

UNIT 4

BIO-ENERGY

4.1 ENERGY FROM BIOMASS

The energy obtained from organic matter derived from biological organisms (plants and animals) is known as biomass energy or simply, bioenergy. Animals feed on plants and plants grow through the photosynthesis process using solar energy.

Photosynthesis process is primarily responsible for the generation of biomass energy. Biomass energy resources are available from botanical plants, vegetation, algae, animals and organisms living on land or in water.

Biomass resources are mainly classified into two categories. They are as follows:

1. Biomass from cultivated fields, crops and forests.
2. Biomass from municipal waste, animal dung, forest waste, agricultural waste, bioprocess waste and fishery waste.

Biomass energy may be transformed either by chemical or biological processes to produce intermediate bio-fuels such as methane, producer gas, ethanol and charcoal etc.

Biomass cycle maintains the environmental balance of oxygen, CO₂, rain etc. Biomass is used for producing the process heat and electricity, gaseous and solid fuels, liquid and chemicals.

4.1.1. Biomass Resources

Biomass resources for energy production encompass a wide spectrum of materials ranging from forest, agriculture, aquaculture (fresh and sea water) and industrial and social activities such as food processing, urban refuse etc.

(i) Forests:

Forests, natural or cultivated, serve as sources of fuel wood, charcoal and producer gas. Some fast growing intensive trees such as eucalyptus, poplar and pine are specially cultivated for the purpose of energy.

(ii) Agricultural residues:

Crop residues such as straw, rice husk, coconut shell, groundnut shell, sugarcane baggage etc., are gasified to obtain producer gas.

(iii) Energy crops:

Certain cultivated plants produce raw material for bio-fuels. They are as follows: (a) Sugarcane:

It is a raw material source for bio-ethanol. The sugarcane stems are milled to obtain the cane juice which is subsequent used for sugar (sucrose) or alcohol (ethanol) production. The residual fraction from the sugarcane stem milling is named as bagasse. One-third of the total energy is available in sugarcane and another similar amount is available in bagasse, leaves and cane tops.

(b) Oil producing plants:

Oil producing plants such as sunflower, rapeseed, palm oil, castor oil, soybean, groundnut and cottonseed have the capabilities of producing energy.

(iv) Aquatic plants:

Some water plants grow very fast and provide raw materials for producing biogas or ethanol. These are water kelp, seaweed and algae, etc.

(v) Urban waste:

Urban waste is of two types. They are given below.

(a) Municipal solid waste (MSW) (b) Sewage (liquid waste).

Advantages and Disadvantages of Biomass Energy

Advantages of biomass energy:

1. It is a renewable source.
2. The pollutant emissions from combustion of biomass are usually lesser than fossil fuels.
3. Commercial use of biomass may avoid or reduce the problems of waste disposal in other industries.
4. Use of biogas plants apart from supplying clean gas also leads to improved and stabilized sanitation.
5. The forestry and agricultural industries which supply feed stocks also provide substantial economic development opportunities in rural areas.
6. The energy storage is an in-built feature of it.

Disadvantages of biomass energy:

1. It is dispersed and land intensive source.
2. It is often of low energy density.
1. It is also labour intensive and the cost of collecting large quantities of biomass for commercial application is significant.

4.1.2 Biomass Fuels

Biomass is an organic carbon-based material that reacts with oxygen in combustion and natural metabolic process to release heat. Some of its forms available to users are given below.

i) Fuel wood:

Wood is the most obvious and oldest source of biomass energy. Direct combustion is the simplest way to obtain heat energy. Its energy density is 16-20 MJ/kg. It can also be converted in to more useful forms such as charcoal or producer gas.

ii)Charcoal:

Charcoal is a clean, dry, solid fuel of black colour. It has 75-80% carbon content and has energy density of about 30 MJ/kg. It is obtained by carbonization process of woody biomass to achieve higher energy density per unit mass. It is also used for making high quality steel.

(iii) Fuel pellets:

Crop residues such as straw, rice husk, cow dung etc., are pressed to form lumps known as fuel pellets and used as solid fuel.

(iv) Bio-ethanol:

Ethanol (C₂H₅OH) is a colourless liquid biofuel. Its boiling point is 78°C and energy density is 26.9 MJ/kg. It can be derived from wet biomass containing sugar starches or cellulose. Commercial ethanol is used in specially designed IC engines.

(v) Biogas:

Organic wastes from plants, animals and humans contain enough energy to contribute significantly to energy supply in many areas. Biogas is produced in a biogas fermenter or digesters. If a raw material is cow manure, the output biogas will contain about 50% to 60% CH₄, 30% to 40% CO₂, 5% to 10% H₂, 0.5% to 0.7% N₂ with trace amounts of O₂ and H₂S. Its energy density is about 23 MJ/m³. It is used for cooking, lighting, heating and operating small IC engines, etc.

Properties of Biogas:

Biogas is a mixture of different components and the composition varies depending upon the characteristics of feed materials, amount of degradation, etc. Biogas predominantly consists of 50 to 70% methane (CH₄), 30 to 40% carbon dioxide (CO₂) and low amount of other gases. Methane is a combustible gas. The energy content of biogas depends on the amount of methane it contains. Methane content varies from about 50% to 70%. The properties of the biogas are given in the following Table 4.1.

Table 4.1 Properties of biogas

| Properties | Range |
|---|---------|
| Net calorific value (MJ/m ³) | 22.6 |
| Air required for combustion (m ³ /m ³) | 5.7 |
| Ignition temperature (°C) | 700 |
| Density (kg/m ³) | 1.2 |
| Flash point (°C) | 650-750 |

(vi) Producer gas:

Woody matter such as crop residue, wood chips, bagasse, rice husk, coconut shell etc can be transformed to producer gas (wood gas, water gas or blue gas) by a method known as gasification of solid fuel. The gas production depends upon the type of biomass and the design of gasifier

(ii) Vegetable oils (bio-diesel):

It can be used as such or blended with diesel as a diesel engine fuel.