elastic potential energy, chemical potential energy, and electrical potential energy. When something is lifted or suspended in air, work is done on the object against the pull of gravity. This work is converted to a form of potential energy called gravitational potential energy. When the item succumbs to the force of gravity, it falls toward Earth, converting potential energy into kinetic energy.

A stretched rubber band has the potential to do work or change things. This form of energy is called elastic potential energy. It occurs when an object (such as our skin or a rubber band) resists being stretched out of shape. The elastic potential energy in a rubber band can be used to do work. For example, toy airplanes fly when a rubber band untwists and spins a propeller. The elastic potential energy in the rubber band was converted to kinetic energy.

It would take millions of rubber bands to move a real airplane, so gasoline is used instead. But you don’t stretch gasoline to make it work, you burn it. You could release energy by burning rubber bands, but it is not practical to do so (it would take too many rubber bands and make too much of a mess!). The chemical makeup of gasoline (the arrangement of its molecules) makes it a good fuel source.

All nonliving and living things, from automobiles to zebras, are made up of molecules. It takes energy to make these molecules and hold them together. The energy stored in molecules is called chemical potential energy. When the bonds that hold a molecule together are broken, energy is released. For example, the energy stored in gasoline is released by burning it. The airplane motor uses this released energy to turn a propeller. There are many examples of chemical potential energy being converted to kinetic energy to do work. The chemical energy in food is used by our bodies to move. In a lighted firecracker chemical energy is used to make a loud sound and to scatter pieces of the firecracker all over.

A battery has chemical potential energy along with electrical potential energy. When you turn on a device that is battery-operated, such as a flashlight or a toy, the electrical potential energy stored in the battery is converted into other forms of energy such as sound, mechanical motion, thermal energy, and light. NOTE: For electrical appliances you plug in, the electrical potential energy is maintained by a spinning generator of a power plant, hydroelectric dam, or a wind generator. A solar cell stores electrical potential energy similar to a battery as long as the sun is shining on it.

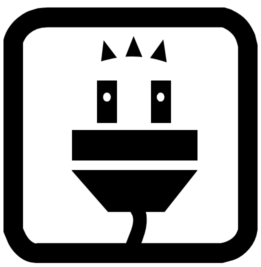
Sound, mechanical motion, thermal energy, and light are not easily classified as kinetic and potential energy. Light is an example of electromagnetic radiation and has no mass, so it has neither kinetic nor potential energy. The remaining forms have qualities of both kinetic and potential energy. Sound is made up of vibrations (put your hand on a stereo speaker), thermal energy consists of moving molecules in air or in an object, and mechanical energy is the combination of kinetic and potential energy of a moving object. A pendulum has mechanical energy; it continually converts kinetic energy into gravitational potential energy and back into kinetic energy as it swings back and forth. A child also has mechanical energy when he moves about. When sitting the child has potential energy; but watch out, before you know it, it will suddenly be converted to kinetic energy!

Electricity Overview

While we have some understanding about where energy comes from, a greater awareness of how we use energy (energy use patterns) can lead to better ways of managing energy use. We know that our homes use electricity, but we don't know how the electricity required for the lights in the kitchen compares to the amount used by the television.

We use energy for lighting rooms, heating and cooling our homes, heating water, and refrigerating food as well as numerous other activities. Such energy uses can be categorized by devices, products, and systems that use energy for the same or for similar purposes. These categories are called energy end use patterns.

A typical house in Wisconsin uses several types of energy to power its various end uses. About two-thirds of Wisconsin homes use natural gas for space heating and the rest use fuel oil, liquid propane gas, electricity, or wood. More than half of Wisconsin homes use natural gas for water heating and most of the rest use electricity. Most homes also use electricity for cooling, refrigeration, and lighting.



There are several things we can do to determine our energy use or consumption patterns. One way to better understand our personal energy use is to conduct a general energy end use survey. Conducting an end-use survey not only increases our awareness of how we use energy in our lives, but also helps us decide how to use energy more efficiently.

Calculating how much energy is used by the electrical appliances and equipment in our homes and schools makes us aware of which ones use large amounts of energy and which ones do not. This can be done through an appliance survey and lead us to adopt strategies for using appliances and equipment when older ones need to be replaced. Although improving the efficiency of all electrical appliances and equipment saves energy and lowers utility bills, focusing efficiency improvements on those that are large energy users should be the first priority.

It is beneficial to learn more about watts, volts, amps, and other terms associated with energy to better conduct the end use and appliance surveys. Power and time of use are the factors that determine how much energy is used by an electrical appliance or piece of equipment. Power is the rate at which energy is used, or work is done, per unit of time. Electrical power is usually measured in watts; hence, electrical power is often referred to as wattage. The higher the wattage, the greater the amount of electrical energy that an electrical appliance or piece of equipment uses over a period of time. For example, a 1,200-watt microwave oven uses twice as much electrical energy and produces twice as much heat in one minute as a 600-watt microwave oven. However, an appliance with a higher wattage will not use much energy if it is used for only a few seconds, whereas an appliance with a lower wattage may use a lot of energy if it is used for a number of hours. For instance, a 1,200-watt microwave used for only 30 seconds uses less energy than a 600-watt microwave does in one-half hour.

The relationship between the wattage, time of use, and the energy used by an appliance or piece of equipment can be expressed by this formula:

Wattage (Power) x Time = Energy Use

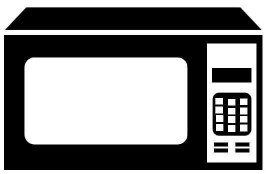
By using this formula, we can compare the energy used by electrical appliances and equipment to see which ones use the most electricity.

Wattage and other electrical information is often listed directly on the appliance or equipment. For example, a label on a microwave oven may look like this:

ACME, Microwave Oven
Model No. X-15Z
120 Volts AC 5 A

600 Watts   60 HZ
Made in USA

The information on the label tells us that the microwave oven needs 120 volts of electricity in the form of alternating current (AC) to operate, and draws 5 amps (amperes) of current during its use. The 60 HZ number means that the current



alternates at a rate of 60 times per second. The wattage of the microwave is 600 watts.

If the voltage and current are listed on an appliance but the wattage is not, the wattage can be calculated by multiplying the voltage by the current. Using the information on the microwave label, the wattage is equal to Voltage x Current = Wattage.

20 volts x 5 amps = 600 watts

If the microwave oven is used an average of a half hour each day, the average amount of energy is uses per day is

Wattage x Time = Energy Use

600 watts x 0.5 hours per day = 300 watt-hours per day

Because watt-hours are small units, electrical energy is more often measured in kilowatt-hours, where one kilowatt equals 1,000 watts. The energy used by the microwave oven each day in kilowatt-hours is

Watt-hours per Day x (1 Kilowatt/1000 Watts) = Kilowatt-hours per Day

300 watt-hours per day x (1 kilowatt/1000 watts) = 0.3 kilowatt-hours per day

Volts, Amps, and Watts: What are they?

Voltage

All sources of electricity, such as batteries or generators, have the potential to do work (e.g., illuminate light bulbs, run electrical appliances). Voltage describes this potential. The greater the voltage, the more potential the electricity source has to do work.

The potential to do work should not be confused with actually doing work. For instance, a battery that is sitting on a table but not connected to anything has a voltage, or the potential to do work such as lighting a light bulb. However, the battery will not light the bulb unless it is connected to the bulb in an electric circuit. Only then will the battery actually do work. The unit of voltage is the volt.

Current - Amperes

Electric current is simply the flow of electrons (or, in some cases, positive charges). In a circuit, current delivers energy from a source of electricity to an electrical device (e.g., a light bulb) or appliance. The unit of current is the ampere, or amp.

The Relationship between Voltage and Current

The relationship between voltage and electric current is similar to the relationship between the height of a waterfall and the water that flows down it. A height is needed for the water to flow down the waterfall. The greater the height of the waterfall, the more energy the water has when it reaches the bottom. If no height exists, the water will not flow and it will not have any energy due to motion.

A voltage (similar to height) is needed to cause an electric current to flow (think of cascading water) so that it can deliver energy to an electrical device or appliance. It is helpful to remember that a current is a flow of electrons and electrons have mass (therefore current is a mass of flowing electrons!). The higher the voltage, the more work an electric current can do. If no voltage exists, a current will not flow and work cannot be done.

DC and AC Current

The current produced by sources of electricity comes in two main forms: direct current (DC) and alternating current (AC). Direct current is current that flows in one direction through a circuit. It is produced by sources of electricity whose positive (+) terminal always stays positive and negative (-) terminal always stays negative. For example, a battery produces direct current because the battery's terminals always remain the same; the negative terminal does not change to a positive terminal, and vice versa. Hence, the current will always flow from the negative terminal of the battery toward the positive terminal.

Alternating current is current whose flow in a circuit periodically reverses direction. It is produced by a source of electricity whose positive and negative terminals switch or alternate back and forth. In other words, one terminal will switch from positive to negative and back to positive, while the other terminal will switch from negative to positive to negative. Alternating the terminals from positive to negative causes the current to flow in one direction, then in the reverse direction, and back to its original direction, and so on. Electrical generators in power plants throughout the United States produce alternating current that reverses direction 60 times per second. The unit used to describe the rate at which current alternates is the cycle per second, or hertz (HZ).

Electric Power

In general, power is defined as the rate at which work is done, or energy is used, per unit of time. Electric power specifically refers to the rate in which a source of electricity produces energy, or refers to the rate in which an electrical device, appliance, or piece of equipment converts electrical energy into other forms of energy. The faster a source of electricity (such as a generator) produces electrical energy, the greater its power output. The faster an electrical device (such as a light bulb) converts electrical energy in light and heat energy, the greater its power consumption. Electric power is related to voltage and current by the following formula:

$$\text{Power} = \text{Voltage} \times \text{Current}$$

The unit of electrical power is the watt. One watt is defined as one volt multiplied by one amp. Because the watt unit is used so frequently, electrical power is often referred to as wattage.

Home Heating Overview

It is no surprise to Wisconsinites that most of the energy they use in their homes or apartments is for keeping warm during the winter. The amount of money spent on heating is also significant. The average homeowner may spend $1,0 00 to over $2,000 on fuel per heating season, depending on the efficiency of the heating system and the type of fuel. Given such a cost range, it makes sense for homeowners who wish to replace their old heating system to compare the efficiency and fuel costs of new systems before buying one.

The majority of homes in Wisconsin use furnaces or boilers that burn natural gas, fuel oil, or propane (also called liquid petroleum gas, or LPG). Electric baseboard heat is used in some houses and apartments. Wood-burning stoves are especially popular in rural areas and in the northern part of the state, where wood supplies are plentiful and access to other fuels is restricted.

There are several important factors to consider when assessing a home heating system. The first factor is efficiency—the percentage of the energy in the fuel that is converted into useful heat. For instance, a 15- to 20-year-old fuel oil or natural gas furnace may be 60 percent efficient, meaning that 60 percent of the heat from the oil or gas is transferred to the interior of the home. Most of the other 40 percent of the heat is lost when exhaust gases are vented up the chimney and outside, and the rest is lost warming up the furnace itself, or is used to restart the furnace after it has cycled off. The efficiency of new heating systems using natural gas, fuel oil, propane, and wood has improved considerably in recent years, and higher efficiency models are now widely available. Heating system efficiency does not vary much with the size of the system; the efficiency of a large-sized gas furnace used in a large house is not much different than that of a small-sized gas furnace used in a small house.

Fuel cost is another important factor to consider when assessing a home heating system. Comparing fuel costs requires thoughtful analysis because different fuel types have different units of measurement. For example, the cost of fuel oil is given in dollars and cents per gallon, while the cost of electricity is given in cents per kilowatt-hour (kWh). The solution is to convert fuel costs to a common unit of energy, such as dollars per million Btu of energy. Typical homes in Wisconsin use between 50 to 100 million Btu of heat energy per year. A survey of average fuel costs in Wisconsin in 2002 shows that wood is the cheapest fuel. Fuel oil and natural gas have costs per million Btu similar to each other while propane is slightly higher. Electricity is two to three times more expensive than the other fuels.

A third important factor in assessing a home heating system is the cost of the system itself. High efficiency furnaces and boilers generally cost a few hundred dollars more than their less efficient counterparts. On the other hand, using a high-efficiency furnace or boiler often leads to noticeably lower fuel bills during the course of Wisconsin’s long heating season, and the savings in fuel costs will often pay for the extra purchase cost of the high-efficiency systems after a few years. Electric baseboard systems are less expensive than furnaces or boilers, but high electricity costs offset this advantage. There is no direct relationship between the cost of a woodstove and its efficiency. Because heating system costs vary widely, the best sources for cost information are local heating contractors, utilities, or woodstove distributors.

Other factors to consider when assessing a home heating system are availability of the fuel in a given locale and, if needed, the cost of air ducts, pipes, fuel tanks (fuel oil and propane), and other auxiliary equipment.

The recent trend toward high-efficiency heating systems benefits homeowners and the environment. By choosing the right combination of an efficient heating system and low-cost fuel, the homeowner can save money in the long term. High-efficiency heating systems also reduce fuel use, which reduces air emissions and contributes to prolonging the supply of energy resources.

Energy Resources Overview

Primary energy sources are those that are either found or stored in nature. The sun is a primary energy source and the principal source of Earth's energy. Energy from the sun is stored in other primary energy sources such as coal, oil, natural gas, and biomass, such as wood. Solar energy is also responsible for the energy in the wind and in the water cycle (the hydrologic cycle). Other primary energy sources found on Earth include nuclear energy from radioactive substances, thermal energy stored in Earth's interior, and potential energy due to Earth's gravity. Secondary energy sources are produced from primary energy sources using technology. For example, we produce electricity - a secondary source - by burning coal in a power plant or by using photovoltaic cells to harness solar energy. We can also produce alcohol fuel from crops.

Non-Renewable Resources

Non-renewable energy resources are either replenished very slowly or not replenished at all by natural processes. A nonrenewable resource can ultimately be totally depleted or depleted to the point where it is too expensive to extract and process for human use.

Oil

Crude oil, or liquid petroleum, is a yellow-to-black sticky substance found inside sponge-like sedimentary rocks (not in giant underground caverns). Oil is made of a mixture of hydrocarbons, which consist of carbon and hydrogen atoms.

Crude oil is formed when dead organisms such as plankton, bacteria, and plant matter are deposited on shallow ocean bottoms. Sediments accumulate on top of the organic material over millions of years, and increasing pressure and temperature slowly change the organic material in oil. Because they are formed in similar ways, crude oil is often found together with natural gas. One gallon of crude oil contains 138,095 Btu of energy. One barrel of oil contains 42 gallons. One quad equals 172.4 million barrels.

Crude oil is transported by pipelines and oceangoing tankers to refineries. Nearly 45 percent of a typical barrel of oil is refined into gasoline. An additional 45 percent is transformed into other fuels such as propane, jet fuel, diesel fuel, home-heating oil, and heavy fuel oils for industries, ships, and electric power plants. The remaining 10 percent is used to make plastics and other products.

After refining, gasoline and other types of fuel oil are transported by barges, rail, and pipelines to local storage tanks, then delivered to homes, businesses, and gas stations by tanker trucks.

Coal

Coal is the most abundant fossil fuel in the United States. When domestic fossil fuel reserves are compared on the basis of energy content, over 90 percent are coal, three percent are crude oil, and four percent are natural gas.

There are four main types of coal, which are classified by how much carbon they contain. Anthracite is the hardest and contains the most carbon per pound. Anthracite is followed by bituminous and subbituminous coal. Lignite, a soft coal, has the lowest amount of carbon per pound. The energy content of coal is approximately related to its carbon content. The energy content of coal is measured in Btu (British thermal units) or quads (1,015 Btu).

Most of the coal produced in the U.S. is burned in power plants to generate electricity. The U.S. consumed about 1.07 billion tons of coal (20.9 quads) in 2002. World consumption was 5.26 billion tons (105 quads). In 2001, the total coal consumption in Wisconsin was 25.9 million tons; 92.9 percent of this was burned in power plants to generate electricity.

Natural Gas

Natural gas is made up of a mixture of substances called hydrocarbons whose molecules are made of carbon and hydrocarbon atoms. Natural gas is mostly made of methane (CH_4) and other gaseous hydrocarbons (dry gas), although a small portion is in liquid form (wet gas).

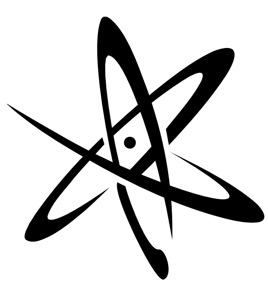
Like crude oil, natural gas is formed when dead organisms like plankton, bacteria, and plants are deposited on shallow ocean bottoms. Sediments accumulate on top of the organic material over millions of years, and increasing pressure and temperature slowly change it into natural gas. Because they are formed in similar ways, natural gas and crude oil are often found together.

The energy content of natural gas is measured in British thermal units (Btu) or quads (10^{15} Btu). One cubic foot of natural gas contains between 1,008 and 1,034 Btu of energy. One therm of natural gas contains 100,000 Btu (a therm equals about 98 cubic feet). An average Wisconsin home with an 80 percent efficient furnace would use about 1,000 therms of natural gas per year.
In 1999, world wide consumption of natural gas was 84.2 trillion cubic feet (84 quads). The United States consumed 21.7 trillion cubic feet of natural gas (22 quads).

Of the 379 billion cubic feet of natural gas used in Wisconsin in 2004, 36 percent was used for residential purposes, 37 percent by industries, 21 percent by commercial businesses and institutions, and 6 percent by electric utilities. A mild winter led to decreased natural gas use in all but the industrial sector. Overall, natural gas use in Wisconsin decreased 3.0 percent from 2003. Natural gas use is down 2.62 percent from 2000.

Nuclear Energy

A recent arrival on the energy scene, nuclear energy is associated with vast quantities of energy. It is also associated with health issues and environmental problems due to radiation and nuclear waste disposal. Nuclear energy can be obtained by a process called nuclear fission (or simply "fission"). For example, fission occurs when a neutron splits the nucleus of a large molecule into two smaller nuclei, releasing energy and additional neutrons. The extra neutrons then split other nuclei, producing still more neutrons that split more nuclei, and so on. This process is called a nuclear chain reaction.



The 104 nuclear power plants in the U.S. produced 21 percent of the nation's electricity in 2003. No new nuclear power plants have been ordered since 1978 though nuclear energy is being revisited by legislators as a solution to our energy needs. The U.S. Department of Energy estimates that about 40 percent of the nation's current nuclear generating capacity will be retired by 2015 as nuclear reactors reach the end of their useful lives.

Wisconsin currently has three nuclear power plants. Wisconsin Electric Power Company owns Point Beach Unit 1 and 2, two nuclear plants located on Lake Michigan north of Two Rivers, Wisconsin. The third plant is the Kewaunee Nuclear Plant. Wisconsin Public Service Corporation operates this plant, which is located on Lake Michigan near the town of Kewaunee. In 2003, these three plants supplied about 17 percent of the state's electrical energy needs.

Nuclear energy can also involve fusion. In fusion, atoms combine rather than are split. The best example of fusion is solar energy. The sun is actually a gigantic nuclear fusion reactor running on hydrogen fuel!

Solar energy is one example of renewable energy. For more information, see “Renewable Energy Resources” on page 15.

Energy Efficiency Overview

Suppose you paid $100 a year to light your home. What if you found out that only one dollar of this payment went toward paying for the light? Would you feel shortchanged? What about the other $99 of energy you paid for? Where did it go? Would you be surprised to know it was “lost in space”?

To find out where the ninety nine dollars worth of energy went, it helps to understand the laws of energy. Energy is hard to conceptualize because it is constantly changing from one form to another. When this change happens it is called an energy conversion. Humans use energy conversions to meet our daily needs. Our bodies convert energy stored in food to kinetic energy or movement. We use technology to convert energy stored in fuels such as coal into electricity. One example of these technologies—or conversion devices—is the light bulb that converts electricity to light.

The first law of energy (or Law of Thermodynamics) states that energy can be neither created nor destroyed. Therefore, according to this law, an equal quantity of energy must exist before and after conversion. So, how does this help solve how $99 was lost lighting your home?

Although the same amount of energy exists before and after conversion, not all the energy is converted into the desired form of energy (such as light). In other words, the quantity of energy is the same but the quality is different. The energy that is wasted when a light bulb shines exemplifies the second law of thermodynamics, which states that with each energy conversion from one form to another, some of the energy becomes unavailable for further use.

To solve the funding problem for lighting your home, it will also help to learn more about the conversion device or the light bulb. Most homes still use incandescent light bulbs for lighting. An incandescent light bulb has a thin wire filament mounted inside it. When the bulb is turned on, an electrical current passes though the filament, heating it up so much that it emits light. In terms of the money used to light your home, most of it goes toward heating the light bulbs’ filaments. The heat energy that is produced by the light bulb is often called waste heat, because it is difficult to use this form of energy to do work. Heat energy eventually escapes or is lost in space.

Using and losing money to heat rather than light a bulb doesn’t sound very efficient. In terms of energy use, the word efficiency describes how much of a given amount of energy can be converted from one form to another useful form. Due to unavoidable compliance with the second law of thermodynamics and the capabilities of current technologies, most of the modern conversion devices—such as light bulbs and engines—are inefficient.

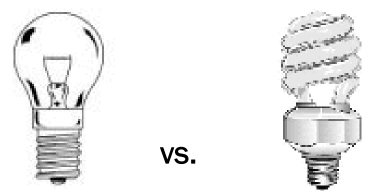
The efficiency of the light bulb is further compromised by the processes used to transfer energy to homes to light the bulbs. The source of electricity in most homes in Wisconsin is coal. It is not possible to take a chunk of coal and use it directly to light a bulb. For power plants to convert the chemical in coal to electricity requires a number of steps. Each of these steps in the coal-fired electrical system involves an energy conversion and varies in efficiency (energy being lost along the way as heat, sound, etc.). The total efficiency of the whole process is called the system efficiency. It is equal to the product of the efficiencies of the individual steps.

After going through various processes needed to convert the coal to electricity, only around 26 percent of the stored energy from the coal is available for home use. Household appliances, such as televisions, washing machines, and light bulbs convert the energy they receive for various end uses (light, heat, etc.). As mentioned above, modern conversion devices are inefficient.

Therefore, once again energy is lost as heat, noise, and other undesired forms. The incandescent light bulb converts only around five percent of the energy it receives into light; the rest is lost as heat. Therefore, the total system efficiency of coal-to-electricity-to-light ends up being only around one percent when incandescent light bulbs are used (five percent of 26 percent = 1.3 percent). Therefore, the case of the missing $99 is explained by heat loss in the process of converting and transporting electricity. Does this mean consumers should simply accept this inefficiency? Of course not.

Even though the coal-to-electricity-to-light process has a low efficiency, it is an improvement over earlier electrical systems. The average efficiency of power plants has risen from 3.6 percent in 1900 to about 33 percent today. Scientists and engineers are developing new technologies to make power plants even more efficient and to improve electrical transmission.

Technological advances have also increased the efficiency of light bulbs. The compact fluorescent light bulb (CFL) was commercially introduced in the 1980s. Instead of using an electric current to heat thin filaments, the CFLs use tubes coated with fluorescent materials (called phosphors) that emit light when electrically stimulated. Even though they emit the same amount of light, a 20-watt compact fluorescent light bulb feels cooler than a 75-watt incandescent light bulb. The CFL converts more electrical energy into light, and less into waste heat. CFLs have efficiencies between 15 and 20 percent, making them three to four times more efficient than incandescent light bulbs.



Incandescent Lamp — Compact Fluorescent Lamp (CFL)

Comparison: A single 20-watt compact fluorescent bulb, compared to a 75-watt incandescent light bulb, saves about 550kWh of electricity over its lifetime. If the electricity is produced from a coal-fired power plant, that savings represents about 500 pounds of coal.

Therefore, individuals—although at the "end" of an energy conversion system—can make noteworthy contributions to the efficiency of the whole system. Using CFLs raises the overall efficiency of a coal-fired electrical system from 1.3 percent to five percent. This may not seem like much of an improvement, but the cumulative results of many people doing this are massive. For example, if every household in Wisconsin replaced one 75-watt incandescent light bulb with a 20-watt compact fluorescent bulb, enough electricity would be saved that a 500-megawatt coal-fired power plant could be retired.

Installing efficient light bulbs is just one action people can take to improve system efficiency. Efficient electrical appliances—such as air conditioners and refrigerators—are available and becoming more affordable. Look for ENERGY STAR labels on appliances; the government uses this label to identify energy efficient appliances. Therefore, individuals—whether they are engineers improving an energy conversion device or they are home owners using energy efficient appliances—can make significant contributions to energy efficiency.

Embodied Energy and the Three R's

As consumers and citizens, we should be aware of the flow of energy throughout the environment and within our industrial society. Just as a tree or human cannot grow without energy, human-created materials such as pencils, airplanes, school lunch bags, and television sets cannot be created or used without expending energy.

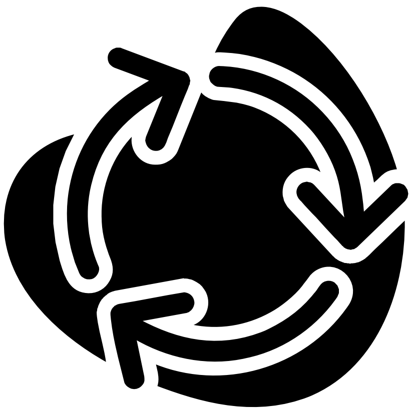
The total amount of energy needed to make and transport a product is called embodied energy. For example, the engine powering a steam shovel used to mine a metal consumes energy in the form of gasoline. The equipment used to fell a tree, whether powered by hand or by engine, consumes energy. The process of transporting the metal-bearing ore to a refining plant or milling the tree requires energy to power the machinery. Combining the processed metal and wood with other raw material to make a finished product draws on even more energy. All the energy used in these processes is used once and is unavailable for future use.

Even after the product is created, energy is used. Energy is needed to produce the packaging and to ship the product to the retailer. Selling the product involves energy use. Depending on the purpose of the product, the consumer may expend energy when using it. Finally, the product is thrown away, which also requires energy.

People in Wisconsin throw out everything from toothpaste tubes to old television sets, food scraps to plastic milk jugs, jelly jars to paper. If you add up all the waste from your house, from the store where you shopped, and from the restaurant where you ate, it would amount to five pounds (2.25 kg) per person of municipal solid waste thrown into the trash every day. Fortunately, Wisconsin residents recycle about 1.25 pounds (0.56 kg) of waste per day. If you multiply the remaining 3.75 pounds (1.69 kg) by 365 days per year, then by five million Wisconsin citizens, your results will show that Wisconsin citizens still throw away more than 3.4 million tons (3.06 million metric tons) of stuff each year!

When a product is thrown away, it is the end of the line for the energy flow history of the product. The embodied energy used to create the product is lost as waste heat and never available for use again. Clearly, we need to develop ways to reduce the amount of embodied energy used during production, to allow the saved energy to be used for alternative purposes. In addition, we should consider the energy that is stored within the product. Wood, plastics (made from petroleum), and glass all have energy stored within their chemical bonds. Wisconsin's trash contains enough energy to heat more than 300,000 homes a year.

So, what else can we do with waste besides send it to a landfill? The approaches most often recommended to decrease the amount of waste we generate are labeled the Three Rs (Reduce, Reuse, Recycle). While people reduce, reuse, and recycle many products, some items should be used only once and then put into a landfill or incinerated. These items include hospital waste such as syringes.



Some communities in Wisconsin have built waste-to-energy plants to deal with solid waste materials. This approach involves using solid waste, specifically the chemical energy stored in the waste, as a fuel source. Waste is burned and the heat produced is used to generate electricity. Each ton of solid waste has the energy equivalent of 70 gallons (265 l) of gasoline — enough energy to drive a small car from coast to coast. However, toxic substances are often released into the air when waste products are burned, and burning also results in the production of a toxic ash. Another drawback to burning waste is that some of the materials that burn the best or contain the most stored energy (paper, plastic) are also the best candidates for recycling and reuse, resulting in greater embodied energy savings compared to the stored energy received from burning.

None of these approaches is the sole solution to our waste disposal problem. In 1990, Wisconsin passed Act 335, the Waste Reduction and Recycling Law, which banned certain items from Wisconsin's landfills and required communities to establish effective recycling programs. Wisconsin currently reuses, recycles, or composts more than 25% (by weight) of its municipal solid waste each year. These actions reduce the need for landfill space and help save energy, sending a message to manufacturers and waste disposal managers that we, as consumers, are serious about conserving energy resources for future generations.

Renewable Energy Use in Wisconsin

A growing number of people in Wisconsin use the sun to heat their homes and businesses at night. How can this be? Are they able to make the sun shine at night? No. Many of these home and business owners have houses and buildings that are designed to store the sun's heat during the day and reradiate it throughout the evening. Other homes and businesses burn firewood. Wood contains stored energy from the sun (trees convert solar energy to chemical energy through the process of photosynthesis). Some homeowners and business owners use sunlight to generate electricity, or they may use the wind, which is a renewable energy resource created by the sun.

Renewable energy systems use resources that are constantly replaced. Examples of renewable energy resources that are used for home heating and electricity include solar, wind, biomass (wood), and hydropower (falling water). In Wisconsin, about four percent of the energy consumed by residents comes from renewable resources; most of this energy (80 percent) is from wood, and the rest is solar.

Today's technological advancements have developed more efficient means of harnessing and using renewable energy sources, and these sources are gaining increasing popularity. They offer us alternatives to nonrenewable energy sources, such as nuclear (which has safety and disposal issues), oil, coal, and natural gas (which can cause acid rain and may contribute to the overall warming of Earth's atmosphere known as the greenhouse effect). Existing renewable energy installations are making significant contributions to the U.S. energy supply, and research activities are demonstrating the far-reaching impact that a greater reliance on renewable energy sources could have on our country's energy security. In addition, ongoing and planned research offers still more possibilities.

Renewable energy systems can be centralized or decentralized. A centralized energy system is one in which large amounts of an energy resource are converted from one form into another form in one location. A decentralized energy system is one in which small amounts of an energy resource are converted from one form into another form in many locations by individuals or small groups of consumers.

Renewable Energy Resources

Renewable energy resources can be replenished. Renewable energy resources can be replaced quickly by natural processes but can sometimes be depleted when their rate of use exceeds their rate of replacement.. Five main renewable energy sources exist: solar, wind, hydropower, biomass, and geothermal. Human societies have used renewable resources to meet their energy needs throughout history. Renewable energy is a reliable energy source for many residential and commercial applications, including heat generation, electricity generation, and vehicle use. Each renewable energy resource has inherent qualities that make it more suitable for some applications than others. The efficiency of converting renewable energy sources to useable energy varies according to the source and/or technology used. The availability of renewable energy varies; some renewable resources are in constant supply, while others are intermittent. Intermittent energy can be stored for future use in batteries.

Solar Energy

Solar energy is produced by the sun, which is a gigantic nuclear fusion reactor running on hydrogen fuel. The sun converts five million tons of matter into energy every second. Solar energy comes to Earth in the form of visible light and infrared radiation. Scientists expect that the sun will continue to provide light and heat energy for the next five billion years.

The electricity output of solar systems is measured in watts, a unit of power. One kilowatt equals, 1,000 watts; one megawatt equals 1,000 kilowatts. Solar electricity is measured in kilowatt-hours, a unit of energy. Energy is power multiplied by time. One kilowatt-hour equals 3,413 British thermal units and is equivalent to the energy needed to run ten 100-watt light bulbs for one hour.

Solar energy can be harnessed to generate solar electricity and for space and water heating.

Solar Electricity

Solar energy can be used to produce electricity in two ways. One way is to use solar cells to convert sunlight directly into electricity. Most cells are made of silicon, a material that comprises 28 percent of the Earth's crust. One solar cell measuring four inches across can produce one watt of electricity on a clear, sunny day. To produce more electricity, cells are wired together into panels, and panels are wired together to form arrays.

The second way to generate electricity is by using solar energy to produce steam that spins a turbine connected to an electrical generator. These systems are called solar thermal-electric systems. One type of system, the solar power tower, uses mirrors to track and focus sunlight onto the top of a heat collection tower. Another type of solar thermal-electric system uses curved, mirrored collectors shaped like troughs that focus the sun's heat on oil-filled pipes running through the middle of the collectors.

In the United States, solar electricity produced 535 million kilowatt-hours of electricity in 2003, which is about 0.07 percent of total U.S. electrical production. In Wisconsin, a negligible amount of electricity from solar energy is currently being generated by individual homeowners and businesses.

Solar Heating

There are two ways to use solar energy for heating. The first uses a solar collector to heat a fluid (e.g., water or air) and then pumps or blows the fluid through tubes or ducts to deliver heat where it is needed. The heat can also be stored in an insulated tank that holds a heated liquid or in heated materials like brick or stone. These systems are called *active solar heating systems*.

The second way to use solar energy for heating is to design buildings that capture solar energy and use it to heat the interior. Rooms called sunspaces or solariums, as well as greenhouses, can be built onto the south side of a home or building to collect solar energy. The building is often designed so that the warmed air from these spaces can naturally circulate to other rooms. Some buildings use brick or stone walls and floors to store solar energy for nighttime heating. These systems are called passive solar heating systems; they differ from active solar heating systems in that they do not use mechanical systems to collect or transfer heat.

In the United States, active solar heating systems produced 63 trillion Btu of heat in 2003. Most of these systems are located in Florida, California, Arizona, Hawaii, and

Puerto Rico, places that receive larger amounts of solar energy than most parts of the nation.

In Wisconsin, solar heating systems produced about 3.9 trillion Btu, which is 0.3 percent of the total energy used in the state that year. Of this amount, active solar heating systems produced 0.2 trillion Btu, while passive solar heating systems produced about 3.7 trillion Btu. Assuming that the average Wisconsin home uses 80 million Btu for heating each year, 3.9 trillion Btu of solar heating is equivalent to the heat used by about 48,000 Wisconsin homes.

A note about solar . . .

Let's say you want to place a solar collector on your home. Where would you locate it? Solar collectors cannot collect the sun's energy unless the sun shines upon them. This may seem obvious, but it can be overlooked when choosing a site for a solar energy system. The altitude of the sun is the angle between the position of the sun in the sky and a point directly below on the horizon. This altitude varies by 47° during the course of one year, and unless homeowners can observe the altitude of the sun all year long, they may be unaware of potential shading problems.

The sun's greatest heating effect in Wisconsin occurs between 9 a.m. and 3 p.m. Standard Time. It is best if no more than 15 percent of a solar collector is shaded during this time (the less the better). Many obstructions may shade a collector: hills, other buildings, fences, chimneys, dormers, evergreen trees, and deciduous trees (although they lose their leaves in winter, large limbs may still cause significant shading). The use of a sun locator allows you to accurately plot the times of day that sunlight is blocked by these kinds of interferences. If you have a site that is generally without shadow from 9 A.M. to 3 P.M. you have a good solar site.

A sun locator is a simple device for identifying your solar window. On the winter solstice, the sun's path follows a low arc in the winter sky, while on the summer solstice, the sun follows a much higher and wider arc across the sky. If you trace the two arcs on an imaginary dome representing our sky, and connect the winter and summer morning points of 9 A.M., as well as the two afternoon points of 3 P.M., the area within t he space is the solar window. Any objects appearing within this solar window subtract from the solar gain of a collector mounted at that position.

Wind Energy

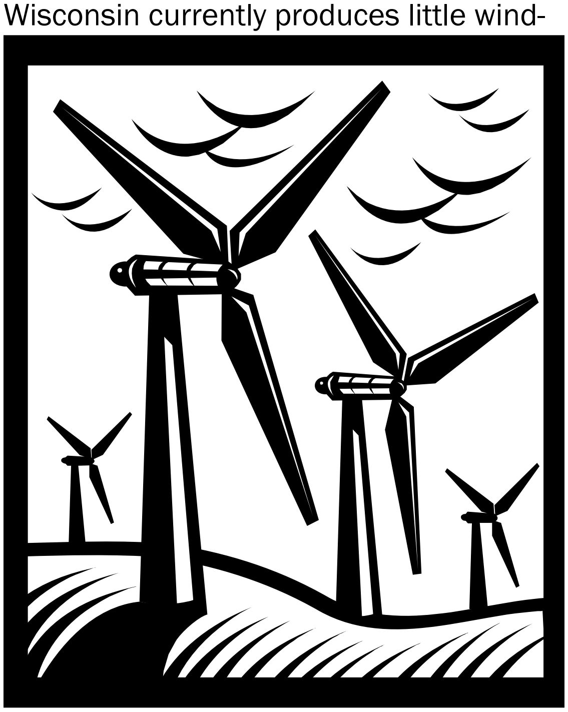
Wind is created when solar energy heats the atmosphere. This heat produces differences in air pressure. Air moves in an effort to equalize these pressure differences, creating wind as a result. In the process, energy from the sun is converted into kinetic energy (energy of motion).

The output of a wind energy system is measured in kilowatts (1,000 watts) or megawatts (1,000,000 watts), units of power. Energy is power multiplied by time. Wind-generated electricity is measured in kilowatt-hours, a unit of energy. One kilowatt-hour of electrical energy equals 3,414 British thermal units.

The energy in wind is converted into electricity using wind turbines. A wind turbine is made up of an electrical generator mounted on a tower and connected to a propeller. The wind turns the blades of the propeller, causing the generator to spin and produce electricity. These turbines have blades that are 6 to 12 feet long and generators that produce 0.5 to 10 kilowatts of electrical power.

Wind turbines can be used to provide electricity to single-family homes, especially in rural areas. The electricity produced can be stored in batteries for use when wind speeds are low or when high winds could damage the turbine.

Electric utilities use larger wind turbines. Often the utility will place many wind turbines together in what is called a wind farm. The largest wind farms in the world are in California, where they take advantage of fast, steady winds funneled through mountain passes. The wind farm at Altamont Pass, California (70 miles east of San Francisco) has 7,500 wind turbines. It generates nearly 1,400 megawatts, enough to provide electricity for 5,000 averaged-sized homes. The U.S. produced 10,725 megawatts of wind-generated electricity in 2003, or 0.11 percent of total U.S. electric capacity. Wisconsin currently produces little wind-generated electricity. Over the last 15 years, Wisconsin utilities have had agreements with private wind turbine owners to buy the electricity they produce, but only a handful of these agreements are operating. Worldwide, there are more than 25,000 wind turbines producing 5,000 megawatts of electrical power.



Hydropower

A hydropower system converts the kinetic energy in flowing water into other forms, such as electricity or mechanical energy. This conversion occurs by allowing the water to flow past a waterwheel, propeller, or turbine. The farther the water falls, the more kinetic energy it has. The kinetic energy of flowing water can be increased by building a dam across a river or stream.

Hydroelectric power is measured in kilowatt-hours. One kilowatt-hour of electrical energy is equal to 3,413 Btu. The power output of a hydroelectric power plant is measured in kilowatts (1,000 watts) or megawatts (1,000,000 watts).

In 2003, hydropower supplied the United States with 275 billion kilowatt-hours, or eight percent of its electricity generation. In Wisconsin, 70 hydroelectric sites with a total generating capacity of 494 megawatts were operating in 2002. During that year, these sites produced about two billion kilowatt-hours of electricity.

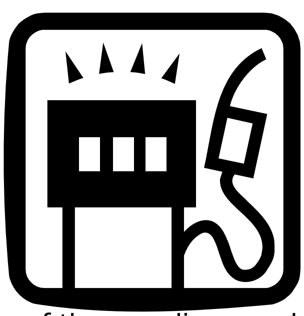
Hydroelectric power provides about 6.5 percent of the world's electricity. In 2003, the world's three largest producers were Canada, Brazil, and China. Canada generates about 57 percent of its electricity from hydropower. Relatively small Norway generates 99 percent of its electricity this way.

Biomass

Biomass is plant or animal matter. Biomass fuels are created from agricultural wastes, alcohol fuels, animal wastes, and municipal solid waste. Wood is also a type of biomass fuel. The energy content of biomass fuels is usually measured in British thermal unit's. The energy produced by a lit match is roughly equal to one Btu.

Agricultural wastes are used to produce energy in many parts of the world. In Hawaii and Brazil, bagasse, a residue left over after sugarcane is harvested, processed and burned in power plants to produce electricity. In Denmark, straw is burned to produce heat for farms. Wisconsin produced 86,121 megawatts of energy from biomass in 2001, an amount equal to the energy used to heat about 10,000 average-sized Wisconsin homes.

Alcohol fuels derived from biomass include ethanol (made from grain alcohol) and methanol (wood alcohol). Both of these fuels can be used to run cars, trucks, and buses.



The United States ethanol production peaked at 3.4 billion gallons in 2004. A year earlier, total ethanol production was equal to 93 percent of the gasoline used by Wisconsin's motor vehicles during that year. Very little methanol produced in the U.S. is made from biomass; it is cheaper to produce it from natural gas. Gasoline mixed with 10 percent ethanol, called gasohol, is currently sold in many service stations throughout the Midwest. Fuels with high concentrations of ethanol and methanol (80 percent or greater) can also be used to run motor vehicles. Brazil's automobiles are powered by pure ethanol produced from sugarcane. Motor vehicle engines that burn gasoline would need to be modified to use alcohol fuels.

Animal wastes such as manure have long provided biomass fuel for rural societies. In developing countries manure is often burned for heating and cooking. Manure can also be placed in tanks called anaerobic digesters, where it is broken down by bacteria and various chemical processes to produce biogas (60 percent methane and 40 percent carbon dioxide) similar to natural gas.
A number of small biogas-fueled power plants are in operation throughout the world. Plants in the U.S. use manure from farms and cattle feedlots. One plant in California that burns manure supplies electricity to as many as 20,000 homes.

Municipal Solid Waste (MSW) is waste disposed of by residents and business. A large percent of this waste is made up of organic materials such as wood, paper products, food waste, and yard waste. Another source of fuel from MSW is landfill gas, which is produced by the breakdown of organic material. Landfill gas, which is similar to natural gas, can be added to natural gas pipelines or burned in small power plants.

Wood

Wood is a type of biomass fuel. Wood was once the main energy resource used during the early history of the United States, but now it plays only a small role in meeting the nation's energy needs. Still, in certain parts of the country, including Wisconsin, wood provides people with a cheap and plentiful source of energy for heating.

Wood for heating is sold in units called cords. A cord is a stack of wood 8 feet long, 4 feet high and 4 feet wide (128 cubic feet). A face cord is a stack 8 feet long, 4 feet high, and 12 to 16 inches wide (32 to 40 cubic feet).

A cord of hardwood such as maple, oak, or hickory may contain twice as much energy as a cord of softwood such as pine or balsam fir. This variation in energy is because a cord of hardwood weighs up to twice as much as a cord of softwood. For example, about twelve cords of white pine are needed to heat an average home in Wisconsin for the year, while only about seven cords of white oak are needed to provide the same amount of heat. These figures assume the average Wisconsin home needs 80 million Btu for heating each year and uses a woodstove with and efficiency of 50 percent.

Wood and other biomass sources provided about 0.3 percent of all the energy used in the United States in 2001. The forest products industry consumes almost two-thirds of all fuel wood. About 20 percent of U.S. homes get some heat from burning wood, while about four percent use it as their primary fuel.

In Wisconsin, about two million cords of wood are cut and burned for energy each year. The total amount of wood energy used in Wisconsin in 2003 was 51.5 trillion Btu, about three percent of the energy used in the State. Worldwide, one-half of all wood that is cut down is used for fuel, while in the developing countries 90 percent is used for fuel. Sweden is a world leader in using wood as an energy source; most of the wood they use is for fueling district heating plants.

Glossary

Active solar heating
A solar heating system that uses a mechanical system to transfer the sun's heat from a solar collector to various parts of a home or building for space heating and water heating purposes.

Alternating current (AC)
An electric current that reverses its direction at regularly recurring intervals.

Ampere (abbrev. Amp; pl. Amperes [Amps])
A unit of electric current. One ampere of current is equal to one coulomb (6.25 x 1,018) of electrons passing a point in an electric circuit in one second. See Electric current.

Battery
A device that converts chemical energy into electrical energy, producing an electric current when connected in a circuit.

Biomass
Plant or animal matter. Biomass can be burned directly as a source of heat or converted to a more convenient gaseous or liquid fuel. Examples include wood and animal waste.

Bituminous coal
A common type of coal containing up to 86 percent carbon and having a high energy content. Bituminous coal is mostly found in the eastern and Midwestern United States. See Coal.

British thermal unit (abbrev. Btu; pl. Btu)
1. A unit of energy equal to 1,055 joules or 252 calories. 2. The amount of energy needed to raise the temperature of one pound of water one degree Fahrenheit. 3. The approximate amount of energy stored in one match tip.

Centralized energy system
Energy system in which large amounts of an energy resource are converted from one form into another form in a central location. The energy is then distributed to and used by a large number of consumers located within a large area. Electricity generated by a nuclear power plant and distributed by transmission lines to a large number of homes and businesses is an example of a centralized energy system.

Chain reaction (also Nuclear chain reaction)
1. A reaction that stimulates its own repetition. 2. A nuclear reaction in which neutrons released from a split uranium-235 (U235) nucleus go on to fission other U235 nuclei. This reaction produces additional neutrons that cause more fissions, which release still more neutrons to cause even more fissions, which release even more neutrons, and so on. See Fission.

Chemical potential energy
The energy stored in chemical bonds holding the atoms of a compound together. Food, wood, batteries, and fossil fuels contain chemical potential energy. See Chemical bond.

Circuit
A conductor or a system of conductors through which electric current flows.

Closed Circuit
An complete electric current through with electrons are flowing electrons from the source, through the circuit, and back to the source.

Coal
A fossil fuel made of sedimentary organic rock that contains more than 40 percent carbon by weight after moisture has been removed. It is formed from plant matter that decayed in swamps and bogs that has been compressed and altered by geological processes over millions of years. Four main types of coal have been identified and ranked based on how much carbon and energy they contain: lignite, subbituminous coal, bituminous coal, and anthracite.

Compact fluorescent lamp (abbrev. CFL)
A small fluorescent lamp designed to fit in light fixtures that use standard incandescent lamps. See Incandescent lamp.

Conduction
1. Heat transfer from particle to particle, occurring most effectively in solids. 2. Transfer of electrical energy through a material via the flow of charged particles, usually electrons.

Conservation
Wise use and careful management of resources, so as to obtain the maximum possible social benefits from them for present and future generations. Energy resources can be conserved by reducing wasteful energy use, using energy for a given purpose more efficiently, or by reducing energy use altogether. See Energy conservation.

Consumption
The process of using natural resources, materials, or finished products to satisfy human wants or needs.

Cord
A volume of wood that measures 8 feet long by 4 feet wide by 4 feet high, or 128 cubic feet. A face cord is equal to about one-third of a cord.

Current (electric)
A flow of electrons in a circuit. It refers to the movement (strength or rate) of electricity past a given point in a fixed amount of time. Electrical current is measured in Amperes (Amps).

Customer charge
A monthly charge that covers the cost of making electric or natural gas service available to a utility's customers. The customer charge includes the cost of meters, meter reading, connecting electric lines or natural gas pipelines to customers, and billing and record-keeping expenses.

Dam
A structure built across a river or stream either for storing water for producing hydropower, or for controlling water flow, or both.

Decentralized energy system
Energy system in which small amounts of an energy resource are converted from one form into another form for use by an individual or small number of consumers. The conversion and consumption of the energy resource usually occurs in the same location. A solar water heater used to provide hot water for a home is an example of a decentralized energy system.

Demand schedule
A chart or table showing the relationship between the price and the quantity of a good or service demanded by customers according to the law of demand. See Law of demand.

Economic sector
A general economic activity that produces or consumes goods and services for the

same or for similar purposes. The five major economic sectors include the residential, commercial, industrial, agricultural, and transportation sectors.

Efficiency
The ratio or percentage of useful output to the total input in any system. See Efficient, Energy efficiency, Inefficient, Conservation, Energy Conservation.

Efficient
Accomplishing a task with a minimum of effort and waste. See Efficiency, Inefficient., Conservation, Energy Conservation.

Elastic potential energy
The energy stored in a solid object when it is stretched or compressed. A stretched rubber band has elastic potential energy.

Electrical circuit (also Electric circuit)
A closed, conducting path or route through which an electric current travels.

Electrical (electromagnetic) energy
Kinetic and potential energy associated with electric charges (e.g., electrons) and their movement. See Electrical potential energy.

Electrical potential energy
Potential energy stored by separating positive and negative electrical charges against electrical forces. A charged battery has electrical potential energy stored in it. See Electrical (electromagnetic) energy.

Electric current (also Current)
A flow of electrically charged particles such as electrons within a conductor or a circuit. See Conduction, Electricity.

Electricity
1. The behavior of negative and positive charges (electrons and protons) due to their attraction and repulsion. 2. The flow of electrons; electric current. See Electrical (electromagnetic) energy, Electric current.

Electromagnet
A magnet made with a coil of wire that has a current passing through it. The magnetic field can be made stronger by coiling the wire around an iron core.

Embodied energy
The total amount of energy needed to manufacture a finished product from raw materials, including the energy used to transport the product.

End use
A set of devices, products, and systems that use energy for the same or for similar purposes. Examples of residential end uses include cooking, lighting, and refrigeration.

Energy
1. The ability to organize or change matter. 2. The ability to do work. See British thermal unit, Calorie, Joule, Kilowatt-hour for units of energy.

Energy charge
The cost of the electricity or natural gas energy used by a utility customer. The energy charge equals the amount of electricity or natural gas used by the customer times the electric or natural gas rate.

Energy conservation
Wise use and careful management of energy resources by reducing wasteful energy use, using energy for a given purpose more efficiently, or reducing energy use altogether. See Conservation.

Energy conversion

The process of changing one form of energy into another. For example, the chemical energy stored in gasoline can be converted into kinetic energy (energy of motion) by an automobile engine. See Energy conversion device.

Energy conversion device
A device specifically designed to convert one form of energy into another. For example, a solar cell is a device that converts solar energy into electrical energy. See Energy conversion.

Energy efficiency
The ratio or percentage of useful work or energy output to total work or energy input in any energy system. For example, the efficiency of a home heating system is equal to the percentage of energy in the fuel or other source that is converted into useful heat. See Efficiency, Efficient, Inefficient.

Energy forms
Basic kinds of energy that are different and distinct from each other. Two main forms of energy are potential energy (the energy stored in matter) and kinetic energy (the energy of motion). More specific forms of energy include thermal, elastic, electromagnetic (e.g., light, electrical, magnetic), gravitational, chemical, and nuclear energy.

Energy resource
Energy source that is used to meet the needs of a human society. For example, oil is an energy resource because it is used to produce fuel for transportation and heating needs. Energy resources are subsets of energy sources. See Energy source.

Energy resource management
Actions and strategies taken by an individual or group to meet their needs by using a specific type of energy resource, reducing wasteful energy use, using energy efficiently, or reducing energy use altogether. See Ecomanagement, Energy use practice.

Energy source
Matter or system from which one or more forms of energy can be obtained. For instance, natural gas is a source of thermal energy, and sugarcane is a source of chemical energy.

Entropy
1. A measure of the dispersal or degradation of energy. 2. A measure of the disorder or randomness in a closed system. For example, the entropy of an unburned piece of wood and its surroundings is lower than the entropy of the ashes, burnt remains, and warmed surroundings due to burning that piece of wood.

Externality cost
Portion of the cost of production and marketing of a product that is borne by society, not by the producer, and thus is not included in the price of the product. For example, the cost of cleaning up a beach after an oil spill is usually not included in the price of motor oil bought at an automotive supply store.

Finite
1. The condition of having boundaries or limits. 2. The condition of having a defined or measurable quantity or value.

First law of thermodynamics
Energy cannot be created or destroyed; it can only be converted from one form to another. For example, the chemical energy stored in coal can be converted into thermal energy.

Fission (also Nuclear fission)
A nuclear process in which the nuclei of a heavy atom (e.g., uranium) is split by a neutron, releasing a large amount of energy and additional neutrons.

Fossil fuel
Carbon-rich fuel formed from the remains of ancient animals and plants. Coal, oil, and natural gas are all fossil fuels.

Fuel
Substances that are burned or consumed by some means to produce energy. Examples of fuels include coal, food, natural gas, oil, and fissionable uranium.

Fuel oil
A liquid fuel composed of a mixture of medium-sized or heavy hydrocarbons and produced by refining crude oil. Lighter varieties of fuel oil include diesel fuel, home-heating oil, kerosene, and jet fuel, while heavier fuel oils are used by industries, ships, and electric power plants to generate heat and power.

Furnace
1. A type of space heating system that heats air. The heated air is circulated throughout a home or building using air ducts and registers. 2. Equipment or enclosure used to convert energy stored in a fuel into heat for any purpose; a combustion chamber.

Fusion (also Nuclear fusion)
A nuclear process in which the nuclei of two light, nonradioactive elements (such as isotopes of hydrogen) are forced together at ultra-high temperatures and pressures to form the nucleus of a slightly heavier element (such as helium) with the release of substantial amounts of energy. The sun's energy comes from nuclear fusion.

Gasoline
A liquid fuel composed of a mixture of small, light hydrocarbons and produced by refining crude oil. Gasoline is mainly used by automobiles, trucks, and other motor vehicles.

Generator
A device or machine that converts mechanical energy into electrical energy.

Geothermal energy
Energy from the heat inside Earth, usually carried to the surface by superheated water and steam.

Gravitational potential energy
A form of potential energy stored in objects by separating them from other objects against the force of gravity. A rock sitting on top of a cliff has gravitational potential energy with respect to the ground (the earth). See Potential energy.

Heat
The transfer of energy from one object at a higher temperature to another object at a lower temperature. Heat can be transferred by conduction, convection, or radiation. Although technically incorrect, the word heat is often used to mean "thermal energy." See Thermal energy.

Horsepower (abbrev. hp)
A unit of power. One horsepower equals 550 foot-pounds per second or 746 watts. See Power.

Hydroelectric power
Electricity produced by the conversion of kinetic energy from falling water using a generator. See Hydropower.

Hydropower
Electricity or mechanical energy produced by the conversion of energy from falling water. Sometimes used to refer only to the

production of electricity from falling water. See Hydroelectric power.

Incandescent lamp
A lamp that contains a wire filament that produces light when heated by an electric current. See Compact fluorescent lamp.

Inefficient
1. Producing only a small useful output from a large total input. 2. Wasteful of time, energy, or materials; not efficient; ineffective. See Efficiency, Efficient.

Insulation
Material that opposes the passage or transmission of heat or electricity.

Isotope
Different forms of atoms of the same element that have different numbers of neutrons in their nuclei. An element may have a number of isotopes. For example, the three isotopes of hydrogen are protium, deuterium, and tritium. All three have one proton in their nuclei, but deuterium also has one neutron, and tritium has two neutrons. See Atom, Neutron.

Joule
A unit of energy. One joule equals 0.2388 calories or 0.0009481 Btu.

Kilowatt (abbrev. kW; pl. Kilowatts)
A unit of power equal to 1,000 watts. See Watt.

Kilowatt-hour (abbrev. kWh; pl. Kilowatt-hours)
1. A unit of energy equal to 3,413 Btu or 3,600,000 joules. 2. An amount of energy that results from the steady production or consumption of one kilowatt of power for a period of one hour.

Kinetic energy
The energy possessed by a moving object. The formula for kinetic energy is 1/2 (mass) x $(\text{velocity})^2$.

Leaking electricity
The energy used by an appliance when the appliance is in its lowest power mode (typically when the appliance is off). A variety of appliances—especially those with remote control devices—consume electricity even after they are turned off. Other appliances—including those with built-in clocks—never stop using electricity.

Life cycle cost
The total cost of an item, product, or finished good over its useful life, including its retail price, energy costs, maintenance costs, and salvage value.

Light
A form of electromagnetic radiation composed of different wavelengths ranging from violet to red that are visible to the naked eye. Light is also a means by which energy can be transferred. See Radiation.

Lignite
A brownish black type of coal containing the lowest percentage of carbon and the lowest energy content of all types of coal. In the United States, lignite is found in Texas, Louisiana, Montana, and North Dakota. See Coal.

Mechanical energy
A combination of potential and kinetic energy. A spring that is expanding and contracting back and forth has mechanical energy. See Kinetic energy, Potential energy.

Megawatt (abbrev. MW; pl. Megawatts)
A unit of power equal to one million watts or 1,000 kilowatts. See Watt.

Meter
A device used to measure and record the amount of electricity or natural gas a utility customer uses.

Meter reader
Utility personnel who read and record information
from a customer's electric and natural gas meters so that energy use and energy costs can be calculated. See Meter.

Motor
A device or machine that converts other forms of energy into mechanical energy. See Electric motor.

Natural gas
An odorless, colorless, gaseous hydrocarbon mixture made up of methane (CH_4) and a small percentage of other light hydrocarbons. Natural gas is found naturally underground or produced by gasification of coal. Natural gas is the cleanest burning fossil fuel.

Newton
A unit that measures force. The unit of force needed to accelerate a mass of one kilogram one meter per second per second.

N-layer
A layer of material used in computer chips, solar cells, and transistors and made by mixing a semiconductor (such as silicon) with substances that have more electrons than the semiconductor has. The n-layer has a negative charge and the excess electrons within it are free to move as part of an electric current. See P-layer, P-N junction, Semiconductor.

Nonrenewable energy resource
Energy resource that is either replenished very slowly or is not replenished at all by natural processes. A nonrenewable resource can ultimately be totally depleted or depleted to the point where it is too expensive to extract and process for human use. Fossil fuels are examples of nonrenewable energy resources.

Nuclear energy
A form of potential energy stored in the nuclei of atoms and released by fission (the splitting of nuclei of heavy atoms such as uranium) or by fusion (the combining of nuclei of light atoms such as hydrogen). See Fission, Fusion.

Open Circuit
A circuit where the path for the current is broken or interrupted. Circuits can be interrupted by an open breaker or fuse or by turning a switch off.

Parallel circuit (also Parallel connection)
An electrical circuit in which each component of the circuit (e.g., a set of light bulbs) is connected across a voltage source (e.g., a battery) so that an electric current flows through each component along a separate path. See Series circuit.

Passive solar heating
A solar heating system that uses a simple solar collector, building materials, or an architectural design to capture and store the sun's heat, but that does not include any mechanical system to transfer the heat to various parts of a home or building.

Petroleum
A mixture of liquid, gaseous, and solid hydrocarbon compounds found naturally underground. The liquid form of petroleum is called crude oil. Petroleum can be processed (refined) into a number of

useful products including asphalt, diesel fuel, fuel oil, gasoline, jet fuel, lubricating oil, and plastics. See Fuel oil, Gasoline, Hydrocarbon.

Photovoltaic cell (abbrevs. pv, PV, pv cell; also Solar cell)
A device that converts solar energy directly into electricity. For example, photovoltaic cells provide electricity for handheld calculators, watches, battery chargers, homes, and satellites.

Photovoltaics
Of, or related to, the use of photovoltaic (solar) cells for producing electricity. See Photovoltaic cell.

P-layer
A layer of material used in computer chips, solar cells, and transistors and made by mixing a semiconductor (such as silicon) with substances that have fewer electrons than the semiconductor has. The p-layer has a positive charge that aids in the attraction of electrons and the flow of electric current. See N-layer, P-N junction, Semiconductor.

Plutonium (symbol: Pu)
A heavy radioactive element that has several isotopes. Plutonium-239 (Pu239, atomic number 94; atomic weight 239) is a fissionable isotope produced artificially by
neutron bombardment of uranium-238 and used as nuclear fuel and in nuclear weapons. Very small amounts of plutonium are also found naturally in uranium ore. See Isotope, Uranium.

P-N junction
The boundary between the n-layer and the p-layer in a semiconductor device such as a solar cell or transistor. The p-n junction forms an electrical barrier that keeps excess electrons in the n-layer separated from the p-layer, which allows the device to work properly in an electrical circuit. See N-layer, P-layer, Semiconductor.

Potential energy
The energy stored in an object because of its position or the arrangement of its parts. Forms of potential energy include chemical, elastic, electrical (electromagnetic), gravitational, nuclear, and thermal energy.

Power
1. The rate in which energy is transferred or converted per unit of time. 2. The rate in which work is done. See Horsepower, Kilowatt, Megawatt, Watt for units of power.

Power plant (also Electric power plant)
1. A human-made industrial system composed of machinery, equipment, and structures designed to convert various energy resources into electricity, usually on a large scale. Examples include coal-fired and nuclear power plants and hydroelectric dams. 2. Any human-made equipment or system that produces power, including the structure that contains it.

Primary energy source
Source of energy either found or stored in nature, such as the sun, coal, and oil.

Propane (formula: C_3H_8)
A colorless hydrocarbon fuel that occurs in both gaseous and liquid form and that is produced from natural gas or crude oil.

Radioactivity
A phenomenon in which certain atomic nuclei spontaneously release particles made of small numbers of protons, neutrons, and electrons and release energy in the form of gamma rays. This

release occurs because the forces holding protons and neutrons together in these nuclei are not completely stable.

Rate
The cost per unit of electricity or natural gas charged to a utility customer. Examples of rates include $0.60 per therm for natural gas and $0.07 per kilowatt-hour for electricity.

Reactor
The part of a nuclear power plant in which energy from nuclear fission is used to heat water for the purpose of producing electricity. A reactor consists of fuel assemblies, control rods, a coolant and moderator, and a pressure vessel. The fuel assemblies, control rods, and coolant/moderator make up the reactor's core. The core is surrounded by the pressure vessel.

Reading date
The date when a meter reader collects consumption information from an electric or natural gas meter.

Recycle
Creating new resources or finished products by processing waste material.

Reduce
Decreasing or diminishing the amount of a natural resource, material, or finished product used for a given purpose.

Renewable energy resource
Energy resource that can be quickly replenished. Certain renewable resources will always be available no matter how they are used (e.g., solar energy), while other renewable resources can be depleted when their rate of use exceeds their rate of replacement (e.g., wood).

Resistance
The opposition of electric current by a material or electrical device. Electrical energy is converted into thermal and other forms of energy when work is done by a current to overcome a resistance.

Reuse
Using a natural resource, material, or finished product more than once in its original form.

R-value
A measure of the ability of a material to insulate against heat loss. The higher the R-value, the better the mat-erial is at insulating. R-values are usually expressed in terms of a standard unit of thickness of the material. For example, loose fiberglass insulation has an average R-value of 2.7 per inch, while rigid boards made of expanded polystyrene insulation have an R-value of 4 per inch.

Secondary energy resource
Energy resource that is produced from a primary energy resource using technology (e.g., electricity produced from solar energy by photovoltaic cells).

Second law of thermodynamics
1. Each time energy is converted from one form to another, some of the energy is always degraded to a lower-quality, more dispersed, less useful form. 2. No system can convert energy from one form to another useful form with 100 percent efficiency. 3. Energy cannot be spontaneously transferred from a cold body to a hot body. 4. The entropy of a system increases over time.

Series circuit (also Series connection)
An electrical circuit in which a voltage source (e.g., a battery) and each component of the circuit (e.g., a set of light bulbs) are connected one after the

other so that an electric current can only flow along one path. See Parallel circuit.

Solar energy
Energy transferred from the sun to Earth in the form of electromagnetic radiation. See Radiation, Sun.

Sound
Mechanical energy vibrations transmitted as waves through a solid, liquid, or gas that can be detected by the human ear.

Space Heating
Heat provided by a self-contained, free standing air heating appliance. It is designed to heat the surrounding area rather than for duct connection.

Stored energy
See Potential energy.

Subbituminous coal
A common type of coal containing up to 50 percent carbon whose energy content is lower than bituminous coal. Subbituminous coal is found in the western United States. See Coal.

Sun
A yellow star around which Earth and the other planets of the solar system orbit. The sun provides nearly all the energy needed to sustain life on Earth. See Solar energy.

Sustainability
As defined by the Brundtland Commission, 1987: Meeting the needs of the present generation without compromising the ability of future generations to meet their own needs.

Switch
A device used to open or close an electric circuit or to divert electric current from one part of a circuit to another.

Therm (pl. Therms)
A unit describing the energy contained in natural gas. One therm equals 100,000 Btu. See Btu.

Thermal energy
The total internal kinetic and potential energy of an object due to the random motion of its atoms and molecules. An object that feels hot has more thermal energy inside it than it does after it has cooled down. Although technically incorrect, the word “heat” is often used to mean thermal energy. See Heat.

Turbine
A machine that converts the kinetic energy of a moving fluid (e.g., pressurized steam) into mechanical energy (the rotating motion of a shaft).

Uranium (symbol: U)
A heavy metallic element that has several isotopes, all of which are radioactive. Of the uranium found in nature, over 99 percent is uranium-238 (U238, atomic number 92; atomic weight 238) and 0.7 percent is uranium-235 (U235, atomic number 92; atomic weight 235). A mixture of U235 and U238 is used as fuel for nuclear reactors. See Isotope.

Volt (abbrev. V; pl. Volts)
A unit of voltage (potential difference). One volt is equal to performing one joule of work to move or separate one coulomb (6.25 x 1,018) of electrons.

Water (formula: H_2O)
A compound that appears in liquid, solid (ice), and gaseous (water vapor) form on or near Earth’s surface that is essential for nearly all plant and animal life.

Watt (abbrev. W; pl. Watts)
A unit of power. One watt equals the production or use of one joule of energy per second. See Joule, Kilowatt, Megawatt, Power.

Wind
The movement and circulation of Earth's atmosphere near its surface; moving air.

Wind generator
A generator specifically designed to convert the kinetic energy in wind into electrical energy (electricity). See Generator.

Work
The transfer of energy from one object or system to another by applying a force over a distance. The formula for work is (force) x (distance).