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The Future of the Biomass Energy in Turkiye and in the World

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Abstract: Energy is a phenomenon that is of great importance for the sustainability of life and shows its effects in all areas of life. People use energy for each of their activities. The concept of energy has an increasingly important position in the globalizing world order and affects the course of country economies. Additionally, when energy is considered in detail with its various aspects, it attracts attention with its many elements. Energy is a factor that is related to many sciences and disciplines and is analyzed from different perspectives. Developing alternative energy sources in the world to meet the need for energy has become a necessity. The search for energy sources that can be alternatives to fossil fuels is already in progress. As an alternative energy source, biomass energy is one of the renewable energy sources in Turkiye and in the world. Developing policies and strategies that can provide simple, acceptable, applicable and effective solutions must utilize biomass energy more efficiently and effectively. For example, it is extremely important to convert biomass into fuel form and use it. In this study, the future of biomass energy in Turkiye and in the world was examined.
Keywords: Biomass, biogas, biodiesel, bioethanol, renewable energy

1. Introduction

Energy consumption is an indicator of the development levels of countries and is indispensable for individuals to live a comfortable life. The increase in energy consumption with developing technology and increasing population poses a significant problem. The fact that fossil fuel resources are rapidly depleting and causing irreparable damage to natural life and environment, threatens the lives of future generations. For this reason, studies on utilizing renewable energy sources have gained greater importance in recent years. Although the capacities of raw materials and energy resources are limited, the need for raw materials and energy is constantly and rapidly increasing and it forces humanity to find new non-traditional resources. In addition to the limited reserves of primary energy resources, increase in fuel price, population growth, industrialization, the necessity of utilizing national resources, the negative effects of existing fuels on the environment and the problem of climate change make necessary the use of renewable energy resources within the scope of new energy technologies [1-4].

All natural substances of plant or animal origin, whose main components are carbohydrate compounds, are defined as biomass energy sources, and the energy obtained from these sources is defined as biomass energy. Biomass is also defined as all organic substances that can be renewed in less than a 100-year period, including plants growing on land and in water, animal residues, food industry and forest products, and urban waste. Biomass energy is perhaps the most important of the resources that can meet the increasing energy needs of the world with its increasing population and industrialization, without polluting the environment and sustainably. Biomass energy is used as heat, electricity and fuel for vehicles. Heat and electricity are obtained from biomass by combustion (traditional and industrial methods) and indirect combustion methods. The use of biomass in energy technology by producing alternative solid, liquid and gaseous biofuels equivalent to existing fuels is achieved by direct combustion or by physical and chemical processes [5-8].

In recent years, factors such as rapid industrialization, population growth, urbanization and rising living standards have increased energy consumption and led to rapid depletion of energy resources. As a result of all these, biomass studies have been accelerated in the world to meet the energy deficit. Considering this great potential as well as the positive economic and environmental characteristics of biomass, interest in bioenergy is increasing. Biomass is an important energy source as it constitutes the fourth largest energy source in the world. Many developed countries figure out the bioenergy as the main energy source of the future. They consider bioenergy as one of the most important renewable energy sources of the future due to its great potential and different social and economic benefits. Biomass can be used directly for heating and electricity purposes and can be converted into solid, gaseous and liquid fuel. Industrial, agricultural and forest residues can be used as biomass. In addition, energyproducing plants such as trees and sugar cane are produced only for the purpose of being converted into energy [9-10]. In this study, the future of biomass energy in Turkiye and in the world was examined.

2. Definition and Technologies of Biomass Energy

Bioenergy means electricity and gas produced from organic substances, also known as biomass. Plants, plant waste, food waste, and even sewage waste are included in this group. The Food and Agriculture Organization (FAO) defines bioenergy as all energy derived from biofuel. In fact, it can be said that with the discovery of fire, biofuel emerged in the form of wood. From this point onwards, humans have developed a continuing relationship with what we know today as bioenergy. Bioenergy can be examined in two main categories: traditional and modern. While traditional use refers to the burning of biomass in forms such as wood, animal waste and traditional coal, modern bioenergy technologies include liquid biofuels produced, biorefineries, biogas, wood pellet heating systems and other technologies [11-12].

The energy obtained from biomass resources is expressed as biomass energy. Biomass energy is used in three basic areas: electricity, heat and mainly transportation purposes (Figure 1). Biomass products are generally considered under two headings: traditional, i.e. first generation biomass with relatively lower efficiency; and modern, i.e. secondgeneration bioenergy products with higher efficiency. Products considered within the scope of traditional biomass are wood and charcoal, which are mostly used in developing countries, and animal waste used in cooking, heating and lighting. Modern bioenergy products are basically evaluated in two categories: production of liquid fuels used in transportation such as bioethanol and biodiesel and producing energy by burning organic wastes in the presence or absence of oxygen through methods such as incineration, pyrolysis and gasification [12,13].

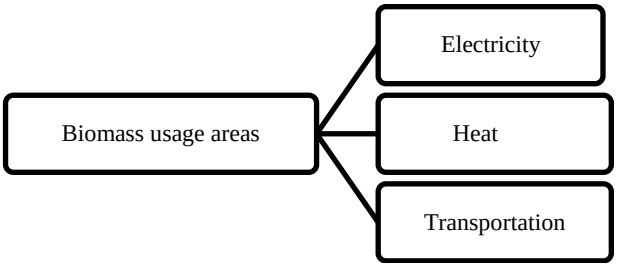

Figure 1. Biomass energy usage areas

Biomass resources appear in almost every aspect of human lives. For example; wood, oilseed crops such as sunflower and soybean, wheat straw, hazelnut shells, agricultural wastes, tea wastes, olive seeds and pulp, waste papers, domestic organic wastes such as fruit and vegetable peels, herbs. Other plant wastes such as stems and roots, mosses, marine algae, animal wastes, manure and industrial wastes, and wastewater treatment plant sludge constitute sources of biomass. Electricity, heat and fuel production from biomass resources can be achieved using many different technologies

. The resources selected for energy production are converted into an energy form suitable for the desired technology by thermo-chemical or bio-chemical conversion methods (Figure 2).The fuels obtained after the biomass conversion process are divided into three groups: solid, liquid and gas (Figure 3). In parallel with the rapidly growing biomass sector, research and development of new technologies continues [12,14].

Direct incineration: Energy production by direct combustion of biomass resources is the most known and widespread technology. It is suitable for use in production ranges up to 100 MW and above. Stock availability and costs determine the size of the projectand affects their economic balance to a great extent. The main components of direct combustion are steam boiler that produces steam at high pressure and at high temperature and then turbines that use this steam in the process of generating electricity.Since direct combustion technologies can produce electricity and heat simultaneously, they can work with the principle of cogeneration system.

Gasification: Gasification is a method in which biomass is obtained as synthesis gas by a thermo-chemical method. It is the most common method today.During the gasification process, approximately 85% of the energy of biomass is converted into gas.can be converted. The mixture of gas obtained at the end of the gasification process contains carbonmonoxide (CO) and hydrogen (H_2). Certain amounts of substances such as methane (CH_4), carbondioxide (CO_2), sulfurdioxide (SO_2) and ethylene (C_2H_4) may be present depending on the characteristics and chemical structures of the waste entering the gasification plant. These lower synthesis gas components are burned in the later stages of the reaction and the remaining waste gases are discharged in the gas washing systemand released into the atmosphere.In addition, the ash remaining after the combustion of waste turns into biochar, which is a substance that may differ depending on the chemical properties of the incoming waste.Gas produced after this point are used in combustion engines, micro-turbines, heat engines, gas turbines and produces heat and power.

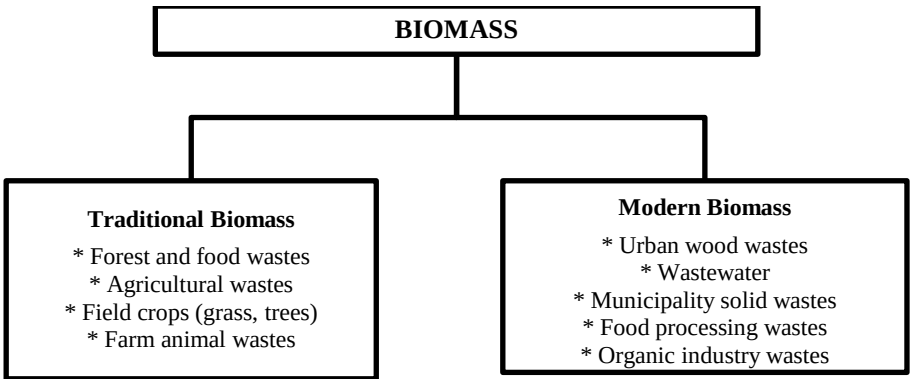

Figure 2. Traditional and modern biomass classification

Pyrolysis: Pyrolysis, one of the gasification cycle techniques, is carried out by heating the biomass source at 400°C-650°C in an anaerobic environment.At the end of this process, low cost bio-oil (60%), synthesis gas (20%) and biochar (20%) is formed. Bio-oil is an advantageous fuel in terms of its reprocessability, high energy and ease of transportation. There exist many researches about the use of biochar and bio-oil in electricity and heat production, it is currently not commercially available.

Anaerobic digestion: Anaerobic digestion is a biochemical conversion system which converts organic matter into microorganisms in an anaerobic environment.Anaerobic digestion is mostly used in the process of converting municipal solid waste into energy. The 50% to 65% of the biogas obtained consists of methane, the remaining majority consists of carbon dioxide. The resulting gas can be burned in engines or turbines to produce power and heat [14-16].

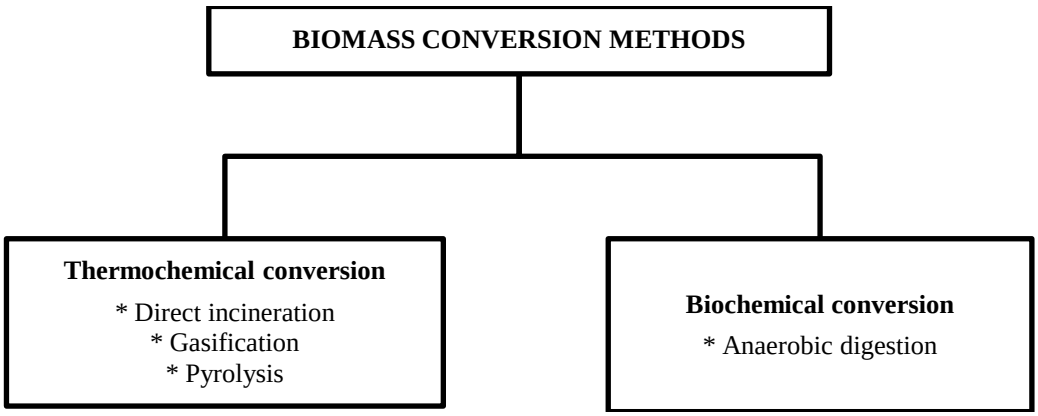

Figure 3. Biomass conversion methods

Renewable energy has become an indispensable part of the energy sector for various reasons, especially energy supply security and reduction of greenhouse gas emissions. Renewable energy, which generally has a higher initial investment cost compared to energy production investments based on fossil fuels and conventional energy sources, is supported by the public through various mechanisms in most countries and in Turkiye. Biomass, which constitutes approximately 10% of the world's total primary energy supply, is used for electricity generation as well as for heating and transportation. In electricity production, biomass energy comes second after wind among renewable energy sources, and solar energy based production comes third [17].

Biomass, which has been used traditionally and predominantly in domestic heating for centuries, has begun to be used in transportation and electricity production. Although more than 70% of the primary energy supply from biomass is currently used for domestic heating purposes, mainly in developing countries, it is predicted that the share of biomass used for transportation and electricity generation, called modern biomass, will increase in the coming period. According to World Energy Outlook, it is predicted that 8% of the fuels used in transportation will be based on biomass by 2035.

3. Importance of Biomass Energy

It is estimated that the bioenergy market is one of the markets with the highest employment potential among renewable energy technologies. In the bioenergy market, which provided direct and indirect employment opportunities to 1.4 million people in 2010, Brazil, the USA and the European Union region are at the top in terms of employment. Especially in Brazil, due to low labor productivity, the sugar cane industry is the single sector that employs the most workers. The increasing importance of biomass and biofuels obtained from biomass is carefully evaluated by world countries and various investments are made in this regard. In the European Union, targets have been set for 25% of energy consumption to be met by renewable energy in 2030 and 15% biofuel use in the transportation sector of each member country. 12 billion kWh of electricity is obtained from 4078 biogas facilities in Germany. In Sweden, another EU member, 60% of the cars run on biogas, and biogas has also been used in trains since 2005. Biogas is used in every area where natural gas is used in Sweden, and it was aimed to abandon the use of natural gas in 2020. In addition, there are approximately 30,000 biogas facilities producing electricity in China, the country that invests the most in renewable energy in the world.

The biogas sector in Turkiyeconsists of biogas production from garbage, from wastewater and facilities of some industrial facilities and municipalities, primarily in the cities of Ankara, Istanbul, Bursa, Kayseri, Gaziantep and Samsun. There are gasification and demonstration projects carried out by the Ministry of Agriculture and Forestry in different regions of Anatolia and qualified biogas projectscarried out by the private sector. In addition to the electricity obtained from the Ankaralandfill, the waste heat generated is used in the greenhouses established on the landfill. Also, algae, which is an efficient biofuel raw material, is grown. Turkiye has an area of 78 million hectares. It has a very rich ecological diversity and forests have an important place in terms of species and composition. According to the findings, forest areas constitute approximately 28% of the country's area. Treeless forest areas are not included in these areas.

The size and changes of forest areas were determined as 22,342,935 hectares (28.6% of the country's total) in 2015, according to the forest inventory assessment results and years carried out so far. According to these inventory results; it has been observed that there has been an increase of approximately 2.1 million hectares in forest area in the last 42 years.Although the biodiesel sector was established in the early 2000s, it is still a troubled sector. In recent years, more than 200 biodiesel plants have been established in Turkey, 56 of which are licensed. Although the total capacity of the established biodiesel facilities is around 1.5 million tons, it is known that many facilities have been closed due to the lack of domestic raw materials. However, very few companies actively produce biodiesel from domestic agricultural products. The imported biofuel does not have any added value to the country, even if it is imported in the composition of the fuel oil. It only supports the farmers and economy of the importing country. In the bioethanol sector, the amount of bioethanol that had to be blended with gasoline in our country in 2017 was approximately 162 million liters. It is aimed to create a business volume of 2.8 million dollars in the service sector. The importance will be given to paving the way for the use of biofuels produced with today's technology in our country by saving 130,000 tons of CO_2, and to the development of advanced generation biofuel technologies using non-food raw materials [10-14].

4. The Future of Biomass Energy

Turkey's strategic geographical location enables it to be an energy bridge between the oil and natural gas producing areas in the Middle East and the Caspian Sea and the consumption market in Europe. The Strait of Gibraltar transports Caspian oil to the European market; Baku-Tbilisi-Ceyhan (BTC) natural gas pipeline; the first international pipeline carrying Caspian oil without passing through Russian territory; its location with the Ceyhan port, where Northern Iraq oil is exported, makes Turkiye an important energy transfer country. Turkiye has become a significant energy consumer in its own region with its growing economy. Energy types where production does not meet demand are provided through imports. The largest share among the resources imported from abroad is oil and natural gas.

According to Ministry of Energy and Natural Resources of Turkish Republic, the total economic energy equivalent of our wastes that can be collected is approximately 3.9 MTEP/year. The installed power based on biomass and waste heat energy is 2172 MW as of the end of June 2022, and its ratio in the total installed power is 2.14%. Turkiye is a developing country with its rich agricultural potential. 70% of the cultivated land consists of wheat in the first, barley in the second and corn in the third place. Industrial crops such as cotton, flax, sesame seeds, soybean and poppy grow in Anatolia. Various types of the fruit grow in almost every part of the country. As seen in the examples above, Turkiye has the possibility of various agricultural residues as a biomass energy source [13,18].

Biogas, which is the product of anaerobic fermentation of animal waste, has an annual potential of 2.2 and 3.9 billion m^3 when all 1-2 million tons of waste can be used for biogas production. 85% of the biogas potential comes from animal waste and the rest from landfill gas. The animal waste gas potential consists of

50% from sheep, 43% from cattle, and 7% from poultry. According to calculations, an average of 80-100 tons of wet biomass (25-30 tons of usable dry biomass material) per hectare can be obtained from the Central Anatolia Region. If the current biogas potential is evaluated, it is seen that it will correspond to approximately 3 million tons/year of hard coal equivalent [19].

In addition to the wastes whose potentials are mentioned above, wastes such as methane gas (CH_4), domestic solid wastes, garden wastes, leather and textile industry wastes, paper industry wastes, food industry wastes, wastewater treatment plants and various production processes of the manufacturing industry can also be used as biomass energy. Considering all this potential data and the fact that when the biomass resource is evaluated on-site, the loss rates will only be due to system efficiency, it can be said that biomass energy resources are candidates to become the most important and sustainable energy source of the world in the coming period.

It is observed that investments in biomass energy are increasing in developed countries of the world and international communities such as the European Union, and its applications are becoming widespread in other countries [20]. The countries that produces the most amount of biodiesel are; Germany, USA,Argentina, Brazil and France. Also, the countries that produce the most bioethanol are; USA, Brazil, China, Canada. The electricity production from biomass resources grew by 15% compared to 2012 and reached a power of 378 TWh. The USA, which produces electricity with biomass resources, comes first on the list with 67 TWh. The USA is followed by the technology giant China, then Germany and Brazil. Although it is not included in the installed capacity list, Japan is among the top five for biomass production. When we examine the annual growth percentages of generating electricity with biomass between 2011 and 2019, China comes next with 25%. There is Japan with 10.5%, and among these, Brazil is among the countries with the highest potential [20-22].

5. Conclusion

Energy, which is an indispensable part of human life, is one of the most discussed topics on the world. Energy continues to be amost important factor in the economic and social development of countries and in increasing social welfare. In the energy sector, which is a strategic field, it is a necessity to approach problems from a strategic perspective. It is seen that energy strategies designed only to meet possible demand in the energy sector will be insufficient and will not be compatible with widespread trends in the world.

The aim of energy policies should be to obtain uninterrupted, reliable, clean and cheap energy. In this context, it is important for energy policies to increase the diversity of resources as well as to use the energy offered for consumption efficiently. Nowadays, efforts to find new energy sources are increasing. Research focuses on discovering new, economical and renewable energy sources, ensuring that renewable energy sources are becoming more widespread day by day. Biofuels can be used as fuel for heat, electricity and vehicles, and can also be used in internal combustion machines and turbines etc. Based on accessible statistical data, it appears that biomass energy has a significant technical potential to be used in the world and in Turkey.

An important issue that needs to be noted regarding the use of bioenergy is the carbon released during production. Emissions can be reduced in the future; carbon capture technologies should be developed. Replacing fossil fuels with biofuels not only has the potential to reduce some of the undesirable aspects of fossil fuel production and use, but demand for biofuels can also increase farm income. On the other hand, since many biofuel raw materials require other resources such as land and water, research points out that biofuel production may cause some undesirable effects. Potential disadvantages include changes in land use patterns that could increase greenhouse gas emissions, pressure on water resources, air and water pollution, and rising food costs.

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