BIOMASS FEEDSTOCKS

Ayhan Demirbas
Sila Science, University Mah, Mekan Sok, No 24, Trabzon, Turkey

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Summary

The term 'biomass' refers to wood, short-rotation woody crops, agricultural wastes, short-rotation herbaceous species, wood wastes, bagasse, industrial residues, waste paper, municipal solid waste, sawdust, bio-solids, grass, waste from food processing, aquatic plants and algae animal wastes, and a host of other materials. Biomass is the name given all the earth's living matter. Biomass as the solar energy stored in chemical form in plant and animal materials is among the most precious and versatile resources on earth. It is a rather simple term for all organic materials that seems from plants, trees, crops and algae. The components of biomass include cellulose, hemicelluloses, lignin, extractives, lipids, proteins, simple sugars, starches, water, hydrocarbons, ash, and other compounds. Two larger carbohydrate categories that have significant value are cellulose and hemicelluloses (holocellulose). The lignin fraction consists of non-sugar type molecules.

1. Wood and Other Forms of Biomass

Wood and other forms of biomass are one of the main renewable energy sources available and provide liquid, solid and gaseous fuels [see also– *Lignocellulose Biorefinery*]. Animal wastes are another significant potential biomass resource for electricity generation, and like crop residues, have many applications, especially in developing countries [see also – *Biogas as renewable energy from organic waste*]. Biomass is the only organic petroleum substitute which is renewable. Biomass as the solar energy stored in chemical form in plant and animal materials is among the most precious and versatile resources on earth. Biomass is the name given to the plant matter which is created by photosynthesis in which the sun's energy converts water and CO_2 into organic matter. Thus, biomass materials are directly or indirectly a result of plant growth. These include firewood plantations, agricultural residues, forestry residues, animal wastes, etc. Fossil fuels can also be termed biomass, since they are the fossilized remains of plants that grew some millions of years ago. Worldwide biomass ranks fourth as an energy resource, providing approximately 14% of the world's energy needs; while in many developing countries its contribution ranges from 40% to 50%. The use of biomass as fuels help to reduce the greenhouse gas emission because the

CO2 released during combustion or conversion of biomass to chemicals is that removed from the environment by photosynthesis during the production of the biomass.

The basic structure of all woody biomass consists of three organic polymers: cellulose, hemicelluloses, and lignin in trunk, foliage, and bark. Three structural components: cellulose, hemicelluloses and lignin which have rough formulae as $CH_{1.67}O_{0.83}$, $CH_{1.64}O_{0.78}$ and $C_{10}H_{11}O_{3.5}$, respectively. Added to these materials are extractives and minerals or ash. The proportion of these wood constituents varies between species, and there are distinct differences between hardwoods and softwoods. Hardwoods have a higher proportion of cellulose, hemicelluloses, and extractives than softwoods, but softwoods have a higher proportion of lignin. In general, hardwoods contain about 43% cellulose, 22% lignin, and 35% hemicelluloses while softwoods contain about 43% cellulose, 29% lignin, and 28% hemicelluloses (on an extractive free basis).

Examples of biomass feedstocks are:
Wastes:
- Agricultural wastes
- Crop residues
- Mill wood wastes
- Urban wood wastes
- Urban organic wastes

Forest products:
- Wood
- Logging residues
- Trees, shrubs and wood residues
- Sawdust, bark etc.

Energy crops:
- Short rotation woody crops
- Herbaceous woody crops
- Grasses
- Starch crops
- Sugar crops
- Forage crops
- Oilseed crops

Aquatic plants:
- Algae
- Water weed
- Water hyacinth
- Reed and rushes

The main components of lignocellulosic biomass are cellulose, hemicelluloses and lignin. Cellulose is a remarkable pure organic polymer, consisting solely of units of anhydro glucose held together in a giant straight chain molecule. Cellulose [see also – *Cellulose Biomass* Refining] must be hydrolyzed to glucose before fermentation to ethanol. Conversion efficiencies of cellulose to glucose may be dependent on the extent of chemical and mechanical pretreatments to structurally and chemically alter the pulp and paper mill wastes. The method of pulping, the type of wood, and the use of recycled pulp and paper products also could influence the accessibility of cellulose to cellulase enzymes. Hemicelluloses (arabinoglycuronoxylan and galactoglucomammans) are related to plant gums in composition, and occur in much shorter molecule chains than cellulose. The hemicelluloses, which are present in deciduous woods chiefly as pentosans and in coniferous woods almost entirely as hexosanes, undergo thermal decomposition very readily. Hemicelluloses are derived mainly from chains of pentose sugars, and act as the cement material holding together the cellulose micells and fiber. Lignins are polymers of aromatic compounds. Their functions are to provide structural strength, provide sealing of water conducting system that links roots with leaves, and protect plants against degradation. Lignin is a macromolecule, which consists of alkylphenols and has a complex three- dimensional structure. Lignin is covalently linked with xylans in the case of hardwoods and with galactoglucomannans in softwoods. Even though mechanically cleavable to a relatively low molecular weight, lignin is not soluble in water. Lignin is generally accepted that free phenoxyl radicals are formed by thermal decomposition of lignin above 525 K and that the radicals have a random tendency to form a solid residue through condensation or repolymerization. Cellulose is insoluble in most solvents and has a low accessibility to acid and enzymatic hydrolysis. Hemicelluloses are largely soluble in alkali and, as such, are more easily hydrolysed.

The solar energy, which is stored in plants and animals, or in the wastes that they produce, is called biomass energy. The biomass energy is a variety of chemical energy. This energy can be recovered by burning biomass as a fuel. Direct combustion is the old way of using biomass. Biomass thermo-chemical conversion technologies [see also – *Thermochemical conversions*] such as pyrolysis, liquefaction and gasification are certainly not the most important options at present; combustion is responsible for over 97% of the world's bio-energy production. The average majority of biomass energy is produced from wood and wood wastes (64%), followed by solid waste (24%), agricultural waste (5%) and landfill gases (5%). Biomass can be economically produced with minimal or even positive environmental impacts through perennial crops.

Biomass has been recognized as a major world renewable energy source to supplement declining fossil fuel resources [see also – *Biomass and Organic Waste Conversion*]. Biomass is the most important renewable energy source in the world. Biomass power plants have advantages over fossil-fuel plants, because their pollution emissions are less. Energy from biomass fuels is used in the electric utility, lumber and wood products, and pulp and paper industries. Wood fuel is a renewable energy source and its importance will increase in future. Biomass can be used directly or indirectly by converting it into a liquid or gaseous fuel. A large number of research projects in the field of thermochemical conversion of biomass, mainly on liquefaction pyrolysis, and gasification, have been performed.

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Biographical Sketch

Professor Ayhan Demirbas was born in Trabzon, Turkey in 1949. He was graduated from Ankara University Department of Chemical Engineering in 1973. He earned her PhD degree in Chemical Engineering from Ankara University in 1980. He became an Assistant Professor in 1982 at Selcuk University (SU). After getting her PhD degree, he made his Post Doctoral Study in the field of "Renewable Based Alternative Energy Sources" in SU between 1980-1986. He became an Associate Professor in 1985 and a Professor in 1991 at Karadeniz Technical University (KTU). Dr. Demirbas is a Professor in Energy Technologies Science Branch between 1991-2001 at KTU and between 2003-2007 at SU. Dr. Demirbas teaches and conducts researches on Renewable Energy Technologies (Biodiesel, Biofuels, Biomass Pyrolysis, Liquefaction and Gasification, Biogas, Bioalcohols and Biohydrogen). His research area is mainly concerned with renewable and sustainable energy related to environmental issues. Other than this, I have some interest on developing new methods pulp from plants especially annual ones. In his earlier works he has used organosolvation techniques as new methods for processing of pulp. He has also studied on the subjects of chemical thermodynamics and engineering thermodynamics, cement chemistry, potentiometric titrations in non-aqueous mediums, heavy metal determinations in mushrooms, supercritical fluid extraction of different biopolymeric materials, briquetting of biomass, chemical education, energy education, kinetics for non-isothermal flash pyrolysis of hazelnut shell and biomass, determination of the higher heating values of different biomass and vegetable oils using noncalorimetric methods, dehydration kinetics of some boron minerals, toxic mineral determinations in mushrooms and chicken meats, sulfur removal from coal using alkali from biomass ashes, toxic emissions from firing and co-firing processes, global climate change, bio-diesel, hydrogen, hazardous materials, persistent, organic pollutants, spectrophotometric determination of carbaryl pesticides in soil, drinking water and, creal analyses etc. He has various national and international books, articles and presentations on EnergyTechnologies. He has supervised 21 and 6 students for successful completion of MS and Ph.D. theses, respectively. He has edited the Journal of *Energy, Education, Science & Technology* since 1998. He is a member of Editorial Board to the Journal of *Recent Patents in Engineering.* He was a member of Editorial Board to the Journal of *Energy Conversion & Management* from 1999 to 2004. He is married and has five children. He is continuing his work as full professor in Sila Science and Energy Company.

His most important contributions to science are:

1. A new Equation for calculation of higher heating values of biomass fuels has been firstly proposed by Demirbas (Fuel, 1997).
2. The studies on hydrogen production from biomass materials have been developed by Demirbas (Fuel, 2001).
3. Saka and Kusdiana (Fuel, 2001) and Demirbas (Energy Conversion and Management, 2002) have firstly proposed that biodiesel fuels may be produced from vegetable oils via non-catalytic transesterification with supercritical methanol.