Energy and Power Technologies

Foundations of Technology (ITEA 16)

Outcomes

In this presentation you will learn:

- Energy cannot be created nor destroyed; however, it can be converted from one form to another. (ITEA 16-J)

- Energy can be grouped into major forms: thermal, radiant. (ITEA 16-K)

- It is impossible to build an engine to perform work that does not exhaust thermal energy to the surroundings. (ITEA 16-L)

- Energy resources can be renewable or non-renewable. (ITEA 16-M)

- Power systems must have a source of energy, a process, and loads. (ITEA 16-N)

Energy

Energy is essential for meeting human needs and wants. It is the foundation for raising standards of living. Energy contributes to increased life expectancies. Over time, people have used more energy. Today, each person uses more than one hundred times the energy early humans used.

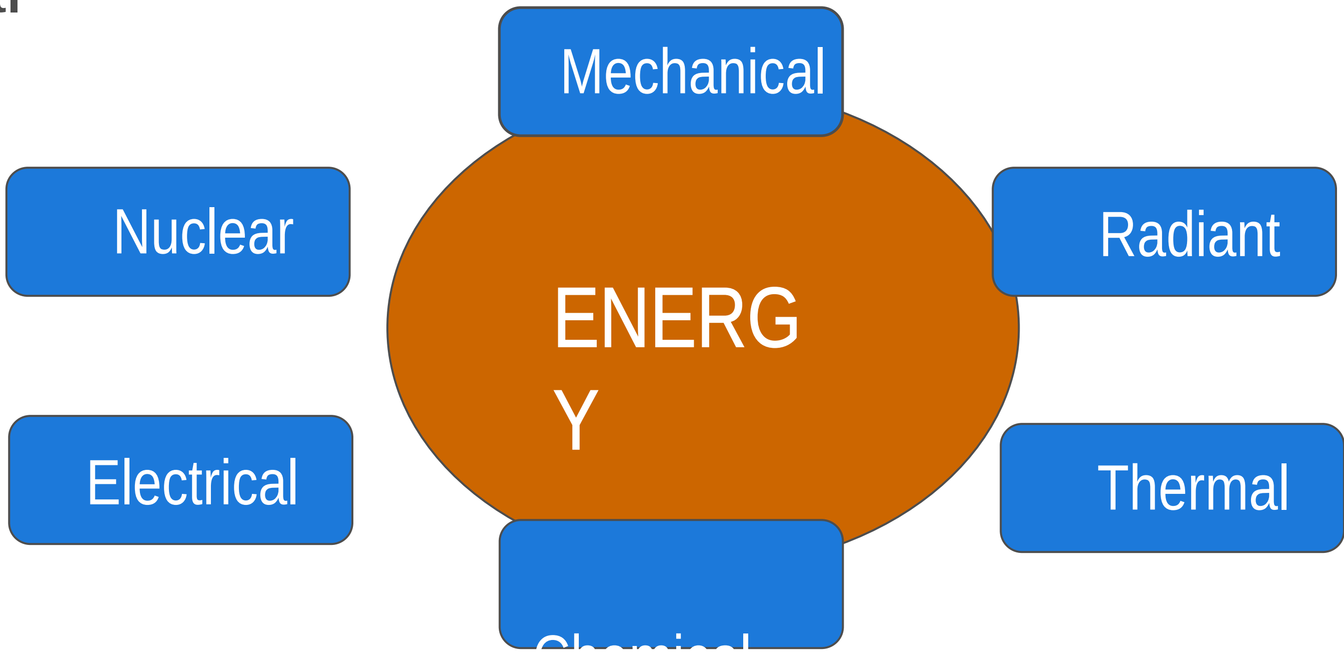
In fact, over the last one hundred years, our energy use has more than tripled. Some people estimate that the demand for energy will double in the next fifty years.

Energy is defined as the ability to do work. Energy is everywhere and is used by all of us.

Six Forms of Energy

Energy is grouped into six major forms —

1. Mechanical
2. Radiant
3. Chemical
4. Thermal
5. Electrical
6. Nuclear



Mechanical Energy

Most of us are familiar with ***mechanical energy***. Often, it is produced by motion of technological devices. We associate machines with mechanical energy. This is correct, but it does not include all types of mechanical energy. Wind and moving water have motion and thus are also sources of mechanical energy.

Radiant Energy

Radiant energy is energy in the form of electromagnetic waves. The main source of radiant energy is the sun. Radiant energy may be emitted by objects heated with a flame or from a light bulb in a lamp.

Chemical Energy

Chemical energy is energy that is stored within a chemical substance. Typical sources of chemical energy are the fuels we use to power our technological machines. The most common are petroleum, natural gas, and coal. Chemical energy is released when a substance is put through a chemical reaction.

Thermal Energy

Thermal energy is another name for heat energy. Thermal energy cannot be seen directly. You can see its effects, however, by watching the heated airwaves above a road on a very hot day. Thermal energy is usually felt. The energy strikes a surface, such as your skin, and elevates its temperature.

Electrical Energy

Electrical energy is associated with electrons moving along a conductor. This conductor may be a wire in a human-developed electrical system. The conductor could also be the air, as with lightning. Lightning is a natural source of electrical energy. Electrical energy is used as a basic source for other forms of energy.

Nuclear Energy

Nuclear energy is associated with the internal bonds of atoms. When atoms are split, they release vast quantities of energy. This process is called ***fission***. Likewise, combining two atoms into a new, larger atom releases large amounts of energy. This process is called ***fusion***.

Nuclear Power

The world is a large energy system. Fuels and biomatter burn. This energy produces the power that drives our society. Yet, it also places dangerous pollutants into the air, land, and water. Nuclear power provides a much longer-lasting source of energy.

Nuclear power plants do not leak the toxic gases into the atmosphere that are produced by chemical consuming power plants. Yet, the waste from nuclear power is more dangerous and longer lasting.

Energy Conservation

Conservation is also important in managing energy sources. Conservation can take various forms, from simply turning off appliances when they are not being used to designing products that are more energy efficient. Make sure you take the time to investigate various approaches to conserving energy.

When new energy and power systems are designed, conservation of energy and environmental concerns must be incorporated. Consideration must be given to the by-products of systems, such as the waste stream given off in industrial use. Using any information you learn will help you design, develop, and test power systems and determine if they are efficient and non-polluting.

Energy Resources

Energy resources can be **renewable** or **nonrenewable**. Examples of renewable resources are the sun and agriculture products, while nonrenewable resources include fossil fuels, such as coal, oil, and natural gas.

Power Plant

Nonrenewable Energy Resources

Nonrenewable energy resources are those materials that cannot be replaced. Once they are used up, we will no longer have that source. The most common nonrenewable energy resources are petroleum, natural gas, and coal. These resources are called ***fossil fuels***. They originated from living matter.

Millions of years ago plant and animal matter were buried under the earth. Over time, this matter was subjected to pressure, and it decayed. This resulted in deposits of solid (coal and peat), liquid (petroleum), and gaseous (natural gas) fuels. These deposits have been found in many locations on the earth.

Coal

Oil

Natural Gas

Peat

Peat is decayed plant matter that sank in swamps. It is made up of moss, reeds, and trees. Other plant matter and soil covered and pressed on it. The decaying matter compressed into solid material. It became somewhat like coal. In some parts of the world, it heats homes. Also, gardeners use peat as a soil additive.

Coal

Coal is also decayed plant matter. It started out just like peat. The weight of soil and rock, however, greatly compacted the coal. Coal became a hard, black, rock-like substance. It is mined in deep mines or in strip mines closer to the surface.

Industry and homes once widely used coal. Coal provided heat for powering steam locomotives. Coal-fired stoves and furnaces were common in homes, factories, and public buildings. Today, coal is a major fuel in electricity generating plants. Also, it is used in steelmaking and as a base for many other products.

Petroleum

Petroleum is a thick liquid. It is thought to be the decayed remains of plant and animal life. Like coal, it became buried and partially decayed. It is pumped from pockets or "wells" deep below ground.

Petroleum requires refining. Refining is a heat process separating the petroleum into more usable products. The products include liquids such as gasoline, diesel fuel, kerosene, and fuel oil.

Natural Gas

Natural gas is lighter than air. It is mostly made up of a gas called ***methane***. This gas is a simple chemical compound made up of carbon and hydrogen atoms. It is usually found near petroleum underground. Like petroleum, natural gas is pumped from below ground.

Natural gas is used for many of the same purposes for which we use petroleum. It is, however, generally used for heating buildings and producing electric power. Natural gas is the key ingredient for making many plastics.

Uranium

Uranium is another exhaustible energy source. It is an element that developed when the solar system came into being. Uranium is a radioactive mineral that is used in nuclear power plants.

Renewable Energy Resources

Renewable energy resources are biological materials that can be grown and harvested. Their supply is directly affected by human propagation, growing, and harvesting activities. These activities can be improved by practices known as bio-related technology or biotechnology, which was a discussion in a previous lesson.

Examples of renewable energy resources are the sun and agriculture products, while nonrenewable energy resources include fossil fuels, such as coal, oil, and natural gas.

Wood and Grains

The most common renewable energy resources are wood and grains. They can be burned directly to generate thermal energy. Corn is often converted to alcohol (ethanol), which then can be used as a fuel.

Also, corn can be fermented to produce ethanol (grain alcohol), which then can be used as a fuel.

Alternative and sustainable energy resources are being developed and tested in order to replace or supplement nonrenewable sources. For example, garbage can be used to produce methane gas and then burned for thermal energy.

Biomass and Biofuels

Organic matter such as garbage, sewage, straw, animal waste, and other waste can be an energy resource. They are often referred to as ***biomass*** resources. The prefix *bio-* means having a biological, or living, origin. The resources can be traced back to plant or animal matter.

These organic materials can be burned directly as ***biofuels***. Also, these materials can be converted into methane, a highly flammable gas. This process generates a ***biogas***, which can replace some exhaustible fuel resources.

Conversion of Energy

Energy, which is the capacity to do work, can be converted from one form to another. Thermal energy is usually a by-product in a conversion process. Some energy converters are more efficient than others.

For example, electric generators are more than 95 percent efficient at converting mechanical energy to electrical energy, while the fluorescent lamp is only about 20 percent efficient in converting electrical energy to radiant energy. However, the fluorescent lamp is more than four times as efficient as the incandescent lamp.

Energy cannot be created nor destroyed; however, it can be converted from one form to another. In scientific terms, this is called the **Law of Conservation of Energy**, which can be stated as, “The total energy of an isolated system does not change.”

Kinetic and Potential Energy

Energy can be classified into two types – **kinetic** and **potential.** Kinetic energy is the energy a body has associated with motion. Potential energy a body has because of its position (if it can be acted upon by a force) or condition; it is often referred to as stored energy.

Kinetic energy is energy in motion. An example of kinetic energy is water spilling over a dam that can be harnessed to do work since it is in motion. Since the water is moving it is said to have kinetic energy. Heat and light are other example of kinetic energy.

Potential energy is stored energy. An example would be water backed up behind a dam is not doing work, but could do work if released. Potential energy is also the electrical energy stored in a battery.

Thermodynamics

Thermodynamics is the study of energy. Thermodynamics is the branch of science dealing with the laws and theories related to energy in the universe. There are two main laws of thermodynamics, the **first** and the **second** law.

First Law of Thermodynamics

The **First Law of Thermodynamics** says that energy under normal conditions cannot be created or destroyed, simply transformed from one type of energy to another.

For example, a chemical reaction such as lighting a match does not create new energy but only converts one type of energy to another. What’s happening with the match is that as the match is burnt, potential energy is released and converted to heat and light, kinetic energy.

Second Law of Thermodynamics

The **Second Law of Thermodynamics** is a bit more complex than the first law, but basically it says that any time you do work, including time you make an energy transformation, some of the starting energy is going to be lost as heat.

For example, when you drive a car some of the gasoline's energy is lost right away as heat, some gets turned into mechanical energy to move the car. Even some of the mechanical energy is also lost as heat. For instance, the tires on a car at the end of a trip will be hot from friction with the road. This heat is an energy loss and is a consequence of the second law.

Energy Loss: Implications of the Second Law

It is impossible to build an engine to perform work that does not exhaust thermal energy to the surroundings. This is one form of the “Second Law of Thermodynamics.” No energy system can be 100 percent efficient.   Large coal-fired electric generation systems strive for 40 percent efficiencies.

That means 60 percent of the energy from the coal is lost in the form of heating the environment rather than being turned into electrical energy. The law also has many wide ranging consequences, such as the fact that there can be no perpetual motion machine.

- First, the process is not 100% efficient, so there is no such thing as a perpetual motion machine
- Secondly and most important, says that living systems will break down unless they have some input of energy.

Closed Systems

Strictly speaking the second law also says that closed systems become more disorganized over time. Often this is expressed by the saying “entropy tends to increase.” Entropy is a measure of disorder or uncertainty about a system.

By a closed system what is meant is a system that is completely isolated from the rest of the universe, nothing can get in or out of the box. For example, if you had a rat and a piece of cheese in a perfectly sealed and insulated box then that would be a closed system.

If the rat would die and over a million years all that would be left in the box is a mass of carbon, and some additional gasses such as carbon dioxide, ammonia, and methane the temperature of the box would be higher than the starting temperature when the rat and cheese were first put in! This is because, in effect as the rat dies, work is being done and energy as heat is being released.

Using the rat as an example, entropy is a measure of disorder and the tie in with the second law is simply that heat is due to random disordered movement of molecules.

Open Systems

Real systems are of course not closed systems but instead are open systems.

Open systems take in or capture matter and or energy from the surrounding environment. Living things are open systems. They fight against entropy by taking matter and energy allowing them to stay organized. For example, a flowering plant as a seed will start out with fairly high entropy and become more organized.

The plant dies and then its entropy increases again. It is not that living things violate the second law, but by doing work they postpone its effects.

Power and Energy: What is the difference?

Power and **energy** are two words people often confuse. They are not the same thing. As we said, energy is the ability to do work. Power, on the other hand, is the amount of work done in a set period of time, or at the rate at which work is done. It is the result of using energy for a definite time span.

The rate at which energy is changed from one form to another or moved from one place to another is also called ***power***. For example, suppose you pedal a bicycle for one mile. That is work. You have used energy to create the movement. The energy you used can be calculated.

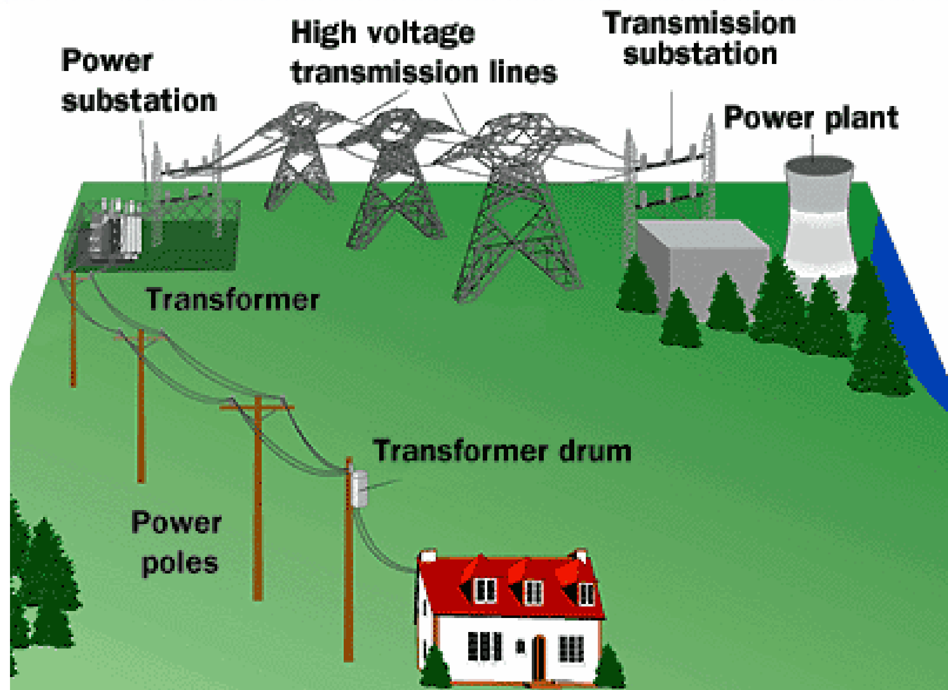
Power Systems

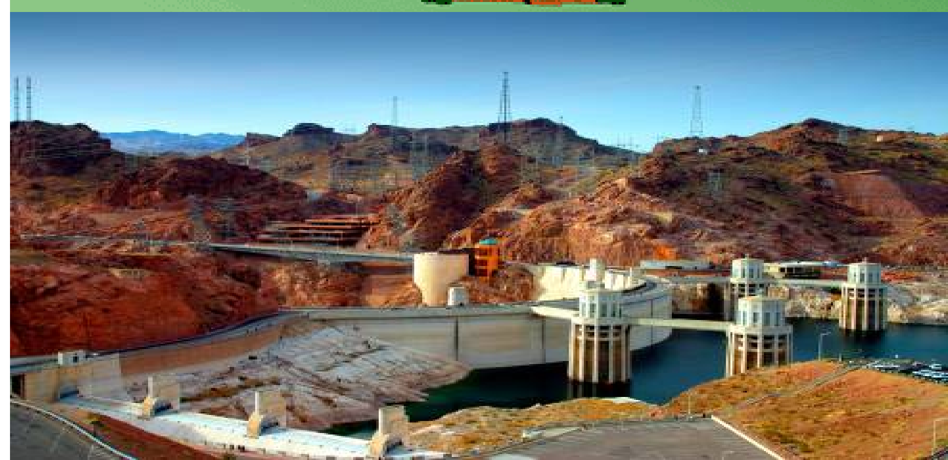
Power systems convert energy from one form to another and may transfer energy from one place to another.

All power systems have

- **Inputs:** thermal, chemical, nuclear, mechanical, radiant, and electrical
- **Processes:** Processes include conversion, transmission, and storage
- **Outputs:** Outputs are work and thermal loss
- **Feedback**

For example, the output of the system is sampled and provides a signal back to the input or process phase of the system in order to modify it.





Measurement of Energy Consumed: Btu

Typically, one of two measurements is used to measure the energy consumed. The first unit of measure is called a *Btu*, or *British thermal unit*. A *Btu* is defined as the amount of heat energy needed to raise the temperature of one pound of water by 1°F, at sea level. One Btu equals the energy in one kitchen match.

As you can see, it is a fairly small unit of measurement. Often we measure energy by thousands of Btu. One thousand Btu equal the energy in an average candy bar. The Btu is the measurement unit used in the United States. In countries using the metric system, energy is measured in Newton-meters, or ***joules*** (pronounced **jewels**).

Scientists around the world use the *joules* unit of measurement. One thousand joules equal one Btu.

When you measure the energy it takes you to ride a bicycle one mile, you are calculating ***power***. As you have just read, power is energy used over time.

It can be calculated with a simple formula: Power equals the distance traveled, times the force required, divided by the time.

The space shuttle's power at takeoff is about 11,000,000,000 Watts, or 11 Giga Watts (GW), or 11,000,000,000 Joules of energy being converted from stored chemical energy to kinetic energy every second. Eleven Giga Watts is the same as 14.75 million horsepower, or 10,424,048 BTU's of chemical energy converting to kinetic energy every second.

Summary

- Energy is defined as the ability to do work
- Energy is grouped into six major forms — mechanical, radiant, chemical, thermal, electrical, and nuclear
- Energy can be classified into two types — kinetic (energy associated with motion) and potential (stored energy)
- All power systems have inputs, processes, outputs, and typically some type of feedback
- All forms of energy come from somewhere. We call those places “sources.”
- Conservation is important in managing energy sources
- Energy resources can be renewable or nonrenewable
- Nonrenewable energy resources are those materials that cannot be replaced
- Renewable energy resources are biological materials that can be grown and harvested
- Energy cannot be created nor destroyed; however, it can be converted from one form to another
- Thermodynamics is the study of energy

Summary

- The First Law of Thermodynamics says that energy under normal conditions cannot be created or destroyed, simply transformed from one type of energy to another
- The Second Law of Thermodynamics says that any time you do work, some of the starting energy is going to be lost as heat
- Entropy is the degree of disorder in a system
- A closed system is a system that is completely isolated
- An open system takes in or captures matter and or energy from the surrounding environment
- The total energy of an isolated system does not change
- Power is the amount of work done in a set period of time, or at the rate at which work is done
- A British thermal unit (*Btu)* is defined as the amount of heat energy needed to raise the temperature of one pound of water by 1°F, at sea level
- Scientists around the world use the *joules* unit of measurement. One thousand joules equal one Btu