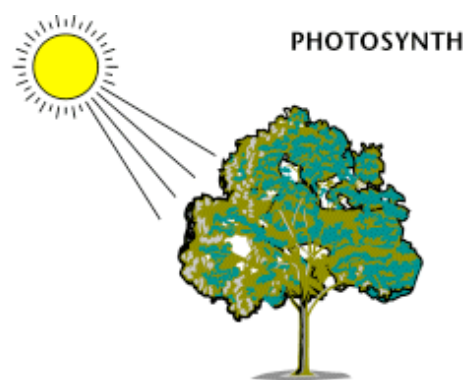
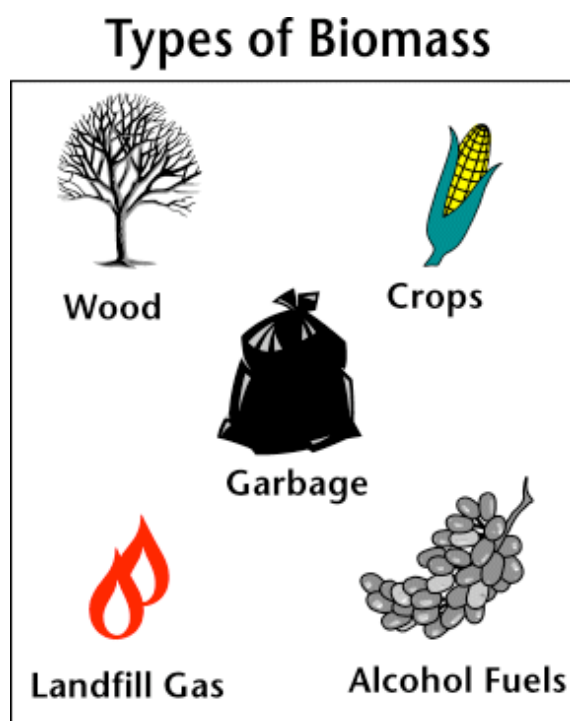


## Renewable Biomass

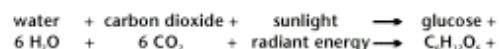
### Biomass Basics

#### Biomass — Renewable Energy from Plants and Animals

Biomass is organic material made from plants and animals. Biomass contains stored energy from the



In the process of photosynthesis, plants convert radiant energy from the sun into chemical energy in the form of glucose - or sugar.



Source: The National Energy Education Project

Source: The National Energy Education Project

sun. Plants absorb the sun's energy in a process called photosynthesis. The chemical energy in plants gets passed on to animals and people that eat them.

Biomass is a renewable energy source because we can always grow more trees and crops, and waste will always exist. Some examples of biomass fuels are wood,

crops, manure, and some garbage.

When burned, the chemical energy in biomass is released as heat. If you have a fireplace, the wood you burn in it is a biomass fuel. Wood waste or garbage can be burned to produce steam for making electricity, or to provide heat to industries and homes.

## **Converting Biomass to Other Forms of Energy**

Burning biomass is not the only way to release its energy. Biomass can be converted to other useable forms of energy, such as methane gas or transportation fuels, such as ethanol and biodiesel.

Methane gas is the main ingredient of natural gas. Smelly stuff, like rotting garbage, and agricultural and human waste, release methane gas — also called "landfill gas" or "biogas."

Crops like corn and sugar cane can be fermented to produce ethanol. Biodiesel, another transportation fuel, can be produced from left-over food products like vegetable oils and animal fats.

## **How Much Biomass Is Used for Fuel?**

Biomass fuels provide about 4% of the energy used in the United States. Researchers are trying to develop ways to burn more biomass and less fossil fuels. Using biomass for energy may cut back on waste and greenhouse gas emissions.

## **Wood & Wood Waste**

### **Burning Wood Is Nothing New**

The most common form of biomass is wood. For thousands of years people have burned wood for heating and cooking. Wood was the main source of energy in the United States and the rest of the world until the mid-1800s. Wood continues to be a major source of energy in much of the developing world.

In the United States, wood and wood waste (bark, sawdust, wood chips, and wood scrap) provide about 2% of the energy we use today.

## Using Wood and Wood Waste

About 84% of the wood and wood waste fuel used in the United States is consumed by industry, electric power producers, and commercial businesses. The rest, mainly wood, is used in homes for heating and cooking.

Many manufacturing plants in the wood and paper products industry use wood waste to produce their own steam and electricity. This saves these companies money because they don't have to dispose of their waste products and they don't have to buy as much electricity.

## Waste-To-Energy

### Energy from Garbage

Garbage, often called municipal solid waste, is a major source of biomass. Biomass is garbage made of organic materials from plants or animals. Organic materials like food scraps, lawn clippings, and leaves are all examples of biomass trash.

Americans produce more and more waste each year. In 1960, the average American threw away 2.7 pounds of trash a day. Today, each American throws away about 4.5 pounds of trash every day. What are we

Hybrid Poplar Wood Chips Being Unloaded in Crookston, Minnesota



Source: National Renewable Energy Laboratory, U.S. Department of Energy

GARBAGE energy



It takes 2,000 pounds of garbage to equal the heat energy in 500 pounds of coal.

Source: The National Energy Education Project

going to do with all our trash?

One solution is to burn it. (Burning is sometimes called combustion.) Organic waste is waste that is made from plant or animal products. All organic waste contains energy. People have burned one type of organic material — wood — for hundreds of thousands of years. Ancient peoples burned wood to keep themselves warm and to cook their food.

## **Waste-to-Energy Plants Make Steam and Electricity**

Today, we can burn garbage in special waste-to-energy plants and use its heat energy to make steam to heat buildings or to generate electricity. There are about 90 waste-to-energy plants in the United States. These plants generate enough electricity to supply almost 3 million households.

Garbage does not contain as much heat energy as coal, the most common fuel burned to generate electricity. It takes one ton (2,000 pounds) of garbage to equal the heat energy in 500 pounds of coal.

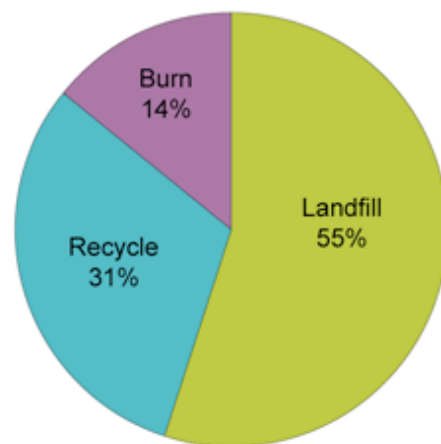
## **Waste-to-Energy Plants Also Dispose of Waste**

But providing electricity is not the major advantage of waste-to-energy plants. It actually costs more to generate electricity at a waste-to-energy plant than it does at a coal, nuclear, or hydropower plant.

The major advantage of burning waste is that it reduces the amount of garbage we bury in landfills. Waste-to-energy plants dispose of the waste of 40 million people.

The average American produces more than 1,600 pounds of waste a year. If all this waste were landfilled, it would take more than two

**What We Do With Our Trash**



Source: The National Energy Education Project

cubic yards of landfill space. That's the volume of a box 3 feet long, 3 feet wide, and 6 feet high. If that waste were burned, the ash residue would fit into a box 3 feet long, 3 feet wide, but only 9 inches high.

### **Solid Waste Incinerators Simply Dispose of Waste**

There also are solid waste incinerators that simply burn trash. They don't use the heat energy to make steam or electricity.

Between waste-to-energy plants and solid waste incinerators, the United States burns 14% of its solid waste.

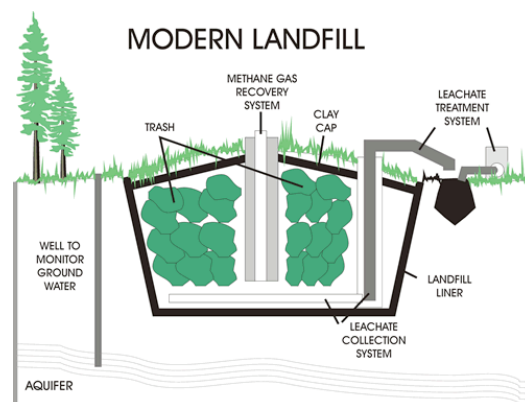
## **Biogas**

### **Collecting Gas from Landfills**

Landfills can be a source of energy. Organic waste produces a gas called methane as it decomposes, or rots.

Methane is the same energy-rich gas that is in natural gas, the fuel sold by natural gas utility companies. It is colorless and odorless. Natural gas utilities add an odorant (bad smell) so people can detect seeping gas, but it can be dangerous to people or the environment. New rules require landfills to collect methane gas as a pollution and safety measure.

Some landfills simply burn the methane gas in a controlled way to get rid of it. But the methane can also be used as an energy source. Landfills can collect the methane gas, treat it, and then sell it as a commercial fuel. It can then be burned to generate steam and electricity.



Source: The National Energy Education Project

## Landfill Gas Energy Projects

Today, there are almost 400 operating landfill gas energy projects in the United States. California has the most landfill gas energy projects in operation (73), followed by Illinois (36), and Michigan (27).

## Using Animal Waste

Some farmers collect biogas from tanks called "digesters" where they put all of the manure, dirt, and waste from their barns. A biogas digester can convert animal waste into useable energy. On some dairy farms, the muck from inside the barn is collected and put into a large digester, or tank. Inside the digester, methane gas is separated from the liquid and solid waste. The methane gas can then be used to generate electricity to light a barn, or to sell to the electric power grid.

Read about a [field trip](#) to a real waste-to-energy plant or learn about the history of MSW.

## Biomass & the Environment

### Each Form of Biomass Has a Different Impact

Biomass pollutes the air when it is burned, but not as much as fossil fuels do. Burning biomass fuels does not produce pollutants such as sulfur that can cause acid rain. When burned, biomass releases [carbon dioxide](#), a [greenhouse gas](#).

But when biomass crops are grown, a nearly equivalent amount of carbon dioxide

is captured through photosynthesis. Each of the different forms and uses of biomass impact the environment in a different way.

## **Burning Wood**

Because the smoke from burning wood contains pollutants like carbon monoxide and particulate matter, some areas of the country won't allow the use of wood-burning fireplaces or stoves on high pollution days. A special clean-burning technology can be added to wood-burning fireplaces and stoves so that they can be used even on days with the worst pollution.

## **Burning Municipal Solid Waste (MSW) or Wood Waste**

Burning municipal solid waste (MSW, or garbage) and wood waste to produce energy means that less of it has to get buried in landfills. Like coal plants, waste-to-energy plants produce air pollution when the fuel is burned to produce steam or electricity. Burning garbage releases the chemicals and substances found in the waste. Some of these chemicals can be dangerous to people, the environment, or both, if they are not properly controlled.

Plants that burn waste to make electricity must use technology to prevent harmful gases and particles from coming out of their smoke stacks. The particles that are filtered out are added to the ash that is removed from the bottom of the furnace. Because the ash may contain harmful chemicals and metals, it must be disposed of carefully.

## **Controlling Air Emissions**

The Environmental Protection Agency (EPA) applies [strict environmental rules to waste-to-energy plants](#). The EPA requires waste-to-energy plants to use anti-pollution devices, including scrubbers, fabric filters, and electrostatic precipitators.

The EPA wants to ensure that harmful gases and particles don't go out the smokestack into the air. Scrubbers clean chemical gas emissions by spraying a

liquid into the gas stream to neutralize the acids. Fabric filters and electrostatic precipitators remove particles from the emissions. The particles are then mixed with the ash that is removed from the bottom of the waste-to-energy plant's furnace when it is cleaned.

A waste-to-energy furnace burns at such high temperatures (1,800 to 2,000°F) that many complex chemicals naturally break down into simpler, less harmful compounds. This chemical change is a kind of built-in anti-pollution device.

## **Disposing of Ash**

Another challenge is the disposal of the ash after combustion. Ash can contain high concentrations of various metals that were present in the original waste. Textile dyes, printing inks, and ceramics, for example, contain the metals lead and cadmium.

Separating waste before combustion can solve part of the problem. Because batteries are the largest source of lead and cadmium in the solid waste stream, they should be taken out of the mix and not burned.

The EPA tests ash from waste-to-energy plants to make sure it's not hazardous. The test looks for chemicals and metals that would contaminate ground water by trickling through a landfill. Ash that is safe can be reused for many applications.

About one-third of all the ash produced is used in landfills as a daily or final cover layer, to build roads, to make cement blocks, and even to make artificial reefs for marine animals.

## **Collecting Landfill Gas or Biogas**

Biogas is a gas composed mainly of methane and carbon dioxide that forms as a result of biological processes in sewage treatment plants, waste landfills, and livestock manure management systems. Methane is one of the greenhouse gases associated with global climate change. Many of these facilities capture and burn the biogas for heat or electricity generation. Burning methane is actually beneficial



because methane is a stronger greenhouse gas than carbon dioxide. The electricity generated from biogas is considered "green power" in many states and may be used to meet state renewable portfolio standards (RPS).

## **Ethanol**

Ethanol was one of the first fuels used in automobiles, and now nearly all gasoline sold in the United States contains some ethanol. The Federal government has set a renewable fuel standard (RFS) that mandates increasing biofuels use through 2022, most of which will probably be ethanol. Ethanol and gasoline fuel mixtures burn cleaner and have higher octane than pure gasoline, but have higher "evaporative emissions" from fuel tanks and dispensing equipment. These evaporative emissions contribute to the formation of harmful, ground-level ozone and smog. Gasoline requires extra processing to reduce evaporative emissions before it is blended with ethanol. Carbon dioxide, a greenhouse gas, forms when ethanol burns, but growing plants like corn or sugarcane to make ethanol may offset these carbon dioxide emissions because plants absorb carbon dioxide as they grow.

## **Biodiesel**

Biodiesel was the fuel used in the first diesel engines. Compared to petroleum diesel, biodiesel combustion produces less sulfur oxides, particulate matter, carbon monoxide, and unburned and other hydrocarbons, but more nitrogen oxide. Similar to ethanol, biodiesel use may result in lower net-carbon dioxide emissions if the source of biodiesel are oils made from plants, which absorb carbon dioxide.