**Bioenergy-A Source of Renewable Energy- A Review**

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**Abstract-**This review discuss about uses of bioenergy and biomass in the future energy supply. The discussion is based on earlier studies on this subject. Energy from biomass plays important role in the global energy system. Bioenergy makes significant contributions to decrease carbon emission, especially from transport, and manufacturing. But land-intensive bioenergy often needs considerable carbon emissions from land-use change as well as production, harvesting, and transportation. In addition, land-intensive bioenergy scales only with the utilization of vast amount of land, a resource that is fundamentally limited in supply. This review also provided an overview of the bioenergy and its challenges associated with its increased development. This review discusses about the opportunities and their problems, risk in relation to the resources, technologies, practices, markets, and policy.

**Key** **Words**-Bioenergy, Biofuel, Renewable energy, Biomass

**Introduction**-

Bioenergy is energy produced from biomass of living organisms mainly plants which are dead. Bioenergy is renewable form of energy which is derived from living organic materials it is also a viable alternative to fossil fuels because its renewable energy source. It includes dung, grass, wood, food crops, forest waste etc. Bioenergy having several forms biofuel, biogas, biomass power, bioenergy in heating and cooling. Biomass is organic matter that comes from animals and plants. Organic waste, food waste, crop waste, animal waste and wood waste is used as source of bioenergy. bioenergy is an important for making a substantial contribution in global energy demand. It is a vital component that utilize carbon dioxide during energy production (Ausilion bauen *et al.,* 2004).

Now a day bioenergy is known as world’s largest source of renewable energy making up 9.6% of worlds total energy supply (55.6 EJ in 2018). In human history biomass is the most important source for basic needs like food, feed, fuel, feed stock, fiber and fertilizers. In early 19th century biomass was main energy source for industrial country (Rosillo Calle and hall 2002, Hall et al.1994). About 2500 years ago Archeologist found that charcoal-based iron melting was responsible for large scale deforestation in central Africa, United states, and other country of Europe. The first step towards the industrialization were based on biomass energy and biomass resources (Hall and overend 1987).

Some researchers stated that industrial Revolution was only possible due to arability of biomass resources. In 19th century industrial Revolution and fuel industrial development was possible due to wood and charcoal (Schubert, 19 57). Worldwide biomass fuel was used in many industries like brick and tile making, metal working, food processing, wearing in recently biomass is used directly or in combined heat with power (CHP), facilities or formation of ethanol.it also utilize for three main reasons population growth, improvement in living standard and increasing environmental concerns. Now a day bioenergy is a main source of energy in many developing countries particularly traditional forms of bioenergy providing on an average 35 per cent energy need of three-quarters of the world’s population. This Percentage increase up to 60 to 90 percent in the poorest developing countries. Hence use of bioenergy and its application are rapidly increase in both industrial and developing countries. Use of modern bioenergy is the largest source of renewable energy globally it accounting for 55% of renewable energy and over 6% of global energy supply. Bioenergy uses increased on an average 3% per year between 2010 to 2030. (IEA 2023 report).

 The world’s largest and most sustainable energy source is biomass. Potentially and infinitely biomass is renewable source containing 220 oven dry tonnes (odt) or about 4500 exajoules (EJ) of annual primary production. the annual bioenergy potential is about 2900 EJ approximately 1700 EJ from forest ,850 EJ from Grasslands and 350 EJ from Agricultural area. (Hall and Rio 1999). In current agricultural land contributed over 800 EJ without effect on Worlds food supply (Faaij et al. 2002).

**Types of Bioenergy**

Bioenergy is a renewable form of energy which is generated from biological sources like food crops, grasses, and edible vegetable oil. This includes biogas, bioethanol, and biodiesel .

**Fig.1. showing Types of bioenergy**

**Bioenergy Technologies-**

Raw form of biomass is used traditional it is incompetent and significantly negative impact on environment. Modern application of bioenergy is rapidly replacing the traditional uses mainly in developing country for example in India increase the use of bioenergy but in China use of bioenergy decrease rapidly (Rosillo-calle2006). modern bioenergy was increase in world due to increase in modernization of biomass technology it includes 3 major categories

1) **Thermochemical** **processes** -combustion, gasification, pyrolysis, CBP.

2)**Biochemical** -Anaerobic Digestion, Fermentation.

3)**Other** **Processes**-Transesterification

 **Thermochemical** **processes-**

1. **Combustion**- This technology produces 90 per cent energy from biomass it converts biomass fuels into usable energy e.g.- hot air, hot water, steam, and electricity for industrial and commercial plants burn in different types of biomass woody biomass to MSW. The simplest forms of combustion technology are burning the biomass in a combustion chamber. Large scale combustion can increase system use low-quality fuels but high-quality fuels frequently used in small application system (Kaltschmitt and Bridgwater, 1997; Kaltschmitt et al, 1998; Walter et al, 2000).
2. **Gasification**-**gasification**- is most important research for power generation it is alternative to direct combustion. Gasification is endothermal conversion technology that use solid fuel and convert it into combustible gas this technology is not new it has been used from two centuries.
3. **Pyrolysis**- From pyrolysis multiple products obtained like liquid fuel it can be easily stored and transported and large number of chemicals (e.g. adhesives, organic chemicals and flavouring) that offer good possibilities for increasing profit. in the past decade in many countries research on pyrolysis is carried out by many researcher’s (Kaltschmitt and Bridgwater, 1997).
4. **CHP** (**Combine** **Heat** **and** **Power**)-this technology is well-known technology in late 19th century CHP system is used by many manufacturing plants CHP is usually executed by addition of heat exchanger that absorb exhausted heat from generator which is wasted this captured energy is used in electrical generator.

**Biochemical Process-**

In biochemical process high temperature, high pressure acid, enzyme and other techniques are used to breakdown of lignin and hemicellulose. hydrolysis enzyme are used to break down of cellulose in to sugar. This sugar is further used in fermentation to produced ethanol (Sass Byrnett et al.,2009).

1. **Anaerobic** **Digestion-**

This process involves decomposition of organic wests (biological wests) with the help of microorganisms in the absence of oxygen. This produce methane and carbon dioxide. Methane is used in production of electricity.

1. **Fermentation** –

In this process sugars are converted into alcohol. Basically, starchy plants are used in biochemical Fermentation. Corn and Sugarcane are commonly used for this process.

**Other** **Processes-**

**Transesterification-**it is a process in which oils or fats are converted in to biodiesel.

It involves removal of water and other contaminates from feedstock by using alcohol and sodium hydroxide. Fatty acid methyl esters and glycerin are biproduct of this process. Glycerin used in pharmaceutical and cosmetic industries and ester are used as biodiesel.

Modern bioenergy was responsible for the half of all renewable energy consumed in 2017. Bioenergy is utilized for electricity is about 3 per cent and around 4 per cent of energy is in transport in 2023(International energy Agency 2018). The bioenergy production is low cost and low emission source of energy. but land intensive bioenergy sources are limited due to arability of land. At present forest, agricultural and municipal residue and west are the main feedstock for the generation of electricity and heat from biomass and small amount of sugar, grain and vegetable oil crops are used in the production of liquid biofuels. Now a day 50 EJ biomass was supplies globally there are many bioenergy routs used in to convert raw biomass in to final energy product.

 IEA in 2017 reported bioenergy usage can be divided into different categories traditional use, modern building heat electricity and co-generation, transport, industry heat, commercial heat and other uses. Out of these, mainly transport is heavily dependent on oil (about 90%). Globally the increase in demand of energy for transport in China rose from 5% in 1980 to 11% in 2005. In India, 27% oil is used for transport currently the total demand for primary oil, and this will increase to 47% by 2030, in Europe and UK it increases up to 60% (IEA2007). To full fill this demand of energy lignocellulosic biomass (plant west material) is best alternatives for fossil fuel (Daioglou, V et al 2015). Bioenergy produced from biomass is essential alternative for fossil energy and it contributed total 9% energy globally (IEA2017). According to the International Energy Agency biomass is any organic matter that comes from biogenic sources and is available on a renewable basis. It includes animals and plants sources like wood and agricultural crops, and organic waste from municipal and industries. For production of plant-based biomass scientist suggested energy crop it include woody crops and grasses, herbaceous plants, starch and carbohydrate-containing crops and oilseeds. Mainly for production of first-generation biofuel Maize and sugarcane is used other plant also used by different countries. In World wild biofuel production is increased. Europe is the leading country in production of biodiesel while the USA is the leading in production of ethanol. Ethanol and biodiesel are the two major fuels to replace gasoline and diesel. The ethanol produced from corn and sugar cane is known as 1st generation bioethanol. In 2015, 25.6 billion gallons of bioethanol was produced by USA with contributing 14.81 billion gallons and Brazil 7.09 billion gallons, between them, the USA and Brazil produced 85% of the worlds’ bioethanol. The USA depends on corn for bioethanol production while Brazil uses sugar cane (IEA2017).

1st generation biodiesel is produced from raw vegetable oils derived from soybean, canola, palm oil, sunflower, animal fats and cooking oil. Biodiesel has beneficial for environmental because it is derived from renewable resources. Burning biodiesel does not increase atmospheric levels of CO2, a greenhouse gas [Due W et al 2004]. Biodiesel is biodegradable produced form recycling waste oils, and produces less air pollution than fossil diesel [Miao. X and WU. Q 2006].

 Second (2nd) generation biofuels are produced from cellulose, hemicellulose or lignin. Lignocellulosic biomass is an alternative to sugarcane and maize. The lignocellulose feedstocks that are more significant in use are corn stover, rice husk, wheat straw, and sugarcane baggase. 2nd generation biofuels can be used with gasoline, which can be combusted in combustion engines and distributed through existing infrastructure or engines that are slightly modified for internal combustion. One example of 2nd generation biofuel is cellulosic ethanol.

Biofuels that obtain from algal biomass is called third (3rd) generation biofuels. Production of biofuel from algae depends on the lipid content. Algae contain a high lipid content (20–50%) and high growth rates, it can grow in adverse’ conditions dur to this reasons alga are important for biofuels. (Christin Y 2008, Larden L 2009). Some species of algae are fast growing species: Chlamydomonas reinhardtii, Dunaliella salina and various chlorella species. Species of Botryococcus braunii, which grow slowly but large quantities of lipids accumulation occur (Scoot S A et al. 2010). 1st, 2nd and 3rdgeneration of biofuels are classified on the basis of raw material used that is either of biomass by origin or as waste. Classifications of biofuels are always difficult due to their limiting application on a global scale. In 4thgeneration biofuels, raw materials that are cheap and widely available are used to convert solar energy to solar biofuels (Hays, S.G.and Ducat, D.C 2015, Scaife, M.A. et al. 2015).

**Current status of Bioenergy**

Globally Denmark, Finland, and Endonia use more than 15% of bioenergy (produced from CHP) for production of electricity, followed other countries like UK, Sweden, Germany and Brazil. (IEA Report 2021). In 2022 China was the leading country in production of bioenergy near about 34.1 gigawatts it is highest bioenergy capacity in the world. Brazil is the second rank in the production of bioenergy with 17.2 giga watts. By comparison, Germany ranked fifth with 9.9 gigawatts. (Lucia Fernandez 2023). Globally Economic, environmental and energy security are the main concerns of many countries resulting forcing countries to find alternatives like biofuels in the form of ethanol and biodiesel (Farrell A E. et al. 2008). Since biofuels can be produced from various crop plants each country is adopting a strategy to take advantages of these crops. For example, the sugarcane and maize are the main crops for ethanol in Brazil and US respectively, in Malaysia biofuel are produced from oil palm. The united status is the largest producer of biofuel in the world near about 41 percent of global biofuel production in 2021 is about 1.64 billion gallons. Brazil and Indonesia ranked second and third produce 840 and 312 petajoules in those years (Jessica Aizarani2023). United status is the world leader in production, consumption and exporter of ethanol. India rank 5th in ethanol production ethanol is used as biofuel for many purposes in India Sangrur, Punjab having largest biofuel production unit with 33 TPD (tonnes per day). The Indian government committee share non-fossil fuel in total capacity to 40% by 2030.India produce about 450-500 million tonnes of biomass per year. government of India has been increasing the use of bioenergy or clean energy sources for better feature, according to the ministry of New and Renewable Energy (MNRE2022) installed capacity of renewable energy is 90 GW excluding hydropower.it stats that 27.41GW energy will be added.

Some researchers concluded that use of bioenergy having some drawback bioenergy could reduce food production and accelerate biodiversity loss (DeCicco & Schlesinger, 2018; European Academies Science Advisory Council, 2019; Searchinger, Wirsenius, Beringer, & Dumas, 2018). bioenergy from plants (e.g., crops, trees, grasses) cultivated or harvested is the primary source for energy. Land intensive bioenergy are substantial carbon emission from and land use change production, harvesting and transportation but land intensive biomass utilization is limited. Bioenergy crops are limited they cannot grow on large scale the utilization of bioenergy is more as compared to production. Biofuel is not used alone it require another fuel to use it blended with petrol and diesel to bring efficiency up to speed.it means it not available to use on large scale. Wood Is used as biomass for bioenergy production increased demand of wood lead to deforestation. monoculture crop grown for the biomass production it shows adverse effect on biodiversity. for large scale production of biomass, it requires construction plants that are costly and harvesting, transportation, storage of organic matter it is costly. It also requires large space mainly because of they grow their won plants or small forest. Biomass fuels also release many gases like nitrogen oxides, carbon monoxide, and methane.

Use of bioenergy negatively impact on environment when plants used as biomass energy it increases use of fertilizers and pesticides it adverse effect on surrounding ecosystem. **Conclusion**-from above study it can be concluded that the bioenergy demand may increases to several hundred exajoules per year in the future. It can also be concluded that the bioenergy demand is sensitive not only to biomass supply potentials, but also to total energy demand and competitiveness of alternative energy supply options. At the same time, the reviewed resource-focused studies have arrived at widely conclusions about how much biomass that can be made available for energy in the future.

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