

**AI 3010 WASTE AND BY PRODUCT UTILIZATION**

**UNIT III NOTES**



## **Electricity generation form surplus biomass**

Biomass is used for facility heating, electric power generation, and combined heat and power. The term biomass encompasses a large variety of materials, including wood from various sources, agricultural residues, and animal and human waste.

Biomass can be converted into electric power through several methods. The most common is direct combustion of biomass material, such as agricultural waste or woody materials. Other options include gasification, pyrolysis, and anaerobic digestion. Gasification produces a synthesis gas with usable energy content by heating the biomass with less oxygen than needed for complete combustion.

Pyrolysis yields bio-oil by rapidly heating the biomass in the absence of oxygen. Anaerobic digestion produces a renewable natural gas when organic matter is decomposed by bacteria in the absence of oxygen.

Different methods work bet with different types of biomass. Typically, woody biomass such as wood chips, pellets, and sawdust are combusted or gasified to generate electricity. Corn stover and wheat straw residues are baled for combustion or converted into a gas using an anaerobic digester. Very wet wastes, like animal and human wastes, are converted into a medium-energy content gas in an anaerobic digester. In addition, most other types of biomass can be converted into bio-oil through pyrolysis, which can then be used in boilers and furnaces.

Compared to many other renewable energy options, biomass has the advantage of dispatchability, meaning it is controllable and available when needed, similar to fossil fuel electric generation systems. The disadvantage of biomass for electricity generation, however, is that the fuel needs to be procured, delivered, stored, and paid for. Also, biomass combustion produces emissions, which must be carefully monitored and controlled to comply with regulations.

### **DESCRIPTION**

Most biopower plants use direct-fired combustion systems. They burn biomass directly to produce high-pressure steam that drives a turbine generator to make electricity. In some biomass industries, the extracted or spent steam from the power plant is also used for manufacturing processes or to heat buildings. These combined heat and power (CHP) systems greatly increase overall energy efficiency to approximately 80%, from the standard biomass electricity-only systems with efficiencies of approximately 20%. Seasonal heating requirements will impact the CHP system efficiency.

A simple biomass electric generation system is made up of several key components. For a steam cycle, this includes some combination of the following items:

- Fuel storage and handling equipment
- Combustor / furnace
- Boiler
- Pumps
- Fans
- Steam turbine
- Generator
- Condenser
- Cooling tower
- Exhaust / emissions controls
- System controls (automated).

Direct combustion systems feed a biomass feedstock into a combustor or furnace, where the biomass is burned with excess air to heat water in a boiler to create steam. Instead of direct combustion, some developing technologies gasify the biomass to produce a combustible gas, and others produce pyrolysis oils that can be used to replace liquid fuels. Boiler fuel can include wood chips, pellets, sawdust, or bio-oil. Steam from the boiler is then expanded through a steam turbine, which spins to run a generator and produce electricity.

In general, all biomass systems require fuel storage space and some type of fuel handling equipment and controls. A system using wood chips, sawdust, or pellets typically use a bunker or silo for short-term storage and an outside fuel yard for larger storage. An automated control system conveys the fuel from the outside storage area using some combination of cranes, stackers, reclaimers, front-end loaders, belts, augers, and pneumatic transport. Manual equipment, like front loaders, can be used to transfer biomass from the piles to the bunkers, but this method will incur significant cost in labor and equipment operations and maintenance (O&M). A less labor-intensive option is to use automated stackers to build the piles and reclaimers to move chips from the piles to the chip bunker or silo.

Wood chip-fired electric power systems typically use one dry ton per megawatt-hour of electricity production. This approximation is typical of wet wood systems and is useful for a first approximation of fuel use and storage requirements but the actual value will vary with

system efficiency. For comparison, this is equivalent to 20% HHV efficiency with 17 MMBtu/ton wood.

Most wood chips produced from green lumber will have a moisture content of 40% to 55%, wet basis, which means that a ton of green fuel will contain 800 to 1,100 pounds of water. This water will reduce the recoverable energy content of the material, and reduce the efficiency of the boiler, as the water must be evaporated in the first stages of combustion.

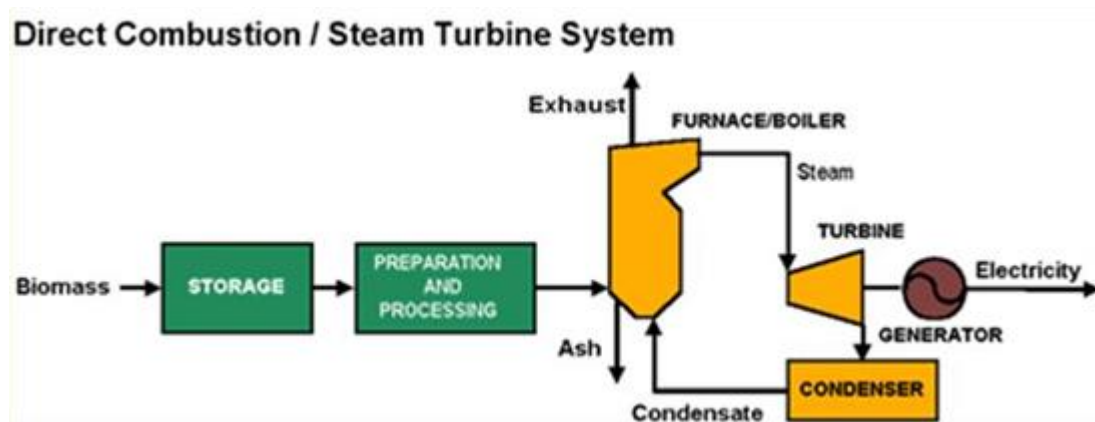
The biggest problems with biomass-fired plants are in handling and pre-processing the fuel. This is the case with both small grate-fired plants and large suspension-fired plants. Drying the biomass before combusting or gasifying it improves the overall process efficiency, but may not be economically viable in many cases.

Exhaust systems are used to vent combustion by-products to the environment. Emission controls might include a cyclone or multi-cyclone, a baghouse, or an electrostatic precipitator. The primary function of all of the equipment listed is particulate matter control, and is listed in order of increasing capital cost and effectiveness. Cyclones and multi-cyclones can be used as pre-collectors to remove larger particles upstream of a baghouse (fabric filter) or electrostatic precipitator.

In addition, emission controls for unburned hydrocarbons, oxides of nitrogen, and sulfur might be required, depending on fuel properties and local, state, and Federal regulations.

### How Does It Work?

In a direct combustion system, biomass is burned in a combustor or furnace to generate hot gas, which is fed into a boiler to generate steam, which is expanded through a steam turbine or steam engine to produce mechanical or electrical energy.



In a direct combustion system, processed biomass is the boiler fuel that produces steam to operate a steam turbine and generator to make electricity.

## Types And Costs Of Technology

There are numerous companies, primarily in Europe, that sell small-scale engines and combined heat and power systems that can run on biogas, natural gas, or propane. Some of these systems are available in the United States, with outputs from about 2 kilowatts (kW), and approximately 20,000 British thermal units (Btu) per hour of heat, to several megawatts (MW). In addition, small-scale (100 to 1,500 kW) steam engine/gen-sets and steam turbines (100 to 5,000 kW) that are fueled by solid biomass are currently available in Europe.

In the United States, direct combustion is the most common method of producing heat from biomass. Small-scale biomass electric plants have installed costs of \$3,000 to \$4,000 per kW, and a levelized cost of energy of \$0.8 to \$0.15 per kilowatt hour (kWh).

The two principal types of chip-fired direct combustion systems are stationary- and traveling-grate combustors, otherwise known as fixed-bed stokers and atmospheric fluidized-bed combustors.

### FIXED-BED SYSTEMS

There are various configurations of fixed-bed systems, but the common characteristic is that fuel is delivered in some manner onto a grate where it reacts with oxygen in the air. This is an exothermic reaction that produces very hot gases and generates steam in the heat exchanger section of the boiler.

### FLUIDIZED-BED SYSTEMS

In either a circulating fluidized-bed or bubbling fluidized-bed system, the biomass is burned in a hot bed of suspended, incombustible particles, such as sand. Compared to grate combustors, fluidized-bed systems generally produce more complete carbon conversion, resulting in reduced emissions and improved system efficiency. In addition, fluidized-bed boilers can use a wider range of feedstocks. Furthermore, fluidized-bed systems have a higher parasitic electric load than fixed-bed systems due to increased fan power requirements.

There are three ways of using biomass to generate electricity. Biomass is either:

1. burned;
2. broken down by bacteria;
3. or converted to a gas or liquid fuel.

Burning biomass is the most used method. This is also called **combustion**. The term for burning matter to generate electricity is thermal generation.

Electricity isn't produced directly from this combustion. Burning solid biomass materials heats giant boilers filled with water. This transforms liquid water into steam. The steam creates pressure in the boiler. The force of the steam rotates a **turbine**. The turbine then moves a wire coil in a generator.

Some biomass plants generate electricity by burning methane. Methane is a gas that can be collected from landfills. These plants use a slightly different process than plants that burn solid biomass. The products of burning methane, instead of steam, cause the turbine to spin. As with solid biomass, the rotation of the turbine drives a generator.

### **Advantages of Biomass Electricity Generation**

Unlike other types of **renewable energy resources**, biomass plants can generate power all the time. They don't rely on intermittent things such as wind or sun. This makes electricity from biomass reliable.

But biomass is different from other types of renewable energy sources. Unlike the wind and the sun, biomass is consumed when electricity is generated. To make biomass renewable, the consumed plant material needs to be replaced as quickly as it is used. This may be through growing new crops or planting trees. If this were to happen, then burning biomass would not increase **greenhouse gas** levels. But if it does not happen, then burning biomass will increase greenhouse gas levels.

Another advantage of using biomass is that it can prevent some types of waste from going to landfills.

### **Disadvantages of Biomass Electricity Generation**

Burning biomass produces similar greenhouse gases to burning fossil fuels. These greenhouse gases contribute to rising global temperatures. Burning biomass also releases other pollutants into the air. These pollutants include particulate matter, nitrogen oxides, and sulphur dioxide. Air pollution can cause respiratory issues, heart disease, cancer, and other health issues.

Biomass-generated electricity can also impact the environment in other ways. For example, cutting down trees can lead to **deforestation**. Growing plants to use as biomass can impact soil quality and water usage. Growing these plants instead of other plants can reduce **biodiversity**.

We could solve some of these problems with technology. For example, more careful land use, air filters or cleaner sources of biomass could help. Other sources of biomass, like methane gas from food waste, may be more common in the future. These technologies may make producing electricity from biomass better for the environment.