



# **Renewable Energy Sources**

**Lesson Plan: NRES F1-2**

# Anticipated Problems

1. What are renewable energy sources?
2. What are advantages and disadvantages of renewable energy sources?

# Terms

- biomass
- biopower
- co-firing
- direct-fire system
- energy
- exhaustible energy source
- fermentation
- gasification



# Terms

- generator
- geothermal power
- hydropower
- inexhaustible energy source
- methanogenesis
- nonrenewable energy source
- photovoltaic system
- renewable energy source

# Terms

- solar power
- tidal power
- transesterification
- turbine
- turbulence
- wave power
- wind power

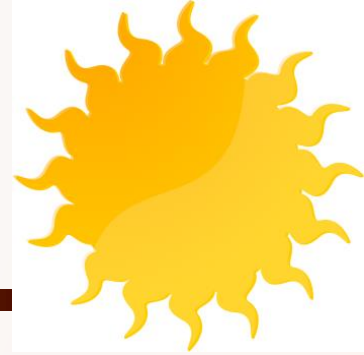
# Energy

- ***Energy*** is the ability to do work. Energy exists in different forms, including:
  - Heat
  - Kinetic or mechanical energy
  - Light
  - Potential energy
  - Electrical
  - Chemical
  - Other

# Sources Energy

- The modern world is greatly dependent on energy.
  - Sources of energy are considered inexhaustible or exhaustible and renewable or nonrenewable.

# Inexhaustible



- An ***inexhaustible energy source*** is a source that will not run out in the foreseeable future.
  - Sunlight
  - Wind
  - Geothermal energy



# Exhaustible

- An ***exhaustible energy source*** is a source available in limited quantity that can be completely used.
  - Some exhaustible natural sources are renewable, while others are nonrenewable.



# Renewable & Nonrenewable

- A ***renewable energy source*** is a source that can be replaced naturally.
- A ***nonrenewable energy source*** is a source that cannot be replaced after use.
  - Fossil fuels
  - Nuclear energy

# Renewable Energy Sources

- Renewable energy sources meet about 8 percent of the total energy needs in the United States.
  - Ten percent of electricity is produced using renewable energy sources.
  - Nearly all electricity is produced with some type of turbine.

# Turbine

- A ***turbine*** is any kind of machine that converts kinetic energy of a moving fluid or gas to mechanical power by the impulse or reaction of the fluid or gas with a series of buckets, paddles, or blades arrayed around a wheel or cylinder.
  - Uses: water, wind, steam, or some other force
  - As the turbine spins, mechanical energy is transferred to a generator.

# Generator

- A ***generator*** is a device that converts mechanical energy into electrical energy. Inside a generator, metal coils are surrounded by magnets. The mechanical energy produced by the turbine causes the metal coils to spin past the magnets. This action creates electricity.

# Renewable Energy Sources

- The energy is then conveyed along transmission lines to homes and businesses. The five renewable energy sources used most often are:
  - Hydropower
  - wind power
  - Solar power
  - Geothermal power
  - Biopower

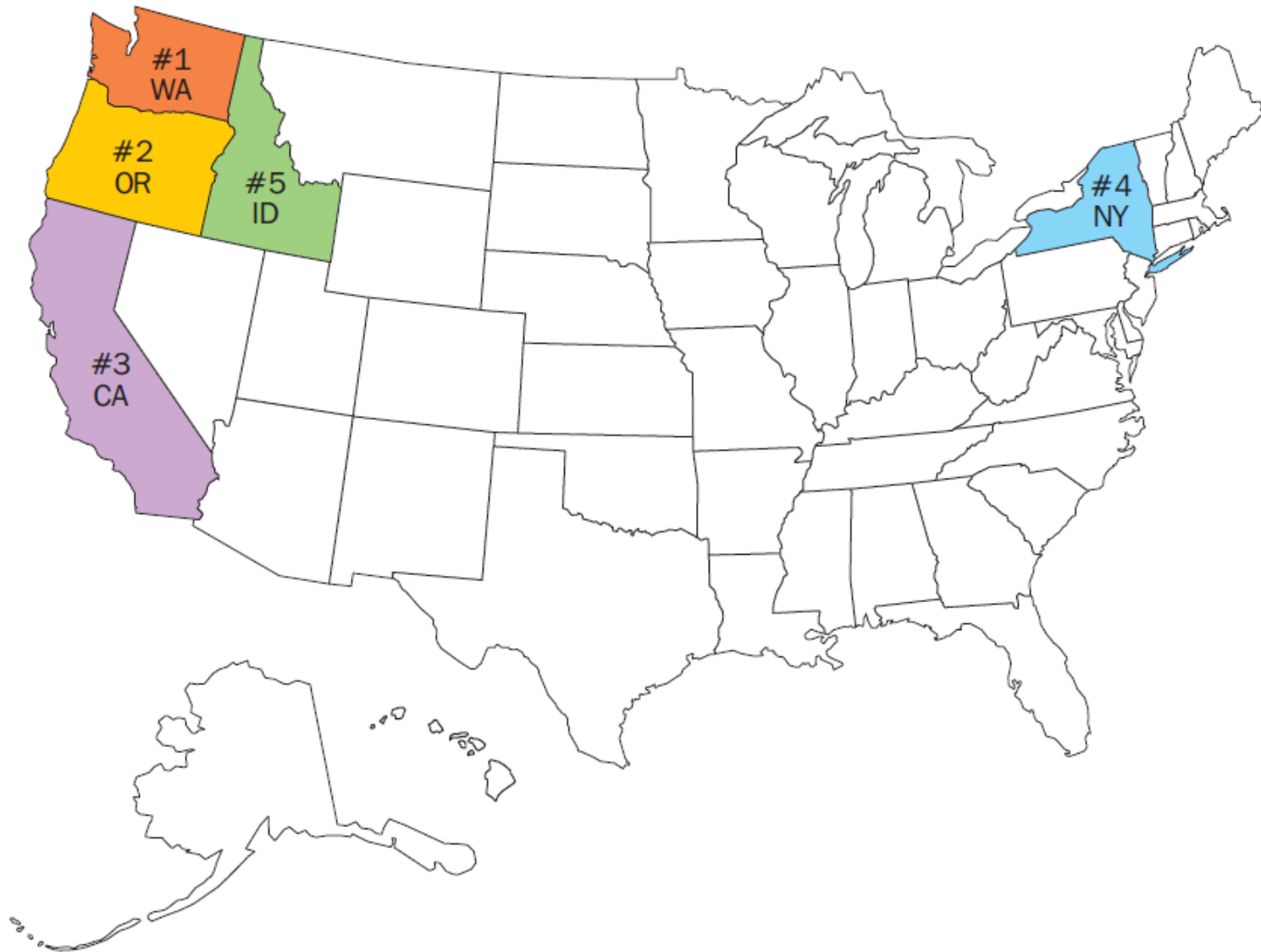
# Hydropower

- ***Hydropower*** is power in the form of electrical energy produced when the mechanical energy of moving water is transferred by a rotating turbine to a generator.
  - In the United States, hydropower accounts for about 6 percent of the total electricity.

# TOP HYDROPOWER-PRODUCING STATES, 2011

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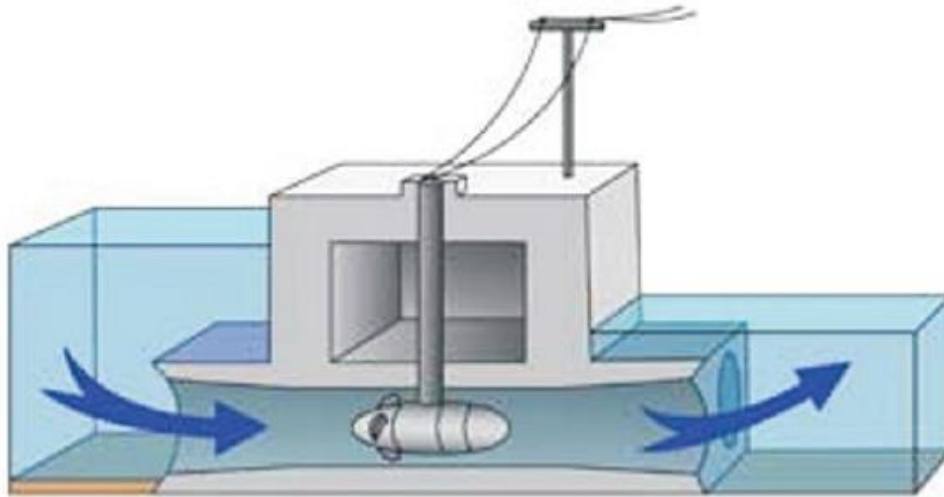
# Types of Hydropower

- Hydroelectric power plants associated with dams or built along streams.
- ***Tidal power*** - electricity is generated through the turning of turbines by ocean tides.
- ***Wave power*** is energy from ocean surface waves used to turn turbines for the production of electricity.

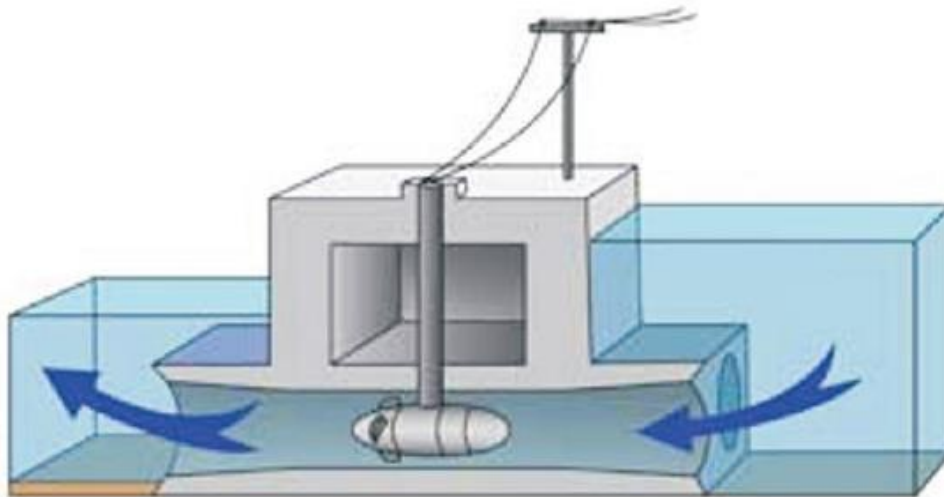
# HYDROPOWER PLANT



# TIDAL POWER



Tide Coming In



Tide Going Out

# WAVE POWER





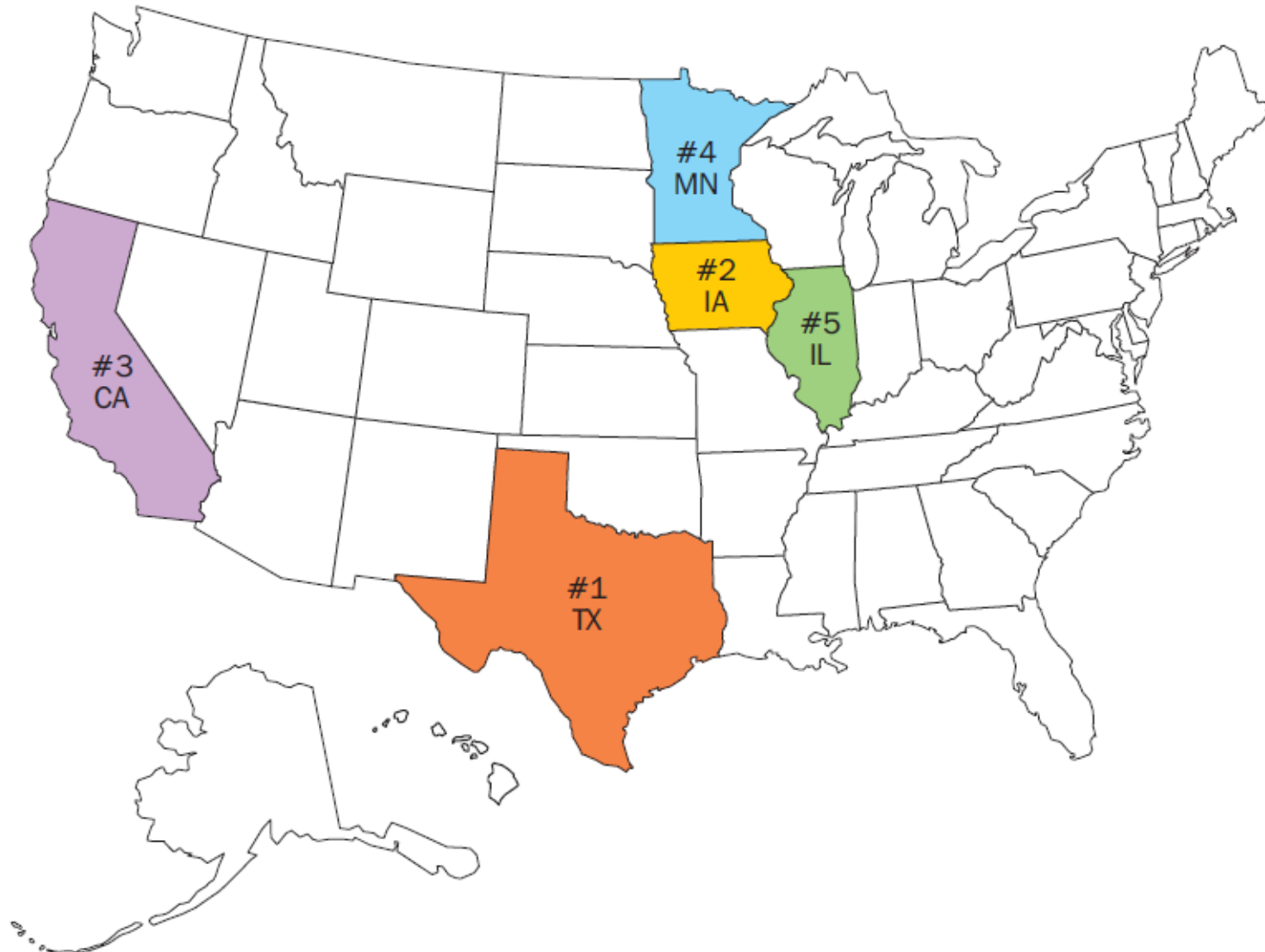
# Wind Power

- ***Wind power*** is energy harnessed from the force of the wind used to create electricity.
  - According to the U.S. Department of Energy, wind power has been the fastest-growing source of new electric power generation for several years.
  - In 2009, generation from wind power increased 33.5 percent over 2008 numbers, bringing the share of total generation to 1.9 percent.

# TOP WIND POWER-PRODUCING STATES, 2011

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# Wind Power

- Wind is produced from the uneven heating of the earth's surface by the sun. The production of electricity requires wind at high speeds.
- A wind energy system requires that the rotors attached to the turbine move smoothly and avoid turbulence.
  - ***Turbulence*** is a situation caused by the unsteady movement of air or water.

# WIND POWER SYSTEM





# Solar Power

- ***Solar power*** is energy from the sun used by mechanical solar systems to produce electricity or to capture the sun's heat for the purpose of heating space or water.

# Photovoltaic System

- A ***photovoltaic system*** is a system that converts solar radiation into direct-current electricity using semiconductors.
  - Semiconductor materials, such as silicon, cause electrons to separate from the atom.
  - The electrons are captured through an electrical circuit and provide usable electricity.

# PHOTOVOLTAIC SYSTEM

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# Geothermal Power

- ***Geothermal power*** is heat energy harnessed from within the earth to produce electricity.
  - “Geothermal” means heat (*thermal*) from the earth (*geo*).
  - Heat from the earth heats water in underground reservoirs.
  - Reservoirs with water temperatures from 225° to 600°F can be used to produce electricity.



# GEOHERMAL PLANT

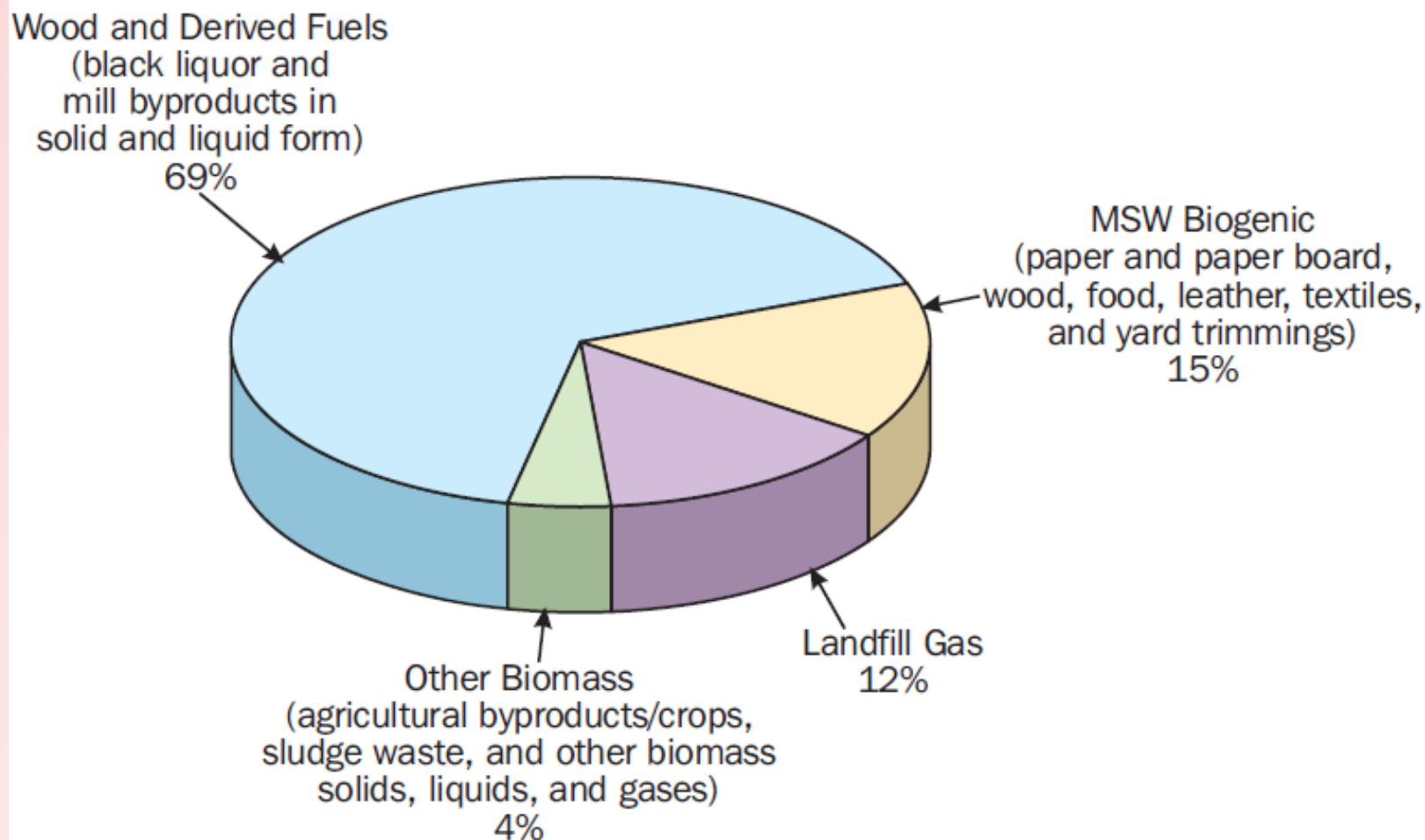




# BioPower

- **Biopower** is electric power produced from biomass. **Biomass** is living and recently living biological material that can be used as fuel or for industrial production.
  - Agricultural or forestry wastes
  - Organic materials from municipal and industrial wastes

# U.S. BIOPOWER GENERATION BY FUEL, 2008





# Biomass

- Biomass can be burned directly or converted into another usable form of energy.
  - Supplies about 4% of the energy used in the US
  - Single largest source of non-hydro renewable electricity

# Direct-Fire System

- A ***direct-fire system*** is a system in which biomass is burned to produce steam that drives a turbine that produces electricity with a generator.
  - Similar to the process used in coal or oil plants
  - Most electricity generated from biomass is produced by direct-fire incineration.

# Co-Firing

- ***Co-firing*** is the burning of biomass in combination with fossil fuels in power plants.
  - The addition of biomass as a fuel can significantly reduce air pollutants, especially sulfur emissions.
  - Most economical use of biomass, uses existing technologies

# Methanogenesis

- ***Methanogenesis***, or anaerobic digestion, is the process of microorganisms feeding on dead plant and animal tissue in the absence of oxygen to produce methane.
  - Methane is the main ingredient in natural gas.
  - Methane gas may be burned to create steam and run a generator or be used in micro-turbines and fuel cells.

# Gasification

- ***Gasification*** is the heating of biomass at high temperatures in an oxygen-free environment to create gases such as carbon monoxide, hydrogen, and carbon dioxide.
  - The mixture of gases is referred to as syngas
  - The syngas is then burned to create electricity.
  - One of the most efficient and least polluting of the conversion technologies.

# Transesterification

- A chemical reaction is a process of combining plant- or animal-derived products to create products such as biodiesel.
- ***Transesterification*** is the chemical reaction process that involves combining triglycerides or soybean oils with alcohols to produce biodiesel. The reaction is catalyzed with the addition of an acid or a base.

# Fermentation

- ***Fermentation*** is a process in which an alcohol (ethanol) is produced from biomass.
  - Biomass is broken down into basic sugars.
  - Yeast is added to convert the sugars to ethanol.

# Advantages & Disadvantages

- Renewable energy sources have both advantages and disadvantages.





# Hydropower

- Advantages: Clean and nonpolluting
  - Dams can prevent flooding
  - Tidal power is inexpensive
  - Wave power is highly efficient, low cost to operate
  - Wave power: no emissions



# Hydropower

## ■ Disadvantages

- Dams: expensive to build
- Dams: harmful environmental consequences
- Tide power: limited to ten hours daily
- Wave power: damage to the marine ecosystem if improperly placed



# Wind Power

## ■ Advantages

- No water or air pollution
- Inexpensive, self maintaining, self-reliant

## ■ Disadvantages

- Intermittent in many places
- May be considered unattractive in communities
- Require a large plot of land



# Geothermal Power

## ■ Advantages

- Last longer than traditional systems
- Once in operation, the energy is practically free
- No water or air pollution

## ■ Disadvantages

- Limited areas of the world can support
- Higher initial cost

# BioPower

## ■ Advantages

- Good commercial electric power generation option
- Available almost everywhere
- May reduce municipal, agricultural, industrial waste

## ■ Disadvantages

- Can contribute to global warming
- More expensive than fossil fuels
- Less efficient

# Review

- What percentage of renewable energy sources meet the total energy needs in the US?\
- List the five renewable energy sources used most often.
- What are some advantages of renewable energy sources?
- What are some disadvantages of renewable energy sources?