Overview of Biomass Energy

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----------ABSTRACT----------

Biomass is a source of renewable energy. The interest in renewable energy has been revived over last few years, especially after global awareness regarding the ill effects of fossil fuel burning. Energy is the source of growth and the mover for economic and social development of a nation and its people. According to this interest, this paper is based on an overview of biomass energy. The main focus of this paper is to give a clear concept of biomass energy and its conversion process. This paper also mentioned the necessities and limitations of this renewable energy.

Keywords— *Advantages and disadvantages of biomass energy, biomass conversion process, types of biomass.*

I. INTRODUCTION

Energy, particularly its electrical form, has become virtually the life line of human activities. Undoubtedly, it is one of the most vital inputs to industry. In fact, there is no field of human activity where the role of energy can be underestimated. But, with a growing demand, both due to rise in populations as well as fast industrialization, the gap between the available electric power and its requirement is ever growing. With the fossil fuels gradually depleting and hydro sources having reached the verge of full exploitation, we are compelled to think in terms of searching for and developing alternative sources of energy [9]. Over the recent years, the problem of environment pollution, sustainability and safety have been added to the scene, calling for development of power generation systems which are techno economically viable, sustainable and safe. Several alternative sources of energy are being thought of, including the nuclear, solar, geothermal, wind, tidal and the biomass based. Keeping in view the three fold objective stated above viz. economic-viability, sustainability and safety, biomass as a source of energy holds a good and bright promise [1]. Biomass Energy is highly under-appreciated as a renewable source of energy despite being the most important source of energy during most of human history. Till the 19th century biomass energy used to account for 70% of the world's energy consumption and still accounts for around 10% of the world consumption. In developing countries the share of biomass energy is still quite high at 30% and it is the major source for energy for rural and backward communities. Biomass is a renewable energy source because the growth of new plants and trees replenishes the supply. It is found in almost all regions of the world [2]. The biomass has been used extensively in the development of societies since the beginning of civilizations. It has played very important role in the development of societies. Many people in the developing countries still depend on the use of biomass for their daily livelihood. They use it for food, fuel as well as a source of income. It is estimated that biomass contributes to about 14% of the world's total energy requirement. In many developing countries the contribution to total energy requirements is as high as 90%. In addition to being useful for human purposes, the biomass acts as an essential medium for sustaining earth's ecological balance. Through photosynthesis process, biomass helps in balancing the CO_2 in the atmosphere, it enriches and conserves the natural vegetation and soil and at the same time provide long-term secondary energy [3].

II. AN OVERVIEW OF BIOMASS

Biomass is carbon based and is composed of a mixture of organic molecules containing hydrogen, usually including atoms of oxygen, often nitrogen and also small quantities of other atoms, including alkali, alkaline earth and heavy metals.

2.1 Definition of Biomass

Biomass refers to the mass of biological material produced from the living processes. Chemically biomass refers to hydrocarbons containing hydrogen, carbon and oxygen, which can be represented in the form

of $C_{6n}(H_2O)_{5n}$. Biomass is solar energy stored in organic matter. As trees and plants grow, the process of photosynthesis uses energy from the sun to convert CO_2 of the atmosphere into carbohydrates (sugar, starch and cellulose) [3]. The process of photosynthesis can be written as follows:

$$6\,CO_2\ (gas) + 6\,H_2O\ (liquid) + lights \rightarrow C_6H_{12}O_6\ (solid) + 6\,O_2\ (gas)$$

Carbohydrates are the organic compounds that make up biomass. When plants die, the process decay converts the organic matter into fossil fuels like coal, gas and oil. The consumption of fossil fuels results in emission of CO_2 back to the atmosphere. In this way one full cycle of CO_2 is completed. In nature, biomass sources ultimately decompose to its elementary molecules with the release of heat. Therefore the release of energy from the conversion of biomass into useful energy imitates natural processes but at a faster rate. Therefore, the energy obtained from biomass is a form of renewable energy. Utilizing this energy recycles the carbon and does not add carbon dioxide to the environment. Of all the renewable sources of energy, biomass is unique in a way that it is effectively stored solar energy. Furthermore, it is the only renewable source of carbon, and it is able to be processed into convenient solid, liquid and gaseous fuels.

2.2 Types of Biomass

2.2.1 Woody biomass

This includes biomass in the form of trees, trees from forest, from farms, commercial plantations etc. The use of woody biomass is mainly for household and industrial application for making furniture, shelter, agriculture tools, etc.

2.2.2 Agricultural residues

This includes crops and plant residues produced in the field. These are the residues that remain after taking out seeds from the crops. For instance, husk, bags', cereal straw, nut shells, etc.

2.2.3 Animal waste

The animal dung and poultry manure come in this category. Animal dung is also used for cooking either directly by burning or converting it into biogas, which is then burned to cook food.

2.3 Biomass Resource

There are many types of waste in the world, and many ways they can be used for energy production. In general there are more than ten kind of waste that we can use as biomass resources to produce energy such as agricultural crops, agricultural residues, animal waste, black liquor, sugar industry waste, forestry crops, forestry residues, industrial waste, municipal solid waste (MSW), and sewage [4] .

2.4 Energy Content of Biomass

A biomass normally contains carbon, oxygen, moisture, ash, etc. Energy content of a biomass varies depending on its ingredients. The presence of carbon in the biomass is the main source of heat energy in a biomass. Moisture and ash content do not contribute to any energy. High moisture content means lower energy contents. Similarly higher ash content means lower energy contents. The energy content of the biomass is measured in terms of calorific value.

TABLE 2.4.1 Energy Content of Biomass Fuels for Various Moisture and Ash Content

Biomass type	Ash content %	Energy content of fuel (MJ/kg)	
		Moisture content 0%	Moisture content 13%
wood	1	18.7	16

Crop residues	5	16.5	14.2
	10	15.8	13.5
	20	14.1	11.9
Animal dung	20	17	14.5
	25	16	13.6

2.5 Calorific Values of Biomass Based Fuels

Typical calorific values of the solid, liquid and gaseous fuels that are obtained from biomass through various conversion processes are given in the Table 2.5.1.

TABLE 2.5.1 Calorific Values of Combustible Fuels Obtained from Biomass Conversions

Type of fuel	Calorific value	Comments
Charcoal	23-33 MJ/kg	Depending on carbon percentage
Producer gas	3.5-5.5 MJ/kg	
Biogas	21-23 MJ/m^3	60% methane
Methane	36 MJ/m^3	
Ethanol	30 MJ/kg	
Methanol	23 MJ/kg	

III. TYPES OF BIOMASS CONVERSION PROCESS

There is a wide variety of forms in which biomass is available. There are number of processes by which biomass is converted to suitable form, for instance, conversion of biomass into gaseous form, conversion into liquid form, conversion into solid form. Following processes are commonly used [5-6]:

3.1 Thermo Chemical Process

In this process, heat is provided to biomass in order to change its chemical composition. Using this process, biomass can be converted to charcoal or producer gas. Thus, process flow looks like:

Biomass → (thermal energy input) → Charcoal, producer gas

The temperature range in which the conversion process occurs can vary from few hundred to several hundred degrees centigrade.

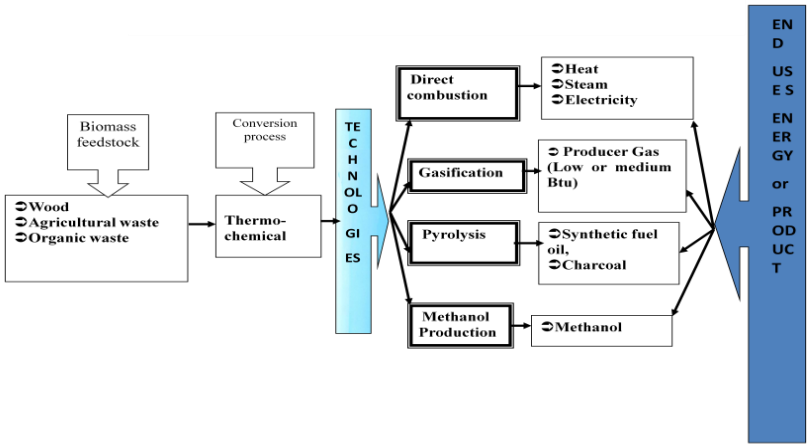

Figure: 1 Thermo chemical conversion process

3.2 Biochemical Process (Aerobic and Anaerobic)

In this process, change in chemical composition of biomass (sugar cane, starch, etc.) occurs due to application of a biological agent. Using this process biomass can be converted into biogas and ethanol. The process flow looks like:

Biomass → (biological process with or without oxygen) → biogas, ethanol

When the biochemical process takes place in the absence of oxygen then it is called an anaerobic process and when the biochemical process takes place in presence of oxygen then it is called aerobic process.

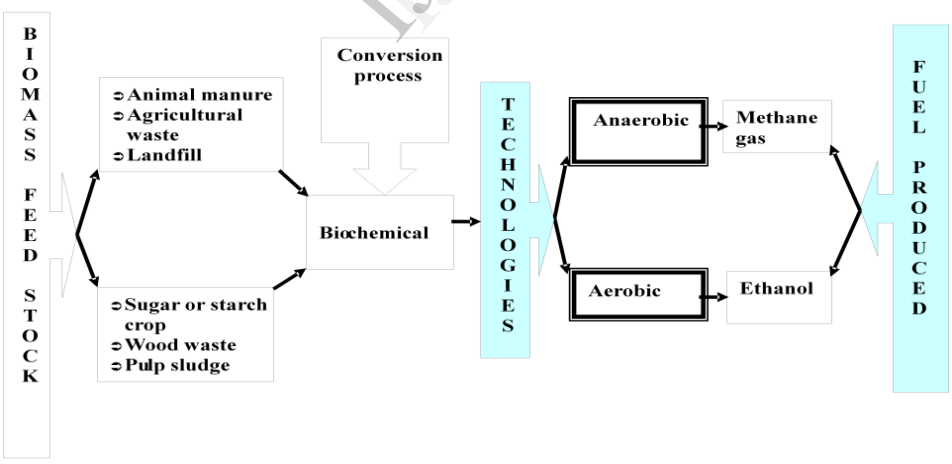

Figure: 2 Biochemical conversion process

3.3 Mechanical Process

In this process, change in chemical composition is obtained by mechanical processing. Using these process vegetable oils can be extracted from biomass. Thus, process flow looks like:

Biomass → mechanical force → vegetable oil

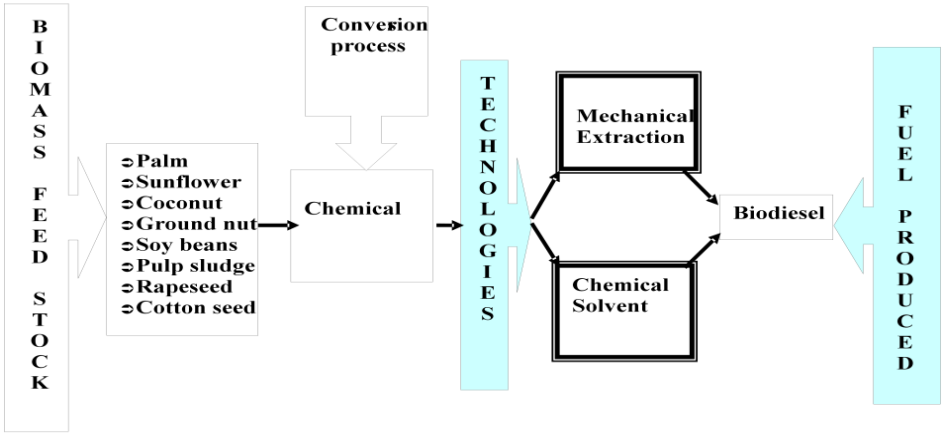

Figure: 3 Chemical conversion process

3.4 Biomass Conversion Technologies

Generating electricity from waste products and domestically grown plants is one of the most promising renewable electricity supplies [7]. The fuel supply either exits currently in waste form, or can easily be grown by agriculture. Additionally, electricity can be harnessed from these supplies through existing energy generating technologies, making large scale increases in bio-power capacity possible in the short run. The oldest way to turn biomass in energy, practiced for thousand years, is simply burn it to produce heat. This is the use to which the main part of biomass is assigned, in any part of the world.

Table 3.4.1 Biomass Technology Chart

Technology	**Conversion Process Type**	**Major Biomass Feedstock**	**Energy or Fuel Produced**
Direct Combustion	Thermo chemical	wood agricultural waste municipal solid waste residential fuels	heat steam electricity
Gasification	Thermo chemical	wood agricultural waste municipal solid waste	low or medium Btu producer gas
Pyrolysis	Thermo chemical	wood agricultural waste municipal solid waste	synthetic fuel oil (biocrude) charcoal
Anaerobic Digestion	Biochemical (anaerobic)	animal manure agricultural waste landfills wastewater	medium Btu gas (methane)

Ethanol Production	Biochemical (aerobic)	sugar or starch crops wood waste pulp sludge grass straw	ethanol
Biodiesel Production	Chemical	rapeseed soy beans waste vegetable oil animal fats	biodiesel
Methanol Production	Thermo chemical	wood agricultural waste municipal solid waste	methanol

IV. ADVANTAGES AND DISADVANAGES OF BIOMASS ENERGY

4.1 Advantages of Biomass Energy [2], [8]

(a) The thing about fossil fuels like petroleum, coal and others is that they are present in limited numbers. It takes millions of years for these fuels to be generated and therefore, when they are consumed and exhausted, civilization will not have to come at a standstill. Biomass fuels can be used as an effective energy source and therefore they reduce the dependency on fossil fuels.

(b) Biomass is one of the most abundant resources in the world. By definition, it is the mass of living or recently dead plants and animals, along with their wastes. This means that there is not a single square centimeter of Earth that does not contain some form of biomass that could be converted to energy.

(c) Biomass is renewable. If people exercise proper conservation techniques, any form of biomass that is harvested to produce energy can be replaced over a period of time.

(d) Biomass can easily be converted from its natural form into concentrated, high energy fuels such as alcohols or a type of gas that is virtually identical to natural gas. These fuels are relatively clean burning when compared with the fossil fuels in use today.

(e) The cost of producing biomass for use as fuels and energy sources is very cheap compared to the cost of finding and extracting fossil fuels. The cost of finding fuel is eliminated when one deliberately plants certain types of plants to be used in the production of biomass fuels.

(f) Biomass reduces the need for landfills and lessens the environmental impact of existing landfills.

(g) With the introduction of biomass energy, methane levels in the atmosphere reduce. Methane is responsible for the greenhouse effect and with the production of biomass energy, the gas levels are lowered. Methane is usually produced when organic matter decomposes therefore by lowering it; the greenhouse effect is reduced as well.

(h) Biomass plants can be built in 1 Mw sizes unlike other types of power which require much large scale. For example nuclear energy requires a typical plants size of at least 500 MW to make it economical. Moreover, Biomass plants can be built in remote areas and used as a distributed form of power generation.

4.2 Disadvantages of Biomass Energy [8]

(a) The first, and possibly worst, disadvantage of biomass energy is that burning biomass directly as a fuel produces more greenhouses gases than can be absorbed by remaining plants, making it a hazardous contributor to global warming. Biomass energy is not entirely clean. Some greenhouse gases are still produced; although the levels of these gases are far less than those produced by fossil fuels.

(b) Combustion of biomass as a fuel also consumes it at a much faster rate than it can be replaced. This means that biomass is not a very efficient source of energy.

(c) One of the disadvantages of biomass energy is the amount of space that it requires. A great deal of land and water are needed for some biomass crops to be produced and, when they have grown, the product requires a large amount of storage room before being converted into energy.

(d) Another biomass energy disadvantage is that the cost of installing and maintaining the infrastructure for processing the biomass is very expensive.

(e) One disadvantage of biomass fuel production is that it is quite expensive, with costs including paying for the large amount of labor involved and transportation costs as this type of energy must be produced close to where the source is obtained.

V. CONCLUSION

Biomass Energy has long been neglected and underappreciated as a source of clean and green energy due to the convenience and cheapness of fossil fuels. However that is changing and with technology advancements in biomass energy production, it is getting more attention. Biomass Energy is growing at a rapid pace though not as fast as wind and solar power. Its use in reducing green house gas emissions and as a viable sustainable source of energy is undeniable.

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