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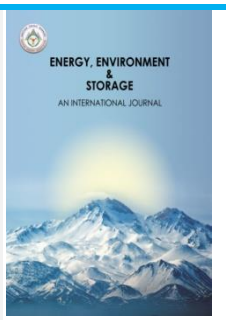

Biomass Potential of Kayseri Province

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Abstract: Today the decrease of fossil fuels, which are used nearly in every area from heating to manufacture and transportation, and the environmental pollution, and external dependency in energy sector, has increased the studies about alternative energy sources not only in Turkey but also throughout the world. Among these alternative sources, biomass has a significant importance. In this study biomass potential of Kayseri province was examined. The aim of this study is to set forth the electric and biogas energy potential of the biomass sources found in the Kayseri city. In this context potential biomass and biogas calculations were realized. In the result of the calculations made, the biomass energy value obtained from the sources in hand is 5,41TW/year. Similarly the biogas energy value is 85, 97 million meter cube/year.

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1. INTRODUCTION

Renewable energy sources (RES) are commonly accepted as the key for future life, not only for Turkey but also for the whole world. This is primarily because RES have some advantages when compared to fossil fuels. Renewable energy power plants have far less environmental impacts than fossil-fuel fired power plants. Usage of these technologies reduces the amount of carbon dioxide produced. RES can also contribute to reducing dependence on energy imports and permit diversification of the energy supply. This will not only reduce Turkey's dependence on imports of fuel for producing energy, but will also ensure a continued local source of energy. In the developing countries, RES are more important because many of these nations do not have scarce fossil energy sources such as crude oil and natural gas. Biomass is one of the most promising RES. It is considered as an alternative to conventional energy and has significant potential in Turkey [1] .

Biomass can be defined as the total mass of the organisms that belongs to a kind or various kinds in a certain time period. It is also admitted as organic carbon. There are different biomass sources such as herbal sources, forest and forest products, animal sources, organic wastes, and also industrial and municipal wastes [2]. In this study, biomass potential of Kayseri Province Turkey was investigated.

2. THE LOCATION AND THE PROPERTIES OF KAYSERI PROVINCE

Kayseri is situated in central Turkey. It covers an area of 17,109 km². The steppe climate is dominant in Kayseri. The city's population is 1.421.455 according to 2021 address –based population registration system [3]. There are 16 districts, 17 municipality and 424 villages in the city. The city has three organized industry zones including many factories that make various types of productions ranging from carpet, jean textile to electric cable, aluminum profile, stainless steel and galvanized pipes, office furniture, beds, towel, furniture, fruit juice, biscuits, chicken etc. Many of these productions are exported to European countries, Middle East and Africa. The agriculture of the province involves cereals growing and animal husbandry. In this scope, fruit and vegetable agriculture, forage and industrial crop growing are

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made. Animal husbandry generally includes bovine and ovine
caprine animal breeding, poultry farming. As you can see there are so many industrial and agricultural business branches in Kayseri so there is a huge amount of energy need in the city. Meeting this energy need from Renewable energy sources (RES) will provide many advantages in terms of saving money, providing new working areas, and also giving contribution to national development of the country by decreasing the foreign energy supply. In this study by taking all these into account we made some the evaluation of biomass potential of Kayseri of course formerly by determining the available energy sources and then by specifying the energy potential in terms of biomass energy. At the end with the comparison made between these, we concluded that it's high time; Kayseri province obtained most of its energy from its biomass potential.

3. KAYSERI PROVINCE EXISTING ENERGY SOURCES

When we examine the Kayseri province Electric energy sources according to plant types we see that the active plant number in Kayseri province is 85 and the total power of these are 855 MWe. This means an annual electrical energy production of 2025 GWh. Today sun power plants (SP) has the biggest share with 62 plants in Kayseri, and hydroelectric power plants (HEP) are following these with 11 plants, additionally wind energy power plants (WP) is the third , and natural gas cogeneration plants (CP) are in the fourth rank. As you can see in the Table 1 biogas energy plants (BEP) are in the last order [4].

Table 1: Renewable Energy Producing Plants in Kayseri [5]**.**

Energy Power Plants	Total Plant Number	Total Power (MW)	It's Share in Total Installed Power in Kayseri (%)
BEP[1]	1	5,78	0,68
CP*	6	45,89	5,37
SP[2]	62	275,05	32,17
HEP[3]	11	255,189	29,85
WP[4]	5	273	31,93
TOTAL	**85**	**855**	**100**

*CP : Cogeneration Plant using Natural gas as fuel. This is not a renewable plant but is written here to specify the total electric power sources in Kayseri province
[1]Biogas Energy Plants (BEP) [2]Sun Power Plants (SP) [3]Hydroelectric Power Plants (HEP) [4]Wind Energy Power Plants (WP)
The installed electrical power of the plants in Turkey is 91.267 MW[6]. On the other hand there are new studies for new plant constructions in Kayseri. These are given in Table 2 below

Table 2. Kayseri Province Electric Power Plants under Construction [7]**.**

Plant Type	Power (MW)
1 piece of HEP	12
6 pieces of SP	18
1 piece BEP	19
Total	**49,5**

When we make observation about the electric production plants in terms of plant type in Turkey , we see that the electric power obtained from installed biogas plants is 1138 MW, but the production of Kayseri is 5,78 MW today. With completion of the new plants an additional 49,5 MW will occur. Nevertheless when we look in terms of production of power this will increase from 0,5% to 4,8% . In order to evaluate the biomass potential of Kayseri we have to found new plants and increase the production. Because we have so much potential than we use below study is made to prove this reality.

4. AIM, DATA, AND THE METHOD

The aim of this study is the determination of the biomass energy potential of Kayseri province. First of all we have started making literature scan about biomass energy in the beginning of our study. After evaluating the information obtained, in order to determine the quality and the quantity of the biomass potential of the city, in terms of husbandry, herbal agriculture, and municipal wastes, we have used the data obtained from some statistical institutions such as; Provincial Directorate of Food, Agriculture and Livestock, Turkish Statistical Institute, Kayseri Metropolitan Municipality and Turkish Republic Ministry of Energy and Natural Sources for the calculations.

4.1. Electric Generation Methods Using Biogas and Wastes

Energy can be generated from biomass and waste by using many different technologies by means of indirect or storable interim methods. These technologies can be examined in two groups; biological and thermal methods. Biological methods include: fermentation and thermo-chemical methods divided into subgroups including incineration, gasification and pyrolysis. About 90% of energy generation from waste across the globe is realized by means of the incineration method. Direct incineration is a widely used method in converting waste to energy. Today, many power plants using waste have direct incineration systems. In such plants, as long as the steam temperature and pressure increases, the efficiency of the plant is raised. Heat and electric generation methods using solid biomass and waste are divided into two groups; generation based on incineration, and generation based on gasification techniques. Generation based on incineration: In incineration, the chemical energy of

converting fuel to heat energy is transmitted to a heat exchanger and the secondary fluid in the heat exchanger expands in a turbine or a similar system, forming the mechanical energy. Generation based on gasification: In gasification, materials were being reacted at high temperature with a controlled amount of oxygen and/or steam, without combustion and a fuel called syngas is produced [1, s. 3].

5. KAYSERI PROVINCE BIOMASS SOURCES

When we consider the data about biomass we should have to take two kinds of data into consideration. One is theoretical and the other is economic values. For instance, the economic value of the LGF calculated by considering the theoretical amount that is obtained will be 40% of the theoretical amount [1, s. 3]. According to these admittances we calculate the below values.

5.1. Municipal Solid Wastes (MSW)

In reference to the address based population registration system Kayseri province population is 1.421.455 person for 2021 [3]. The average MSW amount per person is 1.16 kg/person/day [8]. Pursuant to this data, the annual MSW amount for a person in Kayseri is 0,42 ton/person. Annual MSW amount for the city is 601.885 ton/year. In 20 years the land field gas (LFG) that is obtained from this MSW amount to be used to provide the primary electricity for the city is calculated as 12,03 billion m^3. But this calculation is theoretical and only 40% of the obtained LFG is usable in practical so LFG gained from the specified MSW is 4,81 billion m^3 for a period of 20 years. Accordingly, the annual value of the LFG potential of municipality for the given waste services is 0,24 million m^3/year [9]. When we calculate the potential energy of this LFG, we will have 1,64 TW/year.

5.2. Animal wastes

Total animal amount of Kayseri is 5.786.379 pieces. This total amount includes 347.594 pieces of bovine animal, 649.606 pieces of small cattle, and 4.789.179 pieces of poultry [10]. The total theoretical manure amount derived from these is 1.811.425 tons/year. The annual manure amount held by a bovine animal is 3,6 tons/year, small cattle is 0,7 tons/year and a poultry is 0,022 tons/year.

In Table 3 annual and net manure amounts according to the total animal amounts by species are given.

Table 3. Kayseri Province Animal Manure Amount

	Pieces	Annual Manure Amount (Ton/ Year)	Total Theoretical Animal Manure Amount	Net Animal Manure Amount After 1/3 Lost
Bovine animal	347.594,00	3,60	1.251.338	834.226
Small cattle	649.606,00	0,70	454.724	303.149
Poultry	4.789.179,00	0,02	105.362	70.241
TOTAL	**5.786.379,00**	**4,32**	**1.811.425**	**1.207.616**

According to these acceptations, when we make the animal waste calculations for the animal types in Kayseri province we get the theoretical bovine animal manure amount as 1.251.338 ton/year, the small cattle amount as 454.724 ton/year, and the poultry manure as 105.362 ton/year. But in order to make an approximate calculation we should consider the lost in the forages (1/3 of the total). Hereunder the new calculations are: bovine manure is 834.226 ton/year, small cattle manure is 303.149 ton/year, and the poultry manure is 70.241 ton/year. In terms of animal manure the practically usable net animal manure for Kayseri is 1.207.616 ton/year. In reference to the acceptances for different animal manures, the biogas production is calculated as 50,5 million m^3/year. The heating amount of 1 m^3 biogas changes between 4700-5700 kcal/m^3. So, by making the calculations according to this data the electricity produced from this is nearly 3,57 TW/year [11].

5.3. Herbal wastes

The herbal statistical data of Kayseri is arranged with regards to Bepa [12]. In this context the herbal production is 584.124 tons. The herbal waste amount corresponding to this amount is 864.165 ton. The economical annual equivalence of this herbal waste is 17.706,7 TOE. The technology used to turn this waste into energy is incineration. 1 TOE is 11.600 kWh, by taking this information into account the electric power obtained from this will be nearly 0,2 TW/year. The biogas that is produced due to this amount of herbal waste is 11,3 million m3/year [13].

6. KAYSERI PROVINCE TOTAL BIOMASS POTENTIAL

In reference to the above information and calculations we can summarize the total biomass potential in Table 4 such as below:

Table 4: Kayseri Province Total Biomass Potential

Type of Biomass Source	Produced Biomass (million m^3)	Electric Power Gained (TW/year)
Animals	**50,6**	**3,57**
Plants	**11,3**	**0,2**
Municipality Waste	**24,07**	**1,64**
Total biomass potential	**85,97**	**5,41**

Seeing from the Table 4, we understand that nearly 60% of the biomass energy of Kayseri can be met by animal wastes, while 13% is met by plants and 27% is met by Municipality waste. (Look Figure 1)

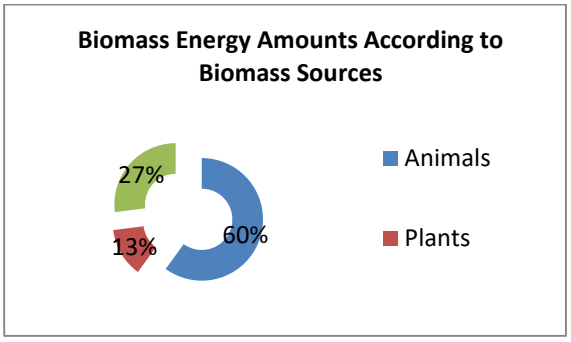

Figure 1: Biomass Energy Amounts According to Biomass Sources

7. CONCLUSION

In this study, the biomass potential of Kayseri province is evaluated according to the renewable energy sources mostly found in Kayseri such as animal, plant and municipal wastes. Effective usage of energy sources in Turkey is very important in terms of dependency on foreign sources. On the other hand using biogas for the generation of electricity provides advantages for clean environment. In comparison to fossil fuels, biomass energy is a clean and sustainable energy source with less air emission values, less waste disposal, and a decreased foreign dependency.

The total electric energy consumption in Kayseri in 2020 is 4,70 TWh. When we evaluate the situation in reference to the above given data and calculations, this is less than the amount that can be produced from biomass energy potential of Kayseri province, this means if we use 87% of total biomass energy potential of Kayseri we can meet the whole energy need of the city. Today according to 2020 data [14] the biomass origin electric power generation in Kayseri is 0,015 TWh , this is only 0,3% of the total consumption of the city. In conclusion, Kayseri province has a big opportunity of producing electricity from its biomass potential.

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