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RENEWABLE ENERGY IN TURKEY: POTENTIAL, CURRENT STATUS AND FUTURE ASPECTS

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Abstract: Due to the numerous advantages such as being unlimited, clean and environmental friendly, usage of renewable energy sources is supported through incentives in Turkey as well as all over the world. Consequently, energy supply from renewables has increased rapidly in the last decade in Turkey. This work represents the renewable energy potential and current status of power production from renewables in Turkey. In addition, future aspects of renewables in Turkey is discussed in the current study. According to the results, it is clear that Turkey still have a huge renewable energy potential that can be very useful to decrease energy import.

Keywords: renewable, energy, potential, status, Turkey

INTRODUCTION

Sustainable energy has the key role in sustainable development especially for Turkey that cannot the energy requirement with indigenous sources and imports approximately 70% of its energy requirement. Sustainable energy equals to renewable energy. Investing in renewable energy is a good chance for Turkey since Turkey can reach three important goals stated in the development action plans with it: Sustainable development, decreasing energy import and increasing energy security [1-4].

As Turkey's reliance on imported natural gas for power generation has given rise to concerns over supply security and the country's bulging current account deficit, support of domestic energy sources such renewables has gained a new urgency [5].

In this paper, renewable energy potential and usage of Turkey for different resources are briefly given and future perspectives are discussed.

ENERGY SUPPLY AND DEMAND OF TURKEY

Turkey is a developing country with a strong economic growth and energy needs of Turkey increases rapidly. Total primary energy supply of Turkey was 129.7 million tons of oil-equivalent (Mtoe) in 2015 representing an increase of 54% compared to 2005 as seen in Figure 1 [6,7]. Natural gas, oil and coal covered 30.2%, 30.1% and 27.3% of this value respectively equal to a third of TPES in 2015. The country is highly depended on oil and gas imports and only 32.2 Mtoe (24.8%) of energy supply is met by domestic production. Renewable sources constituted 48.9% of all domestic energy production with hydro providing 17.9%, geothermal 14.8%, biomass 10.1%, wind 3.1% and solar 3%. It is estimated by the government that TPES will reach 222.4 Mtoe by 2020 [6]. Total final consumption (TFC) of Turkey was 85.8 Mtoe in 2014. Considering TFC for 2004, it has increased by 35.8% in 10 years. Oil consumption accounted for 35.6% of TFC whereas natural gas, electricity and coal

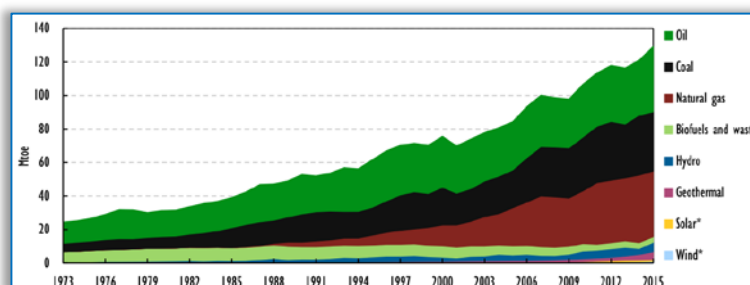


Figure 1. Total primary energy supply of Turkey, 1973-2015

and coal





accounted for 22.6%, 20.6% and 12.3% respectively [7]. A great part of the electricity demand of Turkey is produced from natural gas (38.6%) although most of the used natural gas is imported from various countries. Natural gas is followed by coal (28.3%) which made up 67.7% of total generation from fossil fuels in 2015. Renewables are third pillar in power generation with sharing hydro 25.8%, wind 4.4%, geothermal 1.3%, biofuels and waste 0.6% and solar 0.2% of total production [7]. There is also a rapid increase in electricity demand, which is annually approximately 5%, as given in Table 1 [1]. Turkey's official energy policy goals to minimize energy import and maximize the usage of indigenous energy sources until 2023. According to 2010-2014 action plan of Minister of Energy and Natural Sources, Turkey's goal is to produce 30% of electricity production from renewable energy sources [2].

Table 1. Electricity production and demand of Turkey in last 10 years

Year	Gross production (million kWh)	Rate of increase (%)	Electricity demand (million kWh)	Rate of increase (%)
2005	161,956	7,5	160,794	7.2
2006	176,300	8,9	174,637	8.6
2007	191,558	8,7	190,000	8.8
2008	198,418	3,6	198,085	4.3
2009	194,813	-1,8	194,079	-2.
2010	211,208	8,4	210,433	8.4
2011	229,395	8,6	230,306	9.4
2012	239,496	4,4	242,370	5.2
2013	239,293	-0,1	245,687	1.4
2014	251,963	5,3	257,220	4.7
2015	259,611	3	26,828	2.6

POTENTIAL AND CURRENT STATUS OF RENEWABLES IN TURKEY

Hydropower

Hydropower is a very imported renewable energy option for Turkey because there is huge hydropower potential. The gross theoretical viable hydroelectric potential in Turkey is 433 billion kWh, which is 1% of the world, technically viable potential is 216 billion kWh and the economically viable potential is 158 billion kWh. 104 HEPPs that have 5927 MW installed and 17,875 GWh/year generation capacities are still under construction as seen in Table 2. According to development plans, the installed hydroelectric power capacity will be 46,072 MW once the new HEPPs are constructed and the goal is to produce 140.000 GWh electricity from hydropower by 2023 [8].

Table 2. Present status and plans of HEPPs in Turkey [8]

Potential	Number of HEPP	Total installed Power (MW)	Mean annual production (GWh/year)	Ratio (%)
In operation	562	26,161	90,773	58
Under construction	104	5,927	17,875	11
In program	717	13,984	48,911	31
Total	1,383	46,072	157,559	100

Wind Energy

Total installed capacity has reached 4,498.4 MW in Turkey by the end of 2015. 11,543.050 MWh electricity is produced from 113 wind power plants in this year [1]. The wind energy potential atlas (REPA) is presented by Electrical Power Resources and Development Administration to determine the wind energy potential of Turkey in 2006 and it is presented in Figure 2 [9].

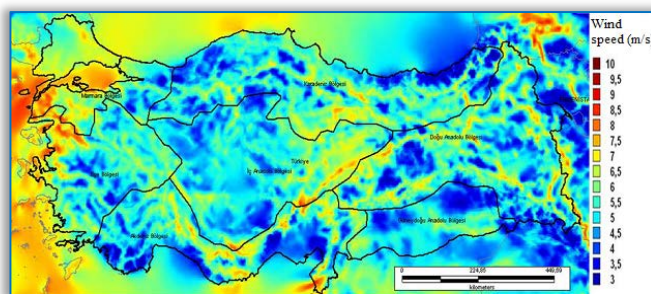


Figure 2. Wind energy potential atlas of Turkey [9]

According to REPA, the most attractive sites of Turkey are west site and Marmara region and there can be 130 billion kWh of electricity from a potential of 48,000 MW generated in areas where the wind velocity is greater than 7 m/s at an elevation of 50 m as given in Table 4 [10,11].

Table 3. Wind energy potential of Turkey [10,11]

Level of the wind	Classification of the wind	Wind power intensity at 50m high (W/m ²)	Wind speed at 50 m high (m/s)	Total area (km ²)	Ratio of the area	Total installed power (MW)
Average	3	300-400	6.5-7	16,781.39	2.27	83,906
Good	4	400-500	7-7.5	5,851.87	0.79	29,259.36
Very good	5	500-600	7.5-8	2,598.86	0.35	12,994.32
Awesome	6	600-800	8-9	1,079.98	0.15	5,399.92
Incredible	7	>800	>9	39.17	0.01	195.84
Total				26.351,28	3.57	131,756.40





If the average wind energy potential is taken also into account, there is total 131,756.40 MW potential in Turkey where the total area of this potential corresponds to 3.57% of Turkey.

Solar Energy

Turkey has huge solar energy potential compared to other European countries. According to study of Electrical Power Resources and Development Administration, the daily mean radiation time is 7.2 hours and the daily mean radiation is 3.6 kWh in Turkey. The solar energy potential atlas of Turkey (GEPA) is given in Figure 3 [9].

Southeastern Anatolian and Mediterranean regions are the areas with highest solar radiation as given in Table 4 [9]. The solar energy potential of Turkey is calculated as 380 billion kWh by taking into account the areas that have inclination lower than three degrees and solar radiation more than 1650 kWh (4600 km²) [9,10]. Turkey is not in bad situation about using solar energy. Water heating with solar energy is very widespread in Turkey. The thermal energy produced by solar collectors has been 290 toe in 2001 [9]. Producing electricity with solar energy becoming more popular because it is clean and easy to use but still usage of it is low since it is still expensive.

By the end of 2015, applications for 4,352 unlicensed solar power plants that have 3642 MW installed power capacity applications are made in total and 371 of these that have 255 MW power capacity has been accepted [1].

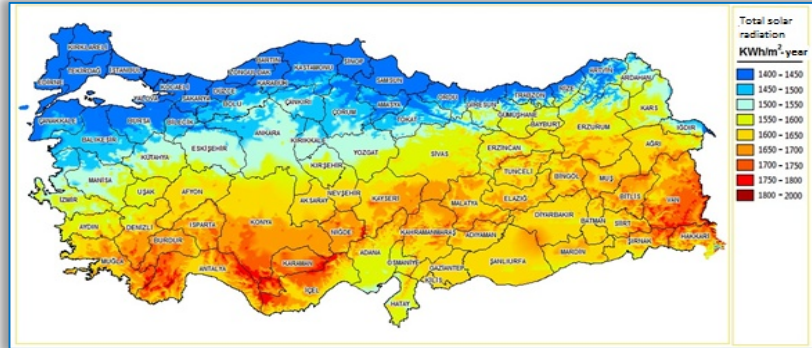


Figure 3. Solar energy potential atlas of Turkey (GEPA) [8]

Table 4. Solar radiation amounts by region in Turkey [9]

Region	Total solar energy (kWh/m ² -year)	Radiation time (hour/year)
Southeastern	1,460	2,993
Mediterranean	1,390	2,956
Eastern Anatolia	1,365	2,664
Central Anatolia	1,314	2,628
Aegean	1,304	2,738
Marmara	1,168	2,409
Black Sea	1,120	1,971

Geothermal Energy

Turkey is in seventh place in the world and in first place in Europe as having geothermal potential between 31,500-60,000 MWt. Actual thermal potential is calculated as 4809 MWt and 34% (1306 MWt) of it is used. Electrical technical potential is calculated as 1000 MWe (6,7 billion kWh/year) and total installed geothermal plant capacity for electrical power generation has been 114 MW by the end of 2011 [1,11,12].

There are 1500 hot and mineral water sources that have temperatures between 20-242°C available in Turkey. Geothermal energy sources distribution in Turkey is shown in Figure 4 [14]. There are 90,000 houses, 3,000 m² stoves, 400 spa facilities that use geothermal energy for heating [1,13].



Figure 4. Geothermal energy sources distribution in Turkey

Bioenergy

Biomass energy is mostly used in low developed regions of Turkey for home heating with classical methods. Studies about energy production with modern biomass plants are very limited in Turkey. Ministry of Energy and natural sources has planned biomass production to be 7530 billion tons' oil equivalent by 2020. This value has been 17 billion toe in 2000. The technical viable potential of Turkey is calculated as 40 Mtoe/year, and the economical viable potential is calculated as 25 Mtoe/year [14]. There are 43 biomass plants that are licensed by the Energy Market Regulatory Authority (EPDK) where





10 and 7 of those are in partial operation and not in operation respectively. The total capacity of biomass power plants in Turkey is 288,583 MW_e[1,10,15]. The biogas potential of Turkey is calculated to be 1.5 – 2 Mtoe/year. Nearly 180 million m³/year biogas is produced from 20 biogas plants in Turkey [16].

FUTURE ASPECTS

As the 17th largest economy in the world and 6th largest in Europe, Turkey will experience an increase in its energy demand in the future. Over the last ten years Turkey has become one of the fastest growing energy markets among the OECD countries in the world, in parallel to its economic growth. In addition, Turkey has been second largest economy on demand for electricity and natural gas after China. Projections performed by Ministry of Energy and Natural Resources of Turkey confirm that this situation will continue to be valid for medium and long term. Turkey's energy policies and strategies are based on energy supply security, alternative energy resources, diversity of energy resources, utilization of domestic energy resources to create additional value to economy, liberalization of energy markets, and energy efficiency. Due to this perspective, special emphasis has been made to maximum utilization of local and renewable energy resources as highest priority. The rapid pace of urbanization, the economic expansion and rising per capita income are the main drivers of the energy demand. The energy demand is expected to increase around 4-6% per annum in the next 10 years [6].

The objective of Turkey's energy policies is to ensure secure, sustainable and affordable energy by diversifying energy supply routes and source countries, promoting indigenous energy production and energy efficiency to moderate growth of total final consumption. These energy ambitions are enshrined in the Vision 2023, Turkey's economic development strategy to 2023, the year that marks the 100th anniversary of the Republic of Turkey. This vision comprises a number of energy targets which aim to make Turkey one of the ten largest economies in the world with annual exports of USD 500 billion. In the area of energy, Vision 2023 aims at promoting indigenous energy resources, including coal (lignite), raising the share of wind and geothermal energy in the electricity mix to reach 30%; reducing energy consumption by 20% below 2010 levels, through improved efficiency and starting up two or three nuclear power plants.

Renewable energy has been one of the important topics on Turkey's energy policy. The significant progress that has been made in the field of renewable energy started after the enactment of the Law on Utilization of Renewable Energy Resources for the Purpose of Generating Electrical Energy (Renewable Energy Law, REL) in 2005. After 2005, the Turkish government kept producing, updating and implementing several laws and regulations to support the investment to reach the goal. According to the Ministry of Energy and Natural Resources, the total amount of investments required to meet the energy demand in Turkey by 2023 is estimated to be around USD 110 billion, more than double the total amount invested in the last decade. Turkey's ambitious vision for 2023, envisages especially interesting targets for the renewable part of the energy sector. These targets include:

- ≡ 34,000 MW capacity of hydro power plants;
- ≡ 20,000 MW capacity of wind power plants;
- ≡ Minimum 5000 MW of solar power plants;
- ≡ Minimum 1000 MWe geothermal energy; and
- ≡ 1000 MWe installed capacity for Biomass energy

RESULTS AND CONCLUSION

Turkey has abundant renewable energy potential. If sufficiently exploited and efficiently distributed, this potential would take a part on meeting the energy demand of Turkey in the future. In this case, Turkey plans to increase hydroelectricity, wind and geothermal energy and the other renewable sources production in the near future. The Turkish government announced a 30% objective for renewable energies by 2023 with plans to push wind energy up to 20000 MW of installations for the same year. The most important and high potential renewables are solar and wind energy among the all renewables. To be more successful about the energy policy, Turkey should figure out long term future perspectives after the year 2023 and 2030.

Note

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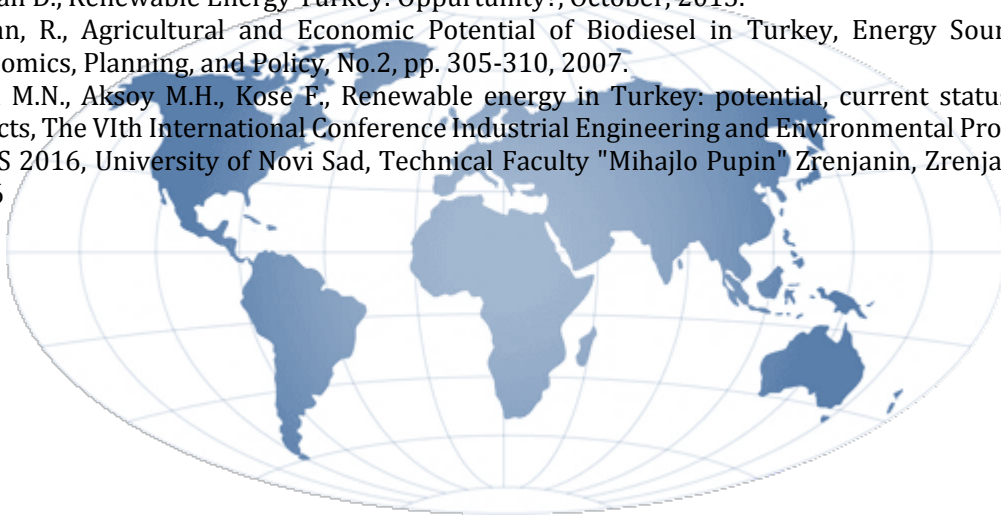
References

- [1.] MMO - Chamber of Mechanical Engineers, Energy outlook of Turkey - 2016, Chamber of Mechanical Engineers, 2016.





- [2.] Kose, F. Aksoy M.H., Ozgoren M., An assessment of wind energy potential to meet electricity demand and economic feasibility in Konya, Turkey International Journal of Green Energy 11 (6), 559-576, 2014.
- [3.] Kose F., Kaya M.N., Analysis on meeting the electric energy demand of an active plant with a wind-hydro hybrid power station in Konya, Turkey: Konya water treatment plant Renewable energy 55, 196-201, 2013.
- [4.] Kaya, M N, and Kose F., "Wind Power Plants for Low Rated Wind Speed Regions: Feasibility Analysis and Simulation of a System." E3S Web of Conferences. Vol. 10. EDP Sciences, 2016.
- [5.] IEA, 2016, Energy Balances of OECD Countries 2016. www.iea.org/statistics.
- [6.] IEA, 2016, Energy Policies of IEA Countries – Turkey 2016 Review.
- [7.] DSI, Turkish State Hydraulic Works. 2015. Activity Report (AR), Ankara, Turkey.
- [8.] GEPA, REPA, Available from: <http://www.eie.gov.tr>.
- [9.] EIEI, Electrical Power Resources and Development Administration, Ankara, Turkey
- [10.] GWEC, Global Wind Energy Council, Global wind energy statistics. 2011. Brussels, Belgium,
- [11.] Energy Market Regulatory Authority of Turkey. www.epdk.gov.tr.
- [12.] Mineral Research and Exploration (MTA), www.mta.gov.tr, Ankara, Turkey.
- [13.] Ültanır MO, 1998, 21. Yüzyıla Girenken Türkiye' nin Enerji Stratejisinin Değerlendirilmesi, TÜSİAD-Türk Sanayicileri ve İşadamları Derneği, yayın no. TÜSİAD T/ 98-12/239, İstanbul.
- [14.] Demirbas, A., 2008, Importance of biomass energy sources for Turkey. Energy Policy 36, 834–842.
- [15.] Kaplan D., Renewable Energy Turkey: Opportunity?, October, 2015.
- [16.] Arslan, R., Agricultural and Economic Potential of Biodiesel in Turkey, Energy Sources, Part B: Economics, Planning, and Policy, No.2, pp. 305-310, 2007.
- [17.] Kaya M.N., Aksoy M.H., Kose F., Renewable energy in Turkey: potential, current status and future aspects, The VIth International Conference Industrial Engineering and Environmental Protection 2016 – IIZS 2016, University of Novi Sad, Technical Faculty "Mihajlo Pupin" Zrenjanin, Zrenjanin, SERBIA, 2016



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