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ARAŞTIRMA MAKALESİ RESEARCH ARTICLE

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Changes in Climate Parameters and Their Effects on Renewable Energy Resources Potential: Bursa Sample[A]

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Abstract: In this study, the objective was to find at what rate Bursa province of Turkey, is affected by the climatic process called "climate change" and the impacts of climate change on the potential of renewable energy resources, especially solar energy and wind energy. As a result of analyzes, it is seen that there is significant warming between 1960 and 2017. Especially soil temperatures and solar radiation intensity support this result. As a result of this work, it was determined that the changes in climate parameters for the province of Bursa have significant effects on renewable energy potential. According to the results obtained, there has been an increase of 34.5% in the solar energy potential, of 8.2% in thermal solar energy potential and of 3.6%-6.7 in soil temperature potential depending on the depths. In the wind energy potential, there was a decrease of 75% between 1960-1998 and an increase of 217.1% between 1999-2017.

Anahtar Kelimeler: Climate change, temperature anomaly, renewable energy, solar energy, wind energy.

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İklim Parametrelerindeki Değişiklikler ve Yenilenebilir Enerji Kaynakları Potansiyeline Etkileri: Bursa Örneği

Öz: Bu çalışmada, Türkiye'nin Bursa ilinin "İklim Değişikliği" adı verilen iklimsel süreçten ne oranda etkilendiği ve iklim değişikliğinin özellikle güneş enerjisi ve rüzgâr enerjisi olmak üzere yenilenebilir enerji kaynakları potansiyeline etkileri ortaya konulmaya çalışılmıştır. Analizler sonucunda 1960 ve 2017 yılları arasında önemli bir ısınma olduğu görülmektedir. Özellikle toprak sıcaklıkları ve güneş radyasyonu yoğunluğu bu sonucu desteklemektedir. Bu çalışma sonucunda, Bursa ili için iklim parametrelerindeki değişikliklerin yenilenebilir enerji potansiyeli üzerinde önemli etkileri olduğu belirlenmiştir. Elde edilen sonuçlara göre, güneş enerjisi potansiyelinde %34.5, ısısal güneş enerjisi potansiyelinde %8.2 ve derinliklere bağlı olarak toprak sıcaklığı potansiyelinde %3.6-6.7 artış olmuştur. Rüzgar enerjisi potansiyelinde 1960-1998 yılları arasında %75 azalma ve 1999-2017 yılları arasında %217.1 artış gözlenmiştir.

Keywords: İklim değişikliği, sıcaklık anomalileri, yenilenebilir enerji, güneş enerjisi, rüzgar enerjisi.

Introduction

Thanks to the greenhouse effect, the earth's atmosphere created the environment in which living things can live. To protect and sustain this environment has extreme importance for the future of the lives of the living things and thus for the future of the lives of us, people. Despite this known reality, we are harming our atmosphere in the name of enhancing human well being and protecting and raising the technological level that we have reached today.

Nowadays, the science people predict that at the end of this century, if no measures are taken to reduce the greenhouse gas emissions that accumulate in the atmosphere, the earth's average temperature will increase by 2 ^{o}C due to climate change (Leggett 1991; Quaschning 2011).

CO_2 accumulation in the atmosphere for 2008 is given at about 385 ppm, which represents an annual increase of 0.4% over the value of the 1750s. Also, methane and ozone gases level increased in the same period and reached 1.77 and 0.03 ppm levels respectively (Quaschning 2010). The annual greenhouse gas index's CO_2 equivalent was 493 ppm in 2017. The accumulation of CO_2, the most important greenhouse gas, in the atmosphere increased from approximately 280 ppm in the pre-industrial period to 405 ppm in 2017. Also, in the pre-industrial period, the accumulation of CH_4, which was approximately 715 ppb, exceeded 1800 ppb in 2017 (Butler and Montzka 2018).

There has been seen an apparent and quick increase in world temperature averages, especially after the 1980s. This period corresponds to the period after the industrial revolution (Leggett 1991). Historical climate data show that such a rapid temperature increase has not occurred to date (IPCC 1990). According to IPCC 5 evaluation reports; because of the increase in average temperature and the irregularities in energy distribution, it has been concluded that there has been an increase in hot or cold weather waves, and in the intensity and frequency of precipitation and arid extreme weather events (IPCC 2013). Yaslıoğlu and İlhan (2018) point out that global warming and climate change continue to be key issues of current work because of their impact on animal and plant life in a particular region, and their regional effects should be considered in addition to the global effects.

These temperature changes, as it is known, directly or indirectly affect other climatic processes. Within this context, climatic events such as wind and precipitation are also changing. If we look at the issue regarding the energy sector; changes in temperature and solar radiation, wind speed, rainfalls also directly affect solar, thermal, wind, and hydroelectric energy production potential. As it is known, renewable energies are used as an energy source in the agriculture sector, as in many areas (Taşkın and Vardar 2016).

Predicting the future climate of Turkey is of great importance in terms of preventing or minimizing the effects of climate change (Görgülü et al. 2009). With this perspective, the main objective of this study is; to analyze the climatic parameters changes specific to the Bursa province and to reveal the potential effects of solar, thermal, wind, and hydraulic energy resources.

Regional Properties

Turkey is located in a microclimate region that is observed in the western part of the subtropical zone lands and called the Mediterranean climate. The Mediterranean climate region carries the characteristics of both the polar (cold) and temperate zone, and the tropical (warm) zone (Dirican 1997, Vardar et al. 2011). Due to Turkey’s geographic location, the country is affected by various pressure systems. Western and northwestern winds have strong effects on the west part of Anatolia. In the summer season, the Azores High-Pressure center results in continual winds from the north, particularly in the western regions (Vok 2015). The annualized average of the total solar radiation as well as the annual sunshine hours differs from one region to another, due to the variabilities in different geographical regions.

Considering the distribution of the industrialization in Turkey's geography, the region to the east of the Marmara Sea is noteworthy. Again, when the population distribution is analyzed, this region comes to the forefront. The provinces in this region are, particularly, Istanbul, Kocaeli, Sakarya, Yalova, and Bursa. Bursa is the 4th most populated city in Turkey with a population of 2936803 (TÜİK 2018). In terms of power plants, thermal power plants and natural gas conversion plants are located in Bursa province. Bursa province was studied due to its importance in the industry in the region.

Bursa Metropolitan Municipality has made a commitment to reduce greenhouse gas emissions by 40% (per capita) in 2030 by signing the Covenant of Mayors, which is an entity within the European Union, in July 2016. In accordance with the decisions taken after the COP21 Paris negotiations held in 2015, the local governments to prepare Action Plan related to Climate Harmonization was required by the Covenant of Mayors Sustainable

Energy Action Plan. For this reason, the Bursa Metropolitan Municipality has prepared the "Climate Adaptation Action Plan" by revising the Bursa Climate Change Action Plan prepared in 2017 as part of the "Urban and Institutional Carbon Footprint Inventory and Bursa Climate Change Action Plan Preparation Project" (Busecap 2017). The greenhouse gas inventory distribution in Bursa province is shown in Figure 1.

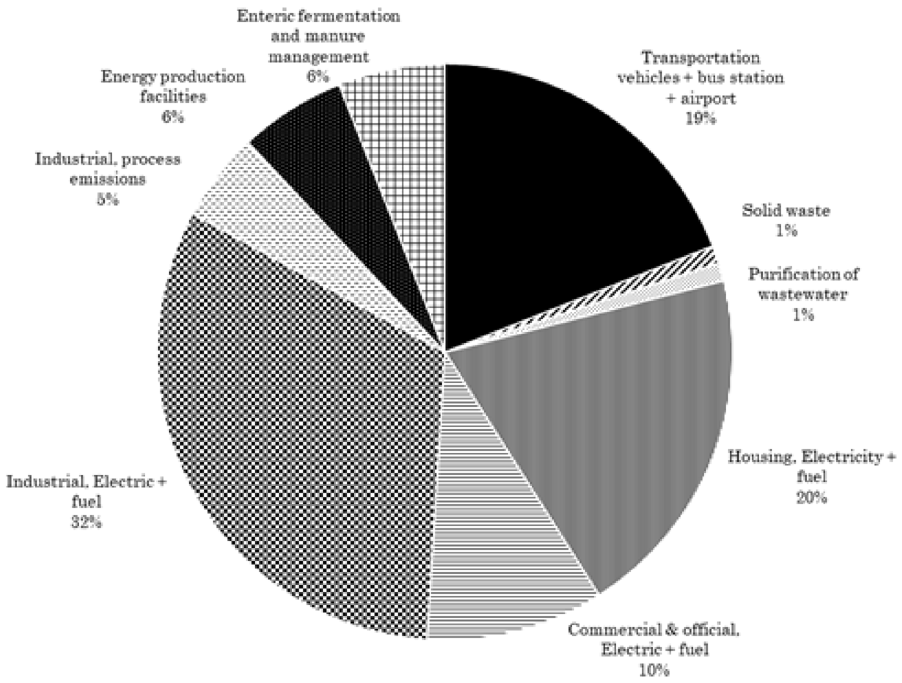

Figure 1: *Bursa 2014 greenhouse gas inventor <(Busecap 2017)>*

Materials and Methods

The meteorological data used in this study cover 58 years between 1960 and 2017 (MGM 2018). In this study, meteorological measurements about sun, wind, soil, and rainfall made by Osmangazi meteorological station in Bursa province and data related to climate were evaluated.

Sulfur dioxide and particulate matter, and fill rate of dams data used in the study were obtained from Turkish Statistical Institute (TÜİK 2018) and General Directorate of State Hydraulic Works 1. Regional Directorate (DSİ 2018).

In the study, initially, the measurement values recorded in the meteorological stations on average on a daily basis were converted into monthly and annual average values. Then, with the help of annual averages, the overall average for long years was found and the overall annual average for long years from the difference of the annual average of every year was calculated (Soysal 1992).

Wind speed values of 30 m from the ground were calculated considering that the stations made measurements at 10 m from the ground in the study. The relevant equation was used for the adaptation of wind speed to 30 m level from the ground (Klug 2001, Pelletier 2006).

In the statistical analyzes, the average monthly values for the 12 months of each year, annual averages, the differences of the annual averages from the general averages for long years, and the minimum and maximum values for each year are taken into consideration. The associations of these values with years were analyzed with the help of SPSS statistical program levels of 1% and 5%.

Results and Discussion

In Bursa, the average annual temperature between 1960 and soil 2017 was 14.5°C. The temperature data has a direct influence on the thermal energy production potential. Within this context, the thermal energy potential increased by 25.4% from 1960 to 2017. Average temperature increased by 1.15°C in 58 years. This value means an average temperature increase of 0.2°C every 10 years. It is determined that May, June, July, August, and September, with the increase by years in annual average temperature and temperature anomalies are significant at a level of 0.01 in the correlation tests. Statistically, the thermal energy potential between 1960 and 2017 increased by 8.2% either.

In comparisons with measurement results from other stations, in order to remove the effect of position and height differences between the stations, instead of the direct temperature measurements, the deviation (anomaly) of the measurements from the average is used (Barlas 2013). Figure 2 shows the temperature anomalies.

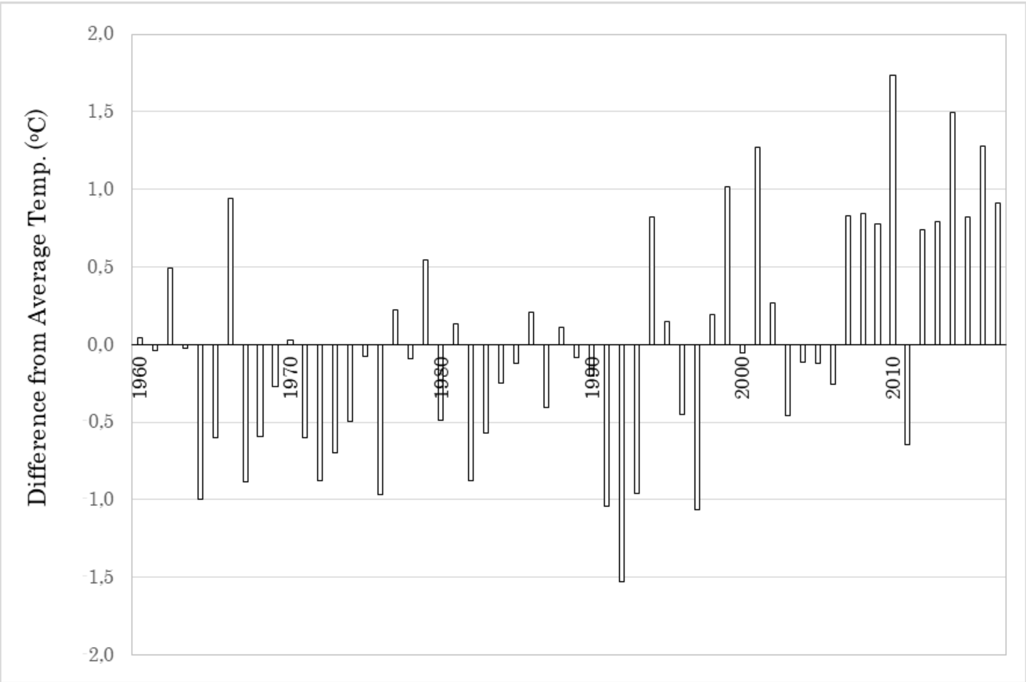

Figure 2: *Temperature anomalies*

It is defended by researchers the atmosphere temperature is increasing by 0.3 °C every 10 years for 1990 to 2005 (IPCC 2007). NASA climate data show that temperatures in Bursa and nearby regions in the first half of 2016 are 2.5°C higher than average temperatures (Nasa 2016). Similar to Bursa data, IPCC estimates that by 2100 the average temperature in the world could increase by 1.8-4.0°C (IPCC 2007). Moss et al. (2000) reported that by 2030 the world temperature could be 1.2°C higher than today. In a study conducted by Caseldine et al. (2006) in Iceland, it was found that an increase of 1.5°C in air temperature occurred in July. In a study conducted by Türkeş (2001), it was reported that the global annual average temperature increased by about 0.7°C from 1900 to 1998.

When the annual averages were taken into consideration, the maximum soil temperature level in Bursa at 5, 10, 20, 50, 100 cm depth was observed in 2007 with 18.2°C, 2007 and 2008 with 17.9°C, 2008 with 17.7°C, 1966 with 17.7°C, and 1966 with 17.4°C, respectively. Monthly average temperature values measured in soil are shown in Table 1.

Table 1. Bursa average soil temperature (1960-2017)

	Soil Temperature (^{o}C)				
Month	5 cm	10 cm	20 cm	50 cm	100 cm
January	5.0^{ns}	5.1^{ns}	5.4^{ns}	6.9^{ns}	8.8^{ns}
February	6.1^{ns}	6.1^{ns}	6.2^{ns}	7.0^{ns}	8.2^{ns}
March	9.1^{ns}	9.0^{ns}	8.8^{ns}	8.9^{*}	9.3^{*}
April	14.7^{ns}	14.3^{ns}	13.7^{ns}	13.0^{ns}	12.2^{ns}
May	21.2^{ns}	20.5^{ns}	19.5^{ns}	18.0^{ns}	16.1^{ns}
June	26.8^{ns}	25.8^{ns}	24.8^{ns}	23.0^{ns}	20.4^{ns}
July	30.0^{**}	29.0^{**}	28.0^{**}	26.4^{ns}	23.7^{ns}
August	29.5^{**}	28.8^{**}	28.0^{**}	27.1^{**}	25.1^{*}
September	23.9^{*}	23.9^{*}	23.6^{**}	24.0^{**}	23.6^{**}
October	16.8^{ns}	17.1^{ns}	17.3^{ns}	18.6^{ns}	19.8^{**}
November	10.7^{ns}	11.0^{ns}	11.4^{ns}	13.3^{ns}	15.3^{ns}
December	6.5^{ns}	6.8^{ns}	7.3^{ns}	9.0^{ns}	11.3^{ns}
Average	16.7	16.4	16.2	16.3	16.2

*, **: significant at p/0.05, and p/0.01, respectively. ns: not-significant

Soil temperature data directly affect the thermal energy production potential, especially regarding heat pump applications. When the data were examined from this point of view, an increase in the thermal energy potential in soil depth was observed. The increases in heat energy potential, which were calculated using the regression equation, were 3.6%, 4.9%, 6.7%, 5.0%, and 4.2%, respectively at 5, 10, 20, 50, and 100 cm soil depths.

In Bursa, solar energy value was calculated as 3.5 kWh m^{-2}day and 1269 kWh m^{-2}year using daily average values between 1960 and 2017. Sunlight intensity and duration were found to be 144.2 W m^{-2} and 6.1 hours day^{-1}, respectively. According to GEPA (2018), the highest solar energy values of Bursa were observed in May, June, July, while the highest sunlight duration was observed in June, July, and August. Data about average solar energy, sunlight intensity, and sunlight duration are given in Table 2.

The average annual solar energy per m^2 increased by 370 kWh m^{-2} year over 58 years. Proportionally, there was an increase of 34.5% in solar energy. The difference between the minimum and maximum solar energy values in 58 years was found to be 37.6%. In a study done by Solanki et al. (2004), it was reported that solar energy had a long-term increase since the 1700s. Öztürk (2005), reported the sunlight duration for the Marmara Region as 6.92 hours day^{-1}. Also, the mean solar energy value in the same study was reported as 3.03 kWh m^{-2}day, and annual sunlight intensity (intensity of solar radiation) was reported as 363 W m^{-2}. The data analyzed for Bursa are parallel to other studies.

Table 2. Average of solar energy, sunlight intensity and sunlight duration (1960-2017)

Month	Daily Average			
	Solar Enegy (kWh m^{-2}day)	Solar Enegy (kWh m^{-2}years)	Solar Intensity (W m^{-2})	Sunshine Duration (hours day^{-1})
January	1.5	548	62.6	2.9
February	2.0	743	84.9	3.3
March	3.0	1078	123.0	4.1
April	4.0	1448	165.3	5.6
May	5.0	1827	208.5	7.7
June	5.7	2088	236.0	9.7
July	5.8	2099	233.1	10.5
August	5.1	1858	212.1	9.8
September	4.0	1468	167.6	7.7
October	2.6	966	110.3	5.4
November	1.8	639	72.9	4.1
December	1.3	471	53.8	2.9
Average	3.5	1269	144.2	6.1

The average solar radiation intensity has increased by 42 W m^{-2} in 58 years. The difference between minimum and maximum solar radiation intensity values in 58 years was found to be 37.6%. Average sunlight duration decreased by 1.6 hours (22.24%) in 58 years. Several components affect the amount of solar radiation. These components can be listed as solar output, Earth-Sun distance, clouds, water vapor, air pollution, forest fires, volcanic ash, location, time of day and season. Due to the influence of these components, solar radiation intensity differs from year to year (Aksungur et al. 2013). In a study by Fröhlich and Lean (2004), it is stated that the energy emitted by the sun fluctuates in the long run. Solar energy and radiation intensity data measured by the Bursa meteorological station also confirm this expression. Figure 3 shows the changes in annual average solar radiation intensity for the period 1968-2017.

The average annual wind speed in the 58 years period was between a minimum of 3.9 m s^{-1} (1998) and a maximum of 7.3 m s^{-1} (1963). While between 1960 and 1998, wind speeds showed a tendency to decrease, they showed a tendency to increase between 1999 and 2017. At this point, the years of 1998-1999 were the breaking points to increase the wind speed. As a general trend, it can be seen that the wind speed decreased by 1.4 m s^{-1}. However, according to 19 year tendency between 1999-2017, wind speed has shown an increase of 2 m s^{-1}. Proportionally, while there was a decrease of 22.2% in the 58 year general tendency, there was an increase of 45% in the 19 year tendency between 1999-2017. This unusual fluctuation in wind speed is thought to have originated from the national airport, which was located close to the wind measurement point and closed in 2001. Besides, it is considered that the structure occurring in the area is also effective.

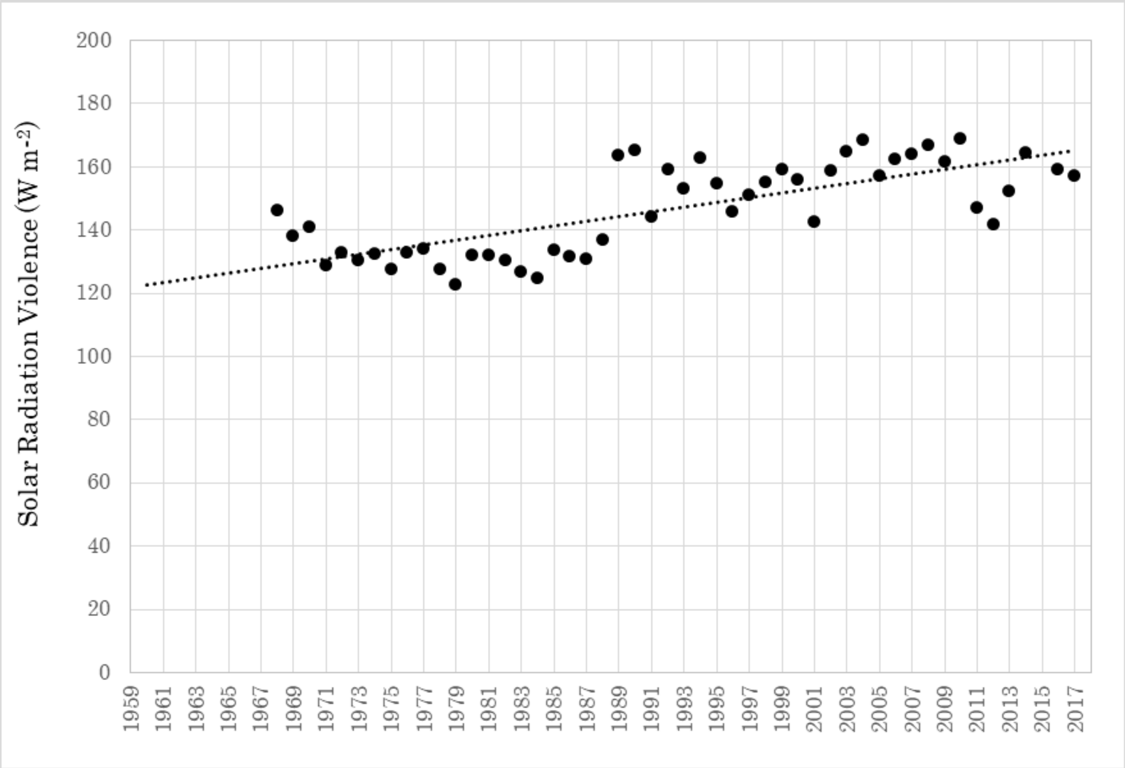

Figure 3: *Annual radiation intensity values* (1968-2017)

The wind energy potential between 1960 and 2017 decreased by 54.9% in general. However; statistically, there was a decrease of 75% in the wind energy potential between 1960-1998 while there was an increase of 217.1% in the wind energy potential between 1999 and 2017. This extreme variability in wind energy potential is also closely related to wind speed measurement results.

The wind speed has a direct effect on the wind power potential and the energy production potential. In this context, the minimum power potential in the unit area at the height of 30 m in the period of 1960-2017 was 35.2 W m^{-2}, and the maximum power potential was 239.8 W m^{-2}. The annual wind energy potential in the unit area was a minimum of 308.3 kWh m^{-2}year and a maximum of 2100.2 kWh m^{-2}year (Figure 4).

The lowest annual average pressure value in Bursa was 1002 hPa in 2010, and the highest average pressure value was 1006 hPa in 1989.

The average annual rainfall in Bursa during the 58 years period between 1960 and 2017 was 711.1 mm. The lowest annual average rainfall in Bursa was 446 mm in 1961, and the highest average rainfall was 1329 mm in 2010. Rainfall values and the fill rates of dams are effective factors on hydroelectric production potential. The decrease in water resources may cause a decrease in hydraulic energy supply in summer and a decrease in hydraulic potential over time. While statistically insignificant, the hydraulic energy potential showed an increase of 13.1%.

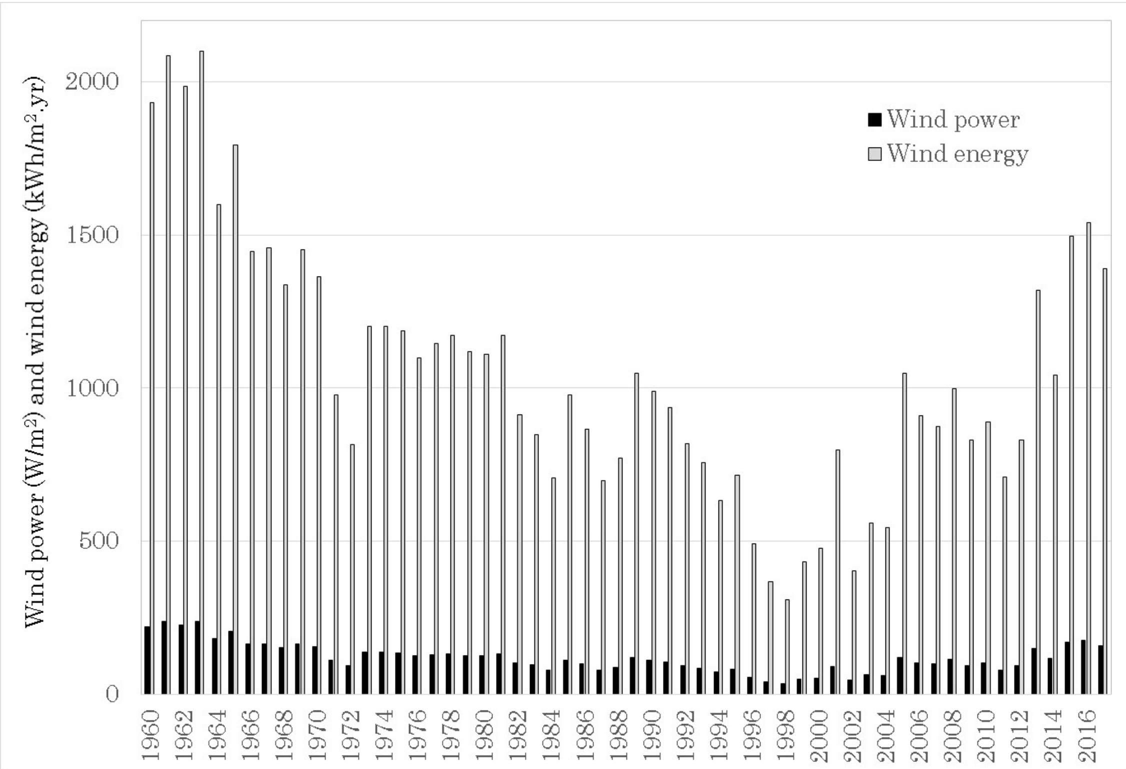

Figure 4: *Change in wind power and wind energy potential per unit area (30 m)*

The average SO_2 in the winter months of Bursa was recorded as 220 µg m-3 in 1991 while it decreased to 50 µg m^{-3} in 1995. This value decreased even further in the present (2017) below 10 µg m^{-3}.

As the temperature and wind speed increase, SO_2 and total suspended particles are decreasing, while there is a direct relationship with relative humidity (Bridgman et al. 2002, Akpinar et al. 2006).

In the study examining the relationship between air pollutants measured in Bursa atmosphere was reported, low concentrations were observed in hot seasons usually (Erbaşlar and Taşdemir 2007).

Conclusion

There was an increase of 34.5% in the solar energy potential, an increase of 8.2% in thermal solar energy potential and, depending on the depths, an increase of 3.6%-6.7 in soil temperature potential. In the wind energy potential, there was a decrease of 75% between 1960-1998 and an increase of 217.1% between 1999-2017. Hydroelectric potential, on the other hand, does not display variability despite the increase in average precipitation, due to fluctuations in fill rates of dams.

As a result of this study, it was demonstrated that climate change-related symptoms are also effective in Bursa and around it. Measures to be developed regarding technology, especially against greenhouse gas emissions originating from the industry, carry great importance in this context.

Replacing and/or converting thermal and natural gas power plants, with the clean and/or renewable energy plants will be a very important measure against climate change, particularly to reduce greenhouse gas emissions.

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References

Akpinar, E.K., Akpinar, S. and Oztop, H.F. 2006. Effects of Meteorological Parameters on Air Pollutant Concentrations in Elazig, Turkey. *International Journal of Green Energy*, 3: 407–421. doi: 10.1080/01971520600873392.

Aksungur, K.M., Kurban, M. and Filik Ü.B. 2013. Analysis and Evaluation of Solar Radiation Data in Different Regions of Turkey. Energy Efficiency and Quality Symposium Proceedings Book (in Turkish).

Barlas, N. 2013. Environmental Problems of Our Era From Global Crises to Sustainable Society. İstanbul, Boğaziçi University Press, (in Turkish).

Busecap, 2017. Bursa Metropolitan Municipality Sustainable Energy and Climate Change Adaptation Plan. Accessed April 10, 2018 (in Turkish). https://www.bursa.bel.tr/dosyalar/Bursa_BUSECAP_2017.pdf

Butler, J.H. and Montzka, S.A. 2018. The Noaa Annual Greenhouse Gas Index (aggi). Accessed: October 20, 2018. https://www.esrl.noaa.gov/gmd/aggi/aggi.html

Bridgman, H.A., Davies, T.D., Jickells, T., Hunova, I., Tovey, K., Bridges, K. and Surapipith, V. 2002. Air Pollution in The Krusne Hory Region, Czech Republic During The 1990s. *Atmospheric Environment*, 36: 3375–3389. doi: 10.1016/S1352-2310(02)00317-5.

Caseldine, C., Langdon, P. and Holmes, N. 2006. Early Holocene Climate Variability and The Timing and Extent of The Holocene Thermal Maximum (HTM) in Northern Iceland. Quaternary Science Reviews 25: 2314-2331. doi: 10.1016/j.quascirev.2006.02.003.

Dirican, M. 1997. What's Happening Up There? *Journal of Science and Technology*, 355: 32-39 (in Turkish).

DSİ 2018. General Directorate of State Hydraulic Works, 1st Regional Directorate (in Turkish).

Erbaşlar, T. and Taşdemir, Y. 2007. The Relationships Among Classic Air Pollutants Measured in The Atmosphere of Bursa. *Uludağ University Journal of The Faculty of Engineering*, 12 (2): 9-19 (in Turkish).

Fröhlich, C. and Lean J. 2004. Solar Radiative Output and Its Variability: Evidence and Mechanisms. *The Astronomy and Astrophysics Review*, 12 (4): 273-320. doi: 10.1007/s00159-004-0024-1.

GEPA 2018. Atlas of Solar Energy Potential. Accessed: April 10, 2018 (in Turkish). http://www.yegm.gov.tr/MyCalculator/pages/16.aspx

Görgülü, M., Koluman, D.N. and Göncü, S. 2009. Raising Livestock and Global Warming. V. National Animal Nutrition Congress. Accessed: March 19, 2018 (in Turkish). http://www.muratgorgulu.com.tr

IPCC 1990. Working Group I Report “Climate Change: The IPCC Scientific Assessment.” Accessed: April 24, 2018. https://www.ipcc.ch/ipccreports/far/wg_I/ipcc_far_wg_I_full_report.pdf

IPCC 2007. IPCC Fourth Assessment Report: Climate Change 2007, Working Group I: The Physical Science Basis. Accessed: April 24, 2018. https://www.ipcc.ch/publications_and_data/ar4/wg1/en/spmsspm-projections-of.html

IPCC 2013. Working Group I Report "Climate Change 2013: The Physical Science Basis" Accessed: April 24, 2018. http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml

Klug, H. 2001. Basic Course in Wind Energy. Istanbul, Turkey: German Wind Energy Institute (DEWI).

Leggett, J. 1991. Global Warming, Der Greenpeace Report. Piper GmbH&Co.KG, München.

MGM 2018. Turkish State Meteorological Service, Ankara (in Turkish).

Moss, A., Jouany J.P. and Newbold J. 2000. Methane Production by Ruminants: Its Contribution to Global Warming. Annales de zootechnie, INRA/EDP Sciences, 49 (3):231-253. doi: 10.1051/animres:2000119.

Nasa 2016. Global Mean Surface Temperature. Accessed: August 10, 2016. https://svs.gsfc.nasa.gov/vis/a010000/a012300/a012305/gistemp_jan-jun16.png

Öztürk, H.H. 2005. Solar Radiation Exergy Changes in the Mediterranean Region. III. Renewable Energy Resources Symposium Proceedings Book, Mersin (in Turkish).

Pelletier, J.D. 2006. Sensitivity of Playa Windblown-Dust Emissions to Climatic and Anthropogenic Change. *J. Arid Environ.*, 66:62–75. doi: 10.1016/j.jaridenv.2005.10.010.

Quaschning, V. 2010. Renewable Energies and Climate Protection. Hanser Verlag, München (in German).

Quaschning, V. 2011. Renewable Energy Systems. Hanser Verlag, München (in German).

Solanki, S.K., Usoskkin, I. G., Kromer, B., Schüssler, M. and Beer, J. 2004. Unusual Activity of The Sun During Recent Decades Compared to The Previous 11.000 Years. Nature 431: 1084-1087. doi: 10.1038/nature02995.

Soysal M.İ. 1992. Principles of Biometry, Trakya University Tekirdag Agricultural Faculty Publication No: 95, Tekirdag (in Turkish).

SPSS (version 23) 2015. Armonk, New York: IBM.

Taşkın O. and Vardar A. 2016. Tarımsal Üretimde Bazı Yenilenebilir Enerji Kaynakları Kullanımı, *Uludağ Üniv. Ziraat Fak. Derg.*, 30(1): 179-184 (in Turkish).

TÜİK 2018. Turkish Statistical Institute. Accessed 01 April 2018 (in Turkish). http://www.tuik.gov.tr

Türkeş, M. 2001. Weather, Climate, Severe Weather Events and Global Warming. Turkish State Meteorological Service seminars in 2000, Technical Presentations. Series of Seminars 1:187-205, Ankara. Accessed: March 13, 2005 (in Turkish). https://www.mgm.gov.tr/FILES/iklim/yayinlar/Havaiklim.pdf

Vardar, A., Darga, A. and Kurtulmuş, F. 2011. Local indications of climate changes in Turkey: Bursa as a case example. *Climatic Change* (2011) 106: 255–266. doi: 10.1007/s10584-010-9904-8.

Vok, M.V. 2015. Renewable Energy Sources: Current Perspectives and Future Prospects in Turkey, *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 37:1, 1-10, doi: 10.1080/15567036.2014.947447.

Yaslıoğlu, E. and İlhan, H. 2018. Effects of Global Climate Changes on Broiler Production in Turkey: Case of The Marmara Region. *Fresenius Environmental Bulletin*, 27:196-203.1990.