

AI3702 RENEWABLE ENERGY IN AGRICULTURAL ENGINEERING

UNIT 1 BIO RESOURCE – AN INTRODUCTION

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UNIT 1

Biomass is organic matter produced by plants, both terrestrial (those grown on land) and aquatic (those grown in water) and their derivatives. It includes forest crops and residues, crops grown especially for their energy content on “energy farms” and animal manure. Unlike coal, oil and natural gas, which takes millions of years to form, biomass can be considered a *renewable energy source* because plant life renews and adds to itself every year. It can also be considered a form of solar energy as the latter is used indirectly to grow these plants by *photosynthesis*.

biomass means organic matter and photo-chemical approach to harness solar energy means harnessing of solar energy by photosynthesis. Solar energy is stored in the form of chemical energy. Hence

Solar energy → Photosynthesis → Biomass → Energy generation.

Biomass resources fall into three categories:

(i) Biomass in its traditional solid mass (wood and agriculture residue) and (ii) biomass in non-traditional form (converted into liquid-fuels). The first category is to burn the biomass directly and get the energy. In the second category, the biomass is converted into ethanol (ethyl alcohol) and methanol (methyl-alcohol) to be used as liquid fuels in engines. The *third* category is to ferment the biomass anaerobically to obtain a gaseous fuel called *bio-gas*.

Bio-gas or methane is produced by the anaerobic decomposition of organic materials. This gas is produced from cowdung and other wastes such as cornhusks, leaves, straw, garbage, flesh of carcasses, poultry droppings, pig dung, human excreta and sewage.

Availability of Biomass

The total terrestrial crop alone is about 2×10^{12} metric tonnes. This includes : (i) Sugar crops such as sugarcane and sweet sorghum; (ii) Herbaceous crops, which are nonwoody plants that are easily converted into liquid or gaseous fuels; and (iii) Silviculture (forestry) plants such as cultured hybrid poplar, sycamore, sweetgum, alder, eucalyptus, and other hardwoods.

1 The terrestrial crops have energy potential of 3×10^{22} joules. The efficiency of solar energy utilisation in natural photosynthesis is only 0.1 to 2 percent. At present only 1 percent of world biomass is used for energy conversion.

Current *research* focuses on the screening and identification of species that are suitable for short-rotation growing and on optimum techniques for planting, fertilization, harvesting, and conversion. Fast growing trees, sugar, starch and oil containing plants can be cultivated which have about 5 percent efficiency of solar energy utilisation.

1 The estimated production of agricultural residue in India is 200 million tonnes per year and that of wood is 130 million tonnes.

1 Aquatic crops are grown in fresh sea and brackish waters, both submerged and emergent plants. These include seaweeds, marine algae etc.

1 *Animal and human wastes* are an *indirect terrestrial crop* from which *methane* for combustion, and *ethylene* can be produced while *retaining the fertilizer value of the manure*. The daily produce of cowdung is about 13.5 kg per cattle which can be used

to produce 0.46 m³ of *biogas* in ‘Gobar gas plant’. This gas is sufficient to produce 1 kWh of electricity in a biogas engine.

The *human waste* can also be used for production of biogas. *Community latrines* can be planned in the villages for collection of night soil for feeding to biogas plants. Wastes of 200 persons can be used to produce about 5 m³ of gas per day to extract 12 kWh of equivalent energy by running a biogas engine.

Sources of biomass

1. Wood: Wood biomass as any timber-derived product (softwood or hardwood) capable of being converted to energy through direct combustion or gasification. Wood may converted to solid fuel through pelletizing, or to liquid fuel through myriad processes. While wood biomass may include any part of the tree, cost differential in the various components is a primary limiting factor.

2. Agricultural crops: Wheat, rice, rapeseed, sunflower, soybeans, corn, sugarcane, and sugar beets are all examples of this type of agricultural bio-mass products. The sugar from corn, sugar beets, and sugar cane are commonly fermented to produce ethanol. Oilseed crops such as rapeseed, sunflower, and soy-beans can be refined into biodiesel.

3. Animal waste: One of the renewable energy sources is biomass of animals such as cow dung, in which converted into energy via gasification process. In some cases, cow dung is so abundant that is easily fed to bio-digester to produce biogas.

4. Algae: These organisms have enormous potential as a source of biomass energy. The most familiar form of algae is seaweed, where it can be grown in ocean water so it does not deplete freshwater resources. It also does not require soil, and therefore does not reduce arable land that could potentially grow food crops. Algae contain oils that can be converted to a biofuel. Algae can be processed under certain heat and pressure creating “green crude” which has similar properties to crude oil, and can be used as biofuel.

5. Sewage sludge: Treatment of sewage results in another sources of biomass. The major part of the dry matter content of this sludge consists of nontoxic organic compounds, which is a combination of primary sludge and secondary (microbiological) sludge. The sludge also contains a substantial amount of inorganic material and a small amount of toxic components. Therefore, there are many options to produce energy (heat, electricity, or biofuel) as one of the key treatment steps.

6. Industrial residues: Include waste materials that generated from many sectors of industry, especially food industry such as meat production, solid wastes from peeling of fruit and vegetables as well as food that does not meet quality control standards. All that waste can be used as biomass energy sources. The potential for these industrial wastes to be anaerobically digested to produce biogas, or fermented to produce ethanol, and several commercial examples of waste-to-energy conversion are already exist.

Advantages of biomass

Biomass is a clean, renewable energy source. Its initial energy comes from the sun, where plants or algae biomass can regrow in a relatively short amount of time. Trees, crops, and municipal solid waste are consistently available and can be managed sustainably. If trees and crops are sustainably farmed, they can offset carbon emissions when they absorb carbon dioxide through respiration. In some bioenergy processes, the amount of carbon that is re-absorbed even exceeds the carbon emissions that are released during fuel processing or usage. Many biomass feedstocks, such as switch grass, can be harvested on marginal lands or pastures, where they do not compete with food crops. Unlike other renewable energy sources, such as wind or solar, biomass energy is stored within the organism, and can be harvested when it is needed.

Disadvantages of biomass

If biomass feedstocks are not replenished as quickly as they are used, they become non-renewable. A forest, for instance, can take hundreds of years to re-establish itself. This is still a much shorter time period than a fossil fuel such as peat. It can take 900 years for just a meter (3 feet) of peat to replenish itself. Most biomass requires arable land to develop. This means that land used for biofuel crops such as corn and soybeans are unavailable to grow food or provide natural habitats. Most biomass plants require fossil fuels to be economically efficient. Biomass has a lower “energy density” than fossil fuels. As much as 50% of biomass is water, which is lost in the energy conversion process. However, converting biomass into pellets (as opposed to wood chips or larger briquettes) can increase the fuel’s energy density and make it more advantageous to ship. Burning biomass releases carbon monoxide, carbon dioxide, nitrogen oxides, and other pollutants and particulates. If these pollutants are not captured and recycled, burning biomass can create smog and contribute to the pollutants released by fossil fuels.

Biomass characteristics

1.Structural composition

Among all these structural compounds such as lipids, protein, simple sugar, and starches, a varying amount of "cellulose, hemicellulose, and lignin" has become three core elements of biomass structural composition.

2.Chemical composition

A composition of chemicals substances and elementary elements present in each biomass determines its ability to produce a better fuel source in contrast with fossil fuel. It can be determined by

Ultimate analysis

It assists with evaluating the percentage of each element such as carbon (C), hydrogen (H), oxygen (O), nitrogen (N), chlorine (Cl), and sulphur (S) present in each sample of biomass and the effect of these components towards the combustion in boiler and environmental outlook. "Biomass with higher nitrogen (N) and (S) will cause the production of toxic gaseous such as oxides of nitrogen (NO_x) and sulphur oxides (SO_x) during the combustion which is the paramount cause of acid rain and releases of particulate matter (PM)"

Proximate analysis