



A Study on The Biomass Energy Potential of Turkey: Example of Wood Pellets

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Geliş/Received: 07.12.2020

Kabul/Accepted: 09.12.2020

How to cite: Toksoy, D., Çolak, S., Bayramoğlu M.M. (2020). A Study on The Biomass Energy Potential of Turkey: Example of Wood Pellets. *J. Anatolian Env. and Anim. Sciences*, 5(5), 867-867.

Atf yapmak için: Toksoy, D., Çolak, S., Bayramoğlu M.M. (2020). Türkiye'nin Biyokütle Enerji Potansiyeli Üzerine Bir Araştırma: Odun Peleti Örneği. *Anadolu Çev. ve Hay. Dergisi*, 5(5), 867-871.

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Abstract: Wood Pellet, one of the biomass fuels in renewable energy sources, stands out among all renewable energy sources with its ease of production technology, environmental friendliness and similar features. Wood pellets, which are fuel pellets of 6-10 mm diameter, which are obtained from the drying of wood waste, milling it into sawdust and then compressing it with high pressure, have become economically comparable with fossil fuels today. Wood pellet trade worldwide increased by more than 21% in 2018 compared to the previous year, reaching a trade volume of 22.3 million tons. The biggest pellet exporter countries in the world since 2012 are USA, Canada, Vietnam, Latvia and Russia respectively. These countries accounted for approximately 69% of the world export volume in 2018. Except for five countries, they continue to work on alternative energy sources and especially the production, technology, use and properties of wood pellets in China. In Turkey, there are studies on the production of wood pellets and the economy. However, these studies need to be updated both in terms of production and economics. In the study, analyzed the current data with the potential that Turkey has developed proposals for the use of this potential.

Keywords: Forestry, economy, biofuel, energy demand.

Türkiye'nin Biyokütle Enerji Potansiyeli Üzerine Bir Araştırma: Odun Peleti Örneği

Öz: Odun Peleti, üretim teknolojisi kolaylığı, çevre dostu olması ve benzeri özellikleri ile tüm yenilenebilir enerji kaynakları içinde öne çıkmaktadır. Odun artıklarının kurutulup, öğütülerek talaş haline getirildikten sonra yüksek basınçla sıkıştırılmasından elde edilen 6-10 mm çapındaki yakıt toprakları olan odun peletin ekonomik açıdan günümüzde fosil yakıtlar ile karşılaştırılabilir konuma gelmiştir. Dünya genelinde odun peleti ticareti, bir önceki yıla kıyasla 2018'de % 21'den fazla artış göstermiş olup 22.3 milyon tonluk ticaret hacmine ulaşmıştır. Dünya'da 2012 yılından itibaren en büyük pelet ihracatçısı ülkeler sırasıyla ABD, Kanada, Vietnam, Letonya ve Rusya'dır. Bu ülkeler 2018 yılında dünya ihracat hacminin yaklaşık % 69'unu oluşturmuşlardır. Beş ülke haricinde Çin'de alternatif enerji kaynakları ve özellikle odun peletinin üretimi, teknolojisi, kullanımı ve özellikleri üzerine çalışmalarını devam ettirmektedirler. Türkiye'de ise odun peletinin üretimi ve ekonomisi üzerine çalışmalar bulunmaktadır. Ancak bu çalışmalar gerek üretim gerekse ekonomik açıdan güncellenmesi gerekmektedir. Çalışmada, Türkiye'nin sahip olduğu potansiyel güncel veriler ile analiz edilerek bu potansiyelin kullanımına yönelik öneriler geliştirilmiştir.

Anahtar kelimeler: Ormancılık, ekonomi, biyo-yakıt, enerji talebi.

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INTRODUCTION

Renewable sources particularly biomass account for an increasing proportion of energy generation. Efforts to limit the use of fossil fuels and the development of alternative energy resources are also effective in this increase (Kaygusuz et al., 2017). Wood pellets are the most popular and traded among biomass fuels (Jagers et al., 2020). Wood pellets from biomass fuels have emerged as a substitute for coal, natural gas and fuel oil both in industry and residential heating (Junginger et al. 2019). Wood pellet is obtained by smashing and compressing the wood residuals such as wood chips and tree bark. Sawdust or wood chips that are compressed under high temperature and pressure bind together, due to their lignin content, to form wood pellet. Wood pellet, which is a subsidiary product obtained from sawdust as a result of wood processing, can now also be obtained from round chocks and battens. Wood pellet is highly preferable to other solid biomass fuels due to its low humidity (less than 10%) and high energy density (Junginger et al., 2011; Stewart, 2006).

Compared to wood pellets to produce 1 MWh of energy; natural gas 3, fuel oil 5 and electric heating release 10 times as much CO₂ into the atmosphere (Saraçoğlu, 2010). For this reason, the production and use of wood pellets is increasing, especially in developed countries. Many countries have made legal regulations on the use and trade of wood pellets in response to this interest (Bayramoğlu & Toksoy, 2015).

The use of renewable energy sources in Turkey has not yet reached the desired level. The use of fossil fuels in industry and residences is quite high. The share of the overall power generation of renewable energy sources, despite a great potential to renewable energy sources is low in terms of Turkey. There has been an increase in energy production from renewable energy sources with the legal regulations (subsidy etc.). Turkey's energy potential of biomass is also high. However, the use and trade of this potential is almost nonexistent. The reason for this situation; Inadequate studies on biomass fuels (especially wood pellets), lack of a market for biofuels produced from wood raw materials, lack of legislation, and not encouraging private sector investments.

Turkey's biomass potential has been demonstrated with this study with updated data compared with other energy sources of wood pellets. The amount of wood pellets that can be produced and its economic value have been calculated.

MATERIALS AND METHOD

Data Collection: In the study, many studies in the literature on climate change, biomass energy and wood

pellet and international conventions, protocols, meeting and conference final declarations related to the emergence and functioning of wood pellet were also used as material. Especially in Turkey, biomass potential and wood pellet, use, trade, legal and institutional report prepared by the relevant ministries for the section dealing with regulations, national action plans and strategy documents were also used.

Methods: Literature review method was used in the study. Detailed information on the subject was obtained and analyzed. The deductive method was used to form the conceptual framework of the study. First of all, the concepts of renewable energy, biomass energy and wood pellet were introduced and wood pellet formed as a result of international processes were explained. Also next to the position of Turkey in the wood pellet market, the situation in the international process, scientific and technical infrastructure and legal and institutional arrangements were discussed.

RESULTS AND DISCUSSION

Biomass Energy Potential of Turkey: Turkey has a significant amount of biomass and bioenergy potential. However, there are different studies regarding the total bioenergy potential. Turkey's total bioenergy potential was estimated Taşdemiroğlu (1986) 17 Mtoe (million tonnes of oil equivalent), WECTNC (1996) 16.92 Mtoe, Ediger and Kentel (1999) 17.2 Mtoe, Kaygusuz (2002) 16.9 Mtoe, Demierbaş et al. (2006) 65 Mtoe, Toklu (2017) 17 Mtoe and Öztürk et al. (2017) 16.92 Mtoe.

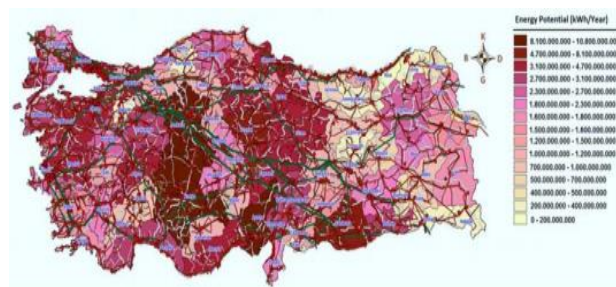


Figure 1. Turkey's total biomass potential (MEF, 2009).

Turkey's main biomass production is given in Table 1. Turkey's main biomass production is based on wheat straw, wood and woody materials, cocoon shell, hazelnut shell, grain dust, crop residues and fruit tree residues (Melikoğlu, 2013). Various agricultural residues such as grain dust, wheat straw and hazelnut shell are available in Turkey as the sources of biomass energy. Approximately 2.6×10^7 tonnes of wheat straw was produced annually in Turkey. The straw is disposed of in the fields either by burning or sometimes by ploughing it back into the soil. Because the higher heating value of

straw is about ½ that of high-grade coal (its higher heating value is about 28 MJ/kg), the surplus straw is equivalent to about 1.3×10^7 tonnes. The hazelnut shell is a potentially important energy source and the amount produced annually in Turkey is estimated to be about 3.5×10^5 tonnes. The higher heating value of the hazelnut shell is 19.2 MJ/kg and its calorific value is equivalent to about 1.9×10^6 kWh (Demirbaş & Şahin, 1998; Sürmen, 2002).

Table 1. Turkey's annual biomass potential (İlleez, 2020).

	Amount (tone/year)	Energy Potential (TEP/year)	Economical Energy Potential (TEP/year)
Animal wastes	193.878.079	4.385.371	1.084.506
Agricultural residues	62.206.754	6.009.049	1.462.159
City residues	32.170.975	3.373.011	485.858
Forest residues	2.739.865	859.899	-
TOTAL	290.995.673	14.627.330	3.032.523

Turkey's electricity generation in the year 2018 303.625 GWh (26 million toe) 68% of this production is from fossil sources, 32% is produced from renewable energy sources. However, the share of biomass in renewable energy remained at a very low level with a share of 2.75% and 0.88% in total electricity generation (İlleez, 2020). In 1990, the heat produced from biomass sources worldwide was realized as 6.2 million TEP and met only 1.6% of the total heat production. In 2018, heat production from biomass reached 7.5% with 26 million TEP. Europe is the world leader with 87% share of heat generated globally due to its widespread and effective use of all biomass resources, including municipal waste, solid biofuels and industrial waste (WEO, 2019). Turkey at the end of 2018 the production of heat energy biomass has had a 10.2% share by approximately 133.000 TEP (IEA, 2020; ETKB, 2020; IRENA, 2019).

Table 2. Present and planned biomass energy production in Turkey (SSI, 1996).

Years	Modern Biomass (ktoe)	Classic biomass (ktoe)	Total (ktoe)
1999	5	7012	7017
2000	17	6965	6982
2005	766	6494	7260
2010	1660	5754	7414
2015	2530	4790	7320
2020	3520	4000	7520
2025	4465	3345	7810
2030	4895	3310	8205

Since the early 2000s, it has prepared the biomass energy production program in Turkey. Present and planned biomass energy production in Turkey is given in Table 2. According to a study by Demirbaş (2006), Turkey's biomass production was 7 million tonnes in 1999, and is predicted to increase to 8.2 million tonnes in 2030. According to the index published by Ernst & Young (2012), Turkey is ranked 30th of 40 countries (index value

39.8) for renewable energy and 28th for biomass (index value 35).

Wood and Woody Biomass Potential of Turkey:

Interest in forests is increasing, especially due to its role in carbon sequestration in mitigation global climate change. In order to reduce the greenhouse gas accumulation of forests; It is necessary to protect forests, planting new forest areas, reducing harvest density, increasing forest growth and carbon storage in harvested wood products (Bilgen, 2014).

Woody biomass (especially fuelwood), as in the world, it is important for rural areas in Turkey because fuelwood is very important source of energy and the major source of energy in rural Turkey. About half of the world's population rely on woody biomass or other biomass for cooking and other domestic use.. About half of the total demand for fuelwood is met through informal cutting of State forests and other woody biomass resources in agricultural areas (Bilgen et al., 2008). Among the biomass energy sources, woody biomass is the most interesting. Because it is high in Turkey's total energy production and conversion techniques are useful to it is not necessarily complicated. Forest biomass consumption compared to total energy has decreased from 22% to 14% (Kaygusuz, 2010).

The latest data of the forest assets in Turkey published in 2015. Turkey's forest area of 22,342,935 hectares have been based on these data in 2015. Turkey forest area constitutes 29% of the 78 million hectares of the country up to the surface. According to 2015 data, 57% (12,704,148 ha) of forest areas are forest areas with more than 10% canopy cover, which is qualified as productive forest in terms of wood raw material production. The remaining 43% of the forest areas (9,638,787 ha) consists of hollow closed forest areas with a closure less than 10% and called degraded or inefficient forest areas. The total forest potential of Turkey is around 1.6 billion m^3 with an annual growth of about 45.9 million m^3 in 2015 (TOD, 2019).

Table 3. Turkey's 2015-2019 industrial and firewood production.

Years	Industrial Wood (m^3)-	Firewood (Stere)
2015	16.637.598	5.022.986
2016	17.009.998	4.877.067
2017	15.521.622	4.359.646
2018	19.080.137	4.890.455
2019	22.113.248	5.589.798

Turkey has produced 22.3 million m^3 industrial wood and 5.58 million stere firewood in 2019. Turkey's 2015-2019 industrial and firewood production are given in Table 3. In the last 5 years, it has produced an average of 18.072.520,6 m^3 industrial wood and 4.947.990,4 stere firewood.

Wood Pellet Potential of Turkey: The forestry sector is a rising trend in Turkey. In order to meet the demand of the sector, industrial wood production has been increased by approximately 33% in the last 5 years. Approximately 25% of a tree is left in the forest as production residue at the end of the production activity (Karayılmazlar et al., 2011). In Turkey, annually about 5 million m³ wood residues is left in the forest. These residues are left to rot as they do not set off the transportation costs. There are different studies on the amount of production residues. Bayramoğlu and Toksoy (2015) stated that approximately 4 million m³ of forest residues could be obtained from 10 million m³ of industrial wood production. According to General Directorate of Forestry (GDF) estimated that there was a total of 3.528.320 stere of production residues in 27 Regional Forest Directorates (RFD) between 2007 and 2009.

Assuming that 1 m³ is equal 0.600 tone, 5 million m³ wood is equal to 3 million tone. Approximately 600 kg wood pellet is produced from 1 tone wood. In this context 1.8 million tone wood pellet can be produced from 3 million tone wood which market value nearly 274 million dollar. The energy value that can be obtained from 1.8 million tonnes of wood pellets is approximately 0.72 Mtep which represents 0.57% of total primary energy consumption in 2015, and 0.75% of the imported amount of energy (95.1 mtep); 0.54% of total primary energy consumption in 2016 and 0.74 % of imported energy (97.3 mtep); 0.49% of total primary energy consumption in 2017 and 0.65% of imported energy (110.1 mtep) of Turkey. From 2015 to 2017, Turkey paid 37.8, 27.1 and 37.2 billion dollars, respectively for imported energy. According to these calculations, if Turkey utilized wood pellet potential, this would result in saved of 28.3 billion dollars in 2015, 20 billion dollars in 2016 and 24.1 billion dollars in 2017.

Economic comparison of the Turkish context indicates that wood pellet is more advantageous than other energy sources. One house in Turkey requires approximately 50.2 GJ heating energy, which would require 2 tonnes of coal, 1142 kg oil fuel, 1454 m³ natural gas or 2.66 tonnes wood pellets.

Table 4. Compare of Energy Sources.

Energy Sources	Energy (kcal)	Amount (kg)	Unit Price (\$)**	Total (\$)
Coal	6000	2000	0.28	560
Fuel Oil	10500	1142	0.47	541
Natural Gas	8250	1454*	0.31	450
Wood Pellet	4500	2660	0.14	371

*Amount of Consumption calculated m3 for natural gas.

**19.09.2020 date 1 \$ = 7.90 TL exchange rate.

Wood pellet has lower energy value than other energy sources because it has lower energy density (18 MJ/kg) . However, this low energy value and high rate of

usage means that wood pellet is cheaper than other energy sources.

In 2017, approximately 23.8 million tone of wood pellets were traded in the world. In 2023, this trading volume is expected to be 29 million tone. The use of wood pellets in developed countries has increased. In 2018, Japan imported over 1 million tone, South Korea 3.4 million, Netherlands 2.5 million and United Kingdom 1.5 million tone of wood pellets. Unfortunately, there is not data on the wood pellet trade in Turkey. If Turkey uses the potential of wood pellet, it is inevitable that it will get a share of the international market.

In this study, Turkey's wood pellet potential was calculated at 1.8 million tone, while Bayramoğlu and Toksoy (2015) calculated approximately 400,000 tone. Although the value of wood pellet is calculated as \$274 million, Bayramoğlu and Toksoy (2015) stated that this value as \$586 million. This difference is due to the change in the amount of wood used in production and the dollar rate. Besides, Bayramoğlu and Toksoy (2015) stated that wood pellet is more economical than other energy sources.

CONCLUSION

As a result of the increase in energy prices in the world, events in energy supply security, the development of alternative energy sources and the legal regulations and policies to reduce the use of fossil fuels in the combat against climate change, the share of renewable energy sources, especially biomass fuels, in energy production is increasing. Wood pellet is a prominent product in biomass fuels due to its ease of production and high raw material potential. Although legal regulations on renewable energy have been made in Turkey, the wood pellet has been in lower demand than expected, especially due to high costs.

Turkey should try to raise more awareness about its bioenergy potential. Legal arrangements must be made to create a market for wood pellets. Private sector investments should be encouraged, and national production standards should be created.

ACKNOWLEDGMENTS

The authors declare that there are no conflicts of interest. This study was presented in ORENKO 2020 held by Karadeniz Technical University, Trabzon.

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