

Wind Energy: Potential, Policies and Status in Turkey

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Abstract— The use of available renewable energy sources for a cleaner and greener energy production is crucial for a country like Turkey. For this reason, the Turkish government, within the scope of Vision 2023, aims to use renewable energy sources such as solar, wind, wave and geothermal in the most effective way. It aims to increase the share of renewable energy sources in electricity generation to 30% by the year 2023. In addition to Turkey having a great potential for wind energy, wind energy is the second most widely used, both actual and planned, energy source after hydro energy for electric generation all over the world. Turkey had been late for studies in the field of wind energy, but it has progressed rapidly. Nevertheless, the 2023 targets are very optimistic and is a serious goal. In order to achieve this goal, there are several requirements, such as identification of available potential, getting technological know-how, obtaining technical equipment, making policies and legal regulations, realizing domestic production and supplying finance as well as duly managing them as a whole. In this study, the wind energy of Turkey was analyzed in terms of historical background, available potential, politics and policies and sectoral development and the 2023 targets were evaluated.

Keywords— Wind energy, vision 2023 targets, renewable energy, wind power plants.

I. INTRODUCTION

The Oil Crisis in 1973 created a serious concern about energy security and caused intense public debate around new and renewable resources all over the world. Although the oil prices fell in the mid-1980s, the concept of "energy security", which arose in the aftermath of the oil crisis, did not come to an end and "energy diversification" has become one of the indispensable elements of energy politics.

Energy security and resource diversity have led renewable energy sources to be included in the energy sector. The emergence of environmental awareness in the 1990s was another event that supported the development of renewable energy sources. This awareness led to understand negative impacts which traditional energy production and consumption cause on the environment and natural resources at local, regional and global levels. Besides, renewable energy sources, which do not produce atmospheric pollutant emission, to be perceived as "clean energies" and be supported.

Turkey is surrounded on three sides by the sea and it has 7200 km coastline, as for the lands Turkey has numerous mountain-valley formations giving the country an average elevation of 1100m. This geolocation and landscape offers Turkey a substantial wind energy potential. So, along with any other renewable energy sources, wind energy has become prominent for its rich potential and its expected good yield. Electricity generation from wind energy is achieved at prices competitive with traditional generation methods in many parts of the world (Demirbas, 2006). Considering all the above, studies aiming to determine the opportunities and potential in wind energy sector have begun. Over the course of last decade sector has grown rapidly all over the world with regard to last technological improvements and with the aid of support mechanisms and new incentives. As a consequence, the share of wind energy in electricity production has continuously increased.

II. POTENTIAL

Earlier wind measurements had been performed by National Meteorology Institute for weather forecast and climatic purposes and measurement generally reflected wind potential in living and agricultural areas. Therefore, any statistical data in hand was not helpful in terms of wind energy potential.

In 1983, General Directorate of Electrical Power Resources Survey Administration (EIE) has launched R&D (Research and Development) projects in wind energy sector and benefited from the statistical data of wind speed and direction obtained by DMI between 1970 and 1980 in estimating average wind power density and wind speed all over Turkey.

Later, the task of wind measurements has been assumed by EIE in 1990, after which the wind speed and wind direction have begun to be measured in areas having high potential for installation of wind power plants.

İlkilic and Nursoy (2010) reports that, amongst the European countries Turkey has the biggest wind energy potential so that even the whole electricity demand can be met. Kurban and Hocaoglu (2010a, 2010b) report Turkey's theoretically available annual potential to be 88,000 MW, 10,000 MW of which is economically feasible. Ogulata (2003) has reported his estimation of this value to be 83,000 MW, which is quite closer. What is more interesting is that more than 98% this potential is in Aegean, East-Mediterranean and Marmara regions (Hepbasli and Ozgener, 2003). Even the evaluation of statistical data obtained from DMI measurements between 1970 and 1980 has shown Marmara region as having the greatest potential with a wind density value of 51.91 W/m^2 (EIE, 1984). Another estimation of wind energy potential of Turkey assuming 5 MW capacity wind mills at a height of 50 m is constructed in areas having wind speed greater than 7.5 m/s revealed the technical potential to be 48,000 MW using a mid-scale weather forecast model and micro scale wind flow model (YEGM, 2010).

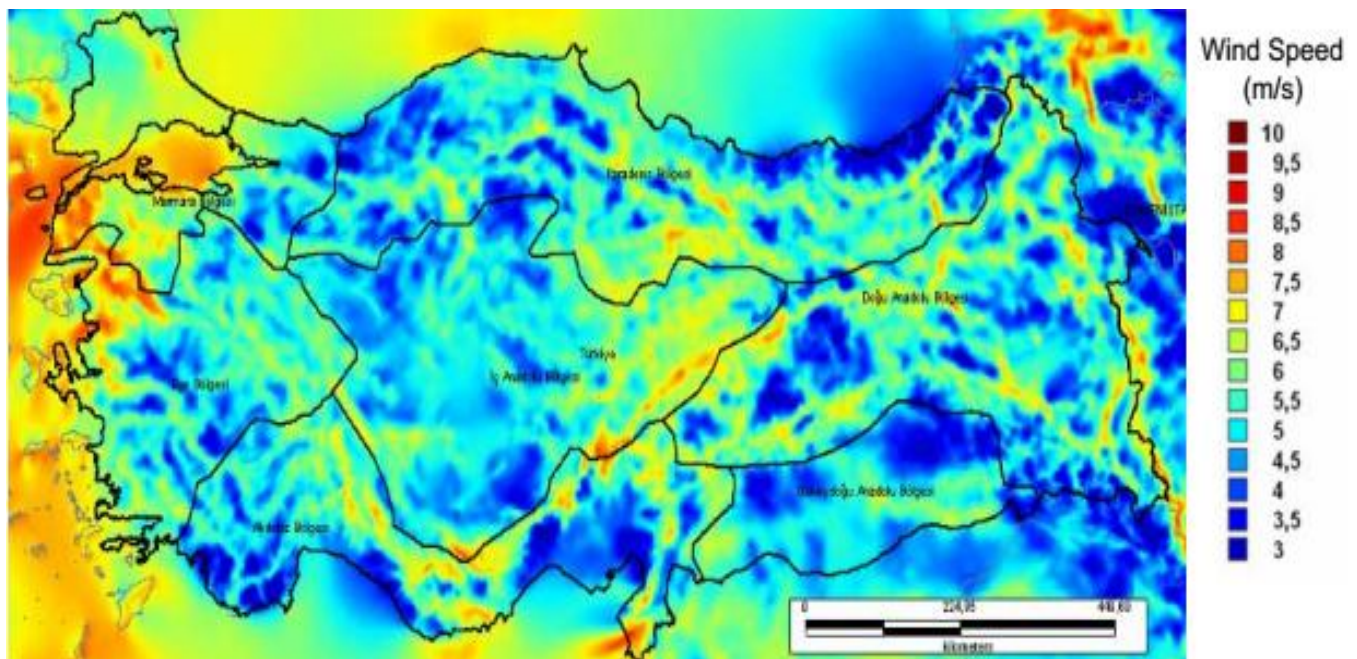


FIGURE 1 ANNUAL AVERAGE WIND SPEED AT 50M ABOVE GROUND OR SEA-LEVEL

TABLE 1

WIND ENERGY POTENTIAL OF TURKEY (ANNUAL AVERAGE WIND SPEED GREATER THAN 7.0 M/S AT 50 M ABOVE THE GROUND LEVEL) (YEGM, 2010)

Annual average wind speed (m/s)	Power density (W/m ²)	Capacity (MW)
7.0–7.5	400–500	29259
7.5–8.0	500–600	12994
8.0–9.0	600–800	5400
>9	>800	196
Total - Onshore		37836
Total - Offshore		10013
Total		47849

Regional wind energy potential, in terms of wind speed, map is given in Figure 1 and the most economic areas having wind speed greater than 7.0 m/s is detailed in Table 1 along with power densities and capacities, both on-shore and off-shore.

III. POLITICS AND ENERGY POLICY

An earlier target on utilization of wind energy, given in Figure 2, aimed to increase the wind energy capacity of Turkey from 1360 MW to 11,200 MW, and its share in electricity generation from 0.5% to 3.6% (Demirbas, 2006).

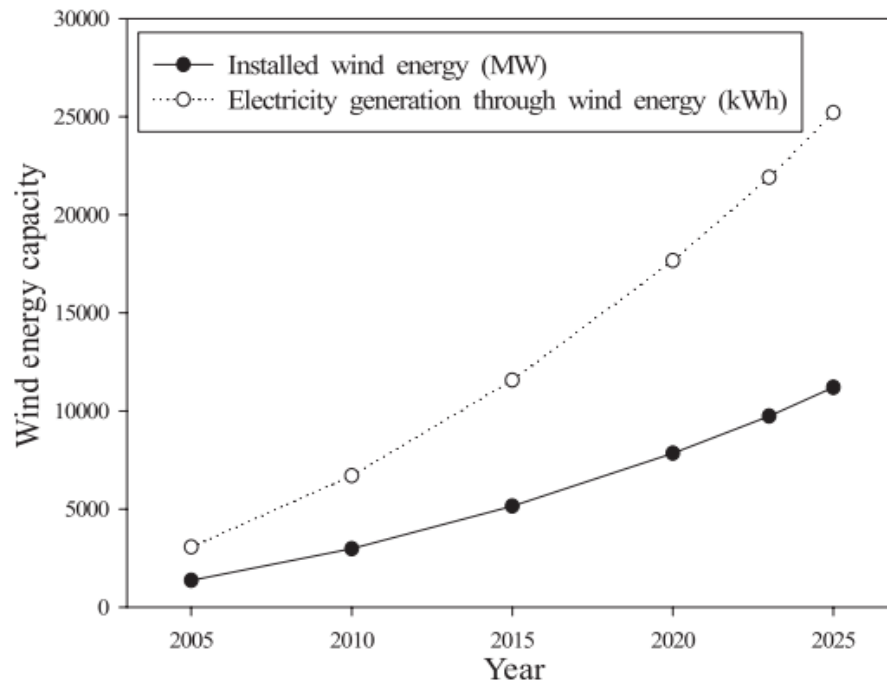


FIGURE 2 PLOTS FOR ESTIMATED WIND ENERGY CAPACITIES OF TURKEY BETWEEN 2005 AND 2025. (DEMIRBAS, 2006)

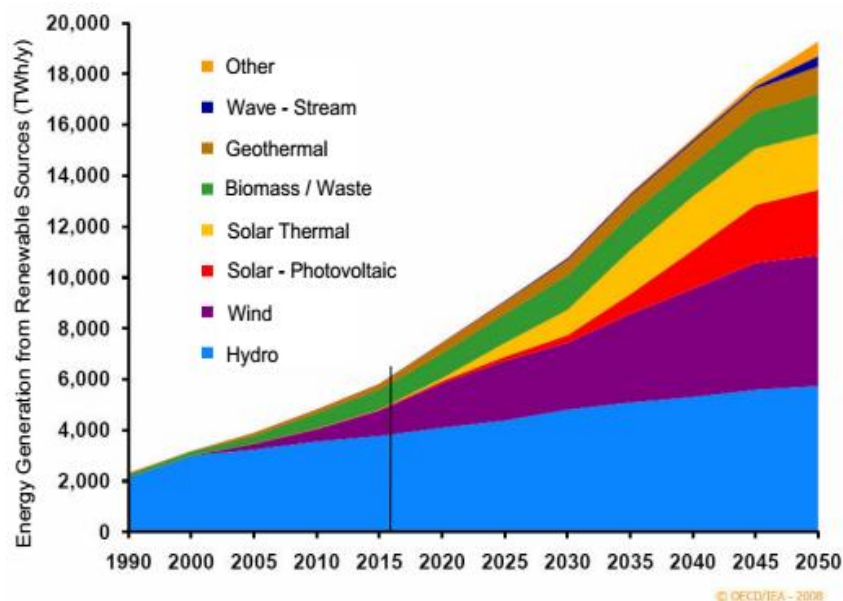


FIGURE 3 THE DEVELOPMENT IN USE OF RENEWABLE ENERGY SOURCES AND PLANNED FUTURE USE

As it can be seen in Fig. 3, the second largest source, after hydro energy, is wind energy, both in actual and planned. For sure, same situation is valid for Turkey. Hence within the scope of Vision 2023, the government has revised its target on utilization of renewable sources and the long-term goal of Turkey now is to make use of the whole technical potential of wind energy, hence the target has been revised to achieve 20,000 MW wind energy utilization (analyzing the off-shore wind energy possibilities as well) by the year 2023 (Kılıç and Urgan, 2016). Nevertheless, another milestone for the year 2015 of 10,000 MW (Ozcan, 2016) installed capacity of wind energy could not be realized and the actual value, being around 5,000 MW, fell far behind. But considering the fact that the growth in recent years has been around 25% and assuming that it continues at this rate, it is still possible to reach 20,000 MW goal by the year 2023.

Not only due to high initial investment costs but also for the lack of technical knowledge and experience, as well as absence of some political arguments, Turkey has failed to harvest much from wind energy (Hepbasli, 2004). Although Turkey has

regulated feed-in tariff and has made policies quite similar to developed countries such as the United States, China and some of the European Union countries, introduction of other subsidies, grants, loans and/or incentives still to come (Kaplan, 2015).

It should also be kept in mind that service life of a wind turbine is 20 to 25 years and will run continuously for no longer than 120,000 hours (EWEA, 2016). Namely, Turkey will continue to spend money in wind Turbines even after the realization of vision 2023 goals since it has not been a significant wind turbine manufacturer, nor has big WPP contractors.

Enercon, a German company, has been producing 0.8 MW turbines in its production line in Izmir since 2005, but Turkey does not benefit much from it. On the other hand, Turkish wind turbine market, dominated by Enercon and Vestas, consists of all foreign investors and contractors such as Enercon (Germany, 36% market share), Vestas (Denmark, 24% market share), GE Wind (USA, 20% market share), Nordex (Germany, 16% market share) and Suzlon (India, 4% market share) (Reuters, 2010). Turkish companies such as SoyutEnerji and Model Enerji are keen to enter the market, and Turkey should pave the way for them.

IV. DEVELOPMENT OF THE SECTOR

Electric generation from wind energy began in 21st century. As to what Hepbasli (2001) reported, electricity generation from wind energy was first achieved in İzmir, at Cesme Golden Dolphin Hotel in 1986 and had 55 kW nominal capacity. There have been other unsuccessful attempts between 1986 to 1996. Soon, Turkey's first wind farm, having a capacity of 1.5 MW, was commissioned under Build-Operate-Transfer (BOT) concept in İzmir, Çeşme / Germiyan in February, 1998 (Kose et al., 2004). Private sector has submitted numerous applications for licensing new wind power plants. Total installed capacity has reached 18.9 MW, Ministry of Energy and Natural Resources (MENR) has evaluated 72 new projects totaling about 2,000 MW in early 2000s (Demirbas, 2006). After commissioning of 30 MW capacity Bandirma WPP Turkey's installed capacity has reached 50.1 MW (Ozgur, 2008). But the objected development level could not be achieved then and the market did not achieve a significant growth until the law for the use of renewable energy sources in electricity production (Law No: 5346) which included a series of policy reforms and subsidies passed in 2005 (Dursun and Gokcol, 2014).

However, by the year 2007, Turkey was quite unsuccessful in making use of its rich potential. Despite the fact that Turkey has doubled its installed capacity for wind energy three times in a row, the installed capacity was only 791 MW in 2009. Continuously growing, the capacity has reached 5.146 MW by the year 2016 (TWEA, 2016). An 11,200 MW of installed capacity is expected to be reached by 2025 (Demirbas, 2006), where the share of wind energy for generating electricity would be around 3.6% (Balat, 2008). Taking into account the TWEA's July Report, we can see that the target is pretty easy to be met with this trend.

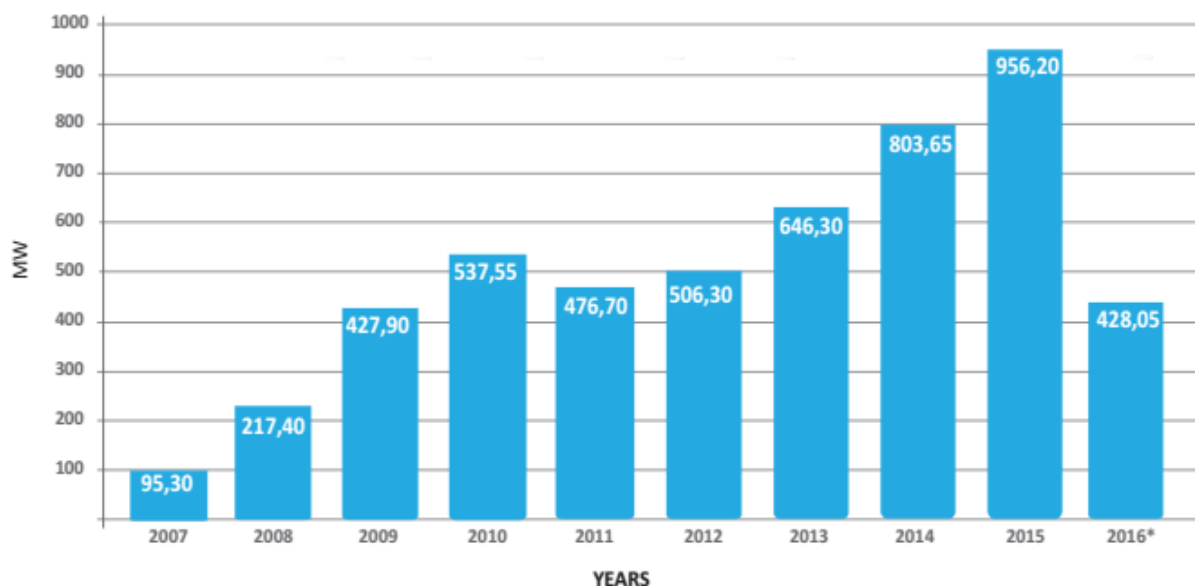


FIGURE 4 ANNUAL INSTALLATIONS FOR WIND POWER PLANTS IN TURKEY (MW)

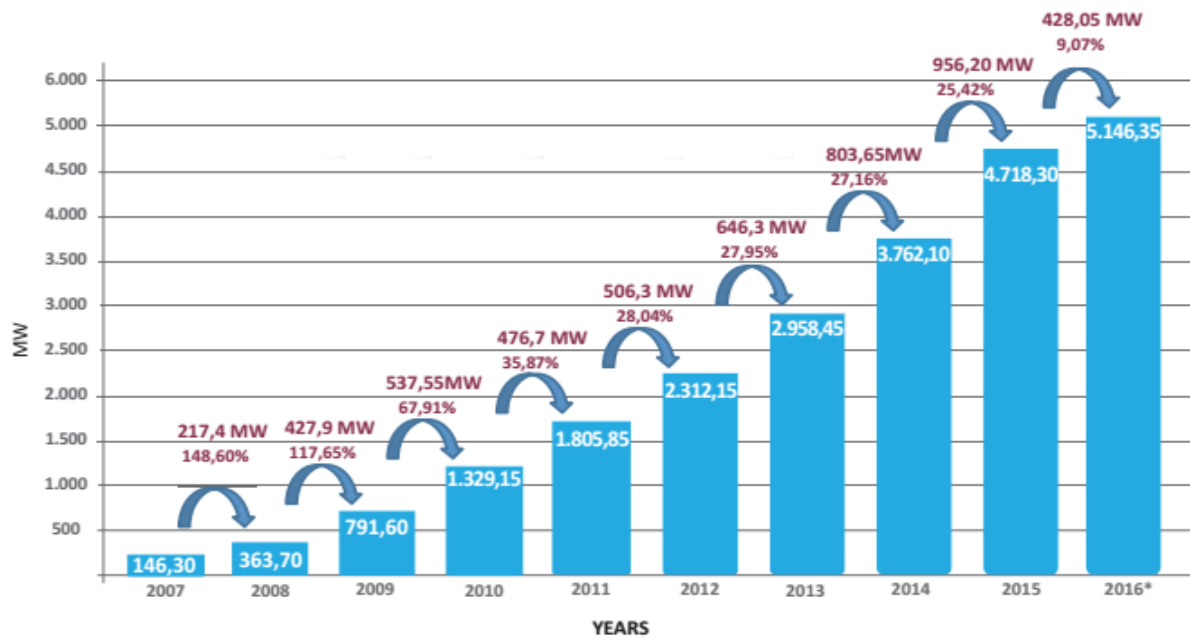


FIGURE 5 CUMULATIVE INSTALLATIONS FOR WIND POWER PLANTS IN TURKEY (MW)

**TABLE 2
TOP TEN WIND POWER PLANTS IN TURKEY (CAPACITY-WISE) (YEGM, 2016)**

Plant Name	Licensed Capacity MW	Location	Status
Geycek WPP	150.00	Kırşehir	Under Construction
Balıkesir WPP	142.50	Balıkesir	Under Construction
Soma/soma WPP	140.80	Manisa	Operational
Osmaniye WPP	135.00	Osmaniye	Operational
Kangal WPP	128.00	Sivas	Under Construction
Karaburun WPP	120.00	İzmir	Under Construction
Şamlı WPP	114.00	Balıkesir	Operational
Bağlar WPP	100.00	Konya	Under Construction
Şah WPP	93.00	Balıkesir	Under Construction
Aliağa WPP	90.00	İzmir	Operational
Bilgin/soma WPP	90.00	Manisa	Operational

According to YEGM's report (2014), 41 (1,478.05 MW) of a total of 126 (4,465.10 MW) licensed wind power plants are operational. With a 4,503 MW installed capacity of wind power plants in operation, Turkey generated 11.552 GWh per annum as of the end of 2015 (MENR, 2014).

As of 2008, referencing to The Energy Market Regulatory Authority (EMRA), had given license to 58 WPPs (totaling 2,126 MW) of 751 applications (totaling 77,871 MW) received (Erdem, 2010).

Installed wind energy capacity was 2312 MW in 2012, 2958 MW in 2013, 3762 MW in 2014, 4718 MW in 2015 and with additional 428 MW in the first half of 2016 this value has raised to 5146 MW (Fig. 4 and Fig. 5).

As of 2016, the top ten largest WPPs in Turkey are given in Table 2, while some have been commissioned and are operational, some are still under construction.

V. CONCLUSION

The major obstacles and handicaps in the path of achieving goals on utilization of wind energy and in the development of sector in Turkey is that there are still some political initiatives and actions to be taken along with getting know-how and industrial developments. Unfortunately having high potential or being rich in resources does not guarantee making use of the potential. Yet, neither do being determined and making regulations. There should be a good arrangement and concordance of all.

In order to meet the Vision 2023 target of 20,000 MW, Turkey needs to commission nearly 16,500 MW WPPs between 2016 and 2023. This requires the market growth rate to be maintained at the same rate it had in recent years, which is roughly around 25%. Considering that a proportional growth is not always possible after a point, as the nominal value of the percentage will rise to an unaffordable figure, we can say that an additional 2,000 MW capacity must be commissioned each year.

Whether the price is affordable and rational for Turkey is up to the Turkish government, but just for the curious; the unit cost of initial investment for electricity generation from wind energy in developed countries varied from 1127 US\$/kW to 1376 US\$/kW in 2014 as reported by International Renewable Energy Agency (IRENA, 2015). And this is apart from the operation and maintenance costs, which is around \$105/kW based on experiences in Germany, Spain, the UK and Denmark. As a result, Turkey needs to invest approximately 2.5 billion US\$ each year in order to meet its Vision 2023 wind energy targets.

Turkey has shown its ability and potency in accomplishing big projects and achieving hard-to-attain goals. As a conclusion, the Vision 2023 target on wind energy is hard to be met for a country at the scale of Turkey, but still theoretically possible both in terms of time and feasibility. However, Turkey may facilitate this task by implementing some subsidies, grants and incentives as well as encouraging local players for entering the market and pave the way for them.

REFERENCES

- [1] Ilkilic C, Nursoy M. The potential of wind energy as an alternative source in Turkey. *Energy Source Part A* 2010;32:450–9.
- [2] Kurban M, and Hocaoglu, F. O. Potential analysis of wind energy as a power generation source. *Energy Source Part B* 2010a;5:19–28.
- [3] Hocaoglu, F.O. and Kurban M. Regional wind energy resource assessment. *Energy Source Part B* 2010b;5:41–9.
- [4] Hepbasli A, Ozgener O. A review on the development of wind energy in Turkey. *Renew Sustain Energy Rev* 2004;8:257–76. <http://dx.doi.org/10.1016/j.rser.2003.10.006>
- [5] Turkish Wind Energy Statistics Report, July 2016. TUREB [TWEA], Turkish Wind Energy Association. (http://tureb.com.tr/files/bilgi_bankasi/turkiye_res_durumu/temmuz_rapor_2016.pdf)
- [6] Balat H. Contribution of green energy sources to electrical power production of Turkey: a review. *Renew Sustain Energy Rev* 2008;12:1652–66.
- [7] Demirbas A. Turkey's renewable energy facilities in the near future. *Energy Source Part A* 2006;28:527–36.
- [8] Ogulata RT. Energy sector and wind energy potential in Turkey. *Renew Sustain Energy Rev* 2003;7:469–84.
- [9] YEGM. Wind Energy Potential of Turkey 2010. (http://www.mgm.gov.tr/FILES/haberler/2010/rets-seminer/2_Mustafa_CALISKAN_RITM.pdf) [accessed 10.12.16].
- [10] YEGM. Turkey's Wind Power Plant Facility Information; 2014. (http://www.eie.gov.tr/eie-web/turkce/YEK/ruzgar/Turkiye_RES.html) [accessed 18.12.16].
- [11] MENR. Wind. Info Bank4Energy 2014; 2014. (<http://www.enerji.gov.tr/enUS/Pages/Wind>) [accessed 15.12.16].
- [12] General Directorate of Electrical Power Resources Survey and Development Administration (EIE). Turkey wind energy natural potential, vol. 85. EIE Publications, 1984. p. 1–34.
- [13] Kurtaran G. Wind energy in Turkey. *Dewi Mag* 2008;33:53–7.
- [14] Erdem, Z.B. The contribution of renewable resources in meeting Turkey's energy-related challenges. *Renewable and Sustainable Energy Reviews* 14 (2010) 2710–2722
- [15] Dursun B, Gokcol C. Impacts of the renewable energy law on the developments of wind energy in Turkey. *Renew Sustain Energy Rev* 2014;40:318–25. <http://dx.doi.org/10.1016/j.rser.2014.07.185>.
- [16] Ozcan, M. Estimation of Turkey's GHG emissions from electricity generation by fuel types. *Renewable and Sustainable Energy Reviews* 53 (2016) 832–840
- [17] Kılıç, R. and Urgan, N. The Effects of the Turn Towards Renewable Energy Resources in Turkey on Country Economy and Its Contributions in Reducing Turkey's Foreign Dependence On Energy. *Dumlupınar University Journal of Social Sciences*. 2016. Vol 47, 148-166
- [18] Demirbaş, A (2006) Turkey's Renewable Energy Policy, *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 28:7, 657-665, DOI:10.1080/00908310600718734

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- [19] Hepbasli A. and Ozgener, O. (2004) Turkey's Renewable Energy Sources: Part 1. Historical Development, *Energy Sources*, 26:10, 961-969, DOI: 10.1080/00908310490473183
- [20] Hepbasli, A., A. Ozdamar, and N. Ozalp. 2001. Present status and potential of renewable energy sources in Turkey. *Energy Sources* 23:33–50.
- [21] Kose, R., Ozgur M. A., Erbas, O., Tugcu, A. The analysis of wind data and wind energy potential in Kutahya, Turkey. *Renewable and Sustainable Energy Reviews*. 2004;8. 277–88.
- [22] Ozgur, M.A. Review of Turkey's renewable energy potential. *Renewable Energy* 33 (2008) 2345–2356
- [23] Kaplan Y.A. Overview of wind energy in the world and assessment of current wind energy policies in Turkey. *Renewable and Sustainable Energy Reviews*. 2015; 43:562–8. <http://dx.doi.org/10.1016/j.rser.2014.11.027>.
- [24] IRENA. Renewable Power Generation Costs in 2014; 2015.
- [25] EWEA. Wind energy frequently asked questions (FAQ) | EWEA. Eur Wind Energy Assoc; 2015. (<http://www.ewea.org/wind-energy-basics/faq/>) [accessed 18.12.16].
- [26] Reuters. Turkish wind energy growing fast with feed-in-tariff in the pipeline. 2009, (<http://uk.reuters.com/article/mnEnergy/idUK325544061320090731>) [accessed Jan 2010].