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Climate and Energy Analysis for Erzurum

Erzurum için İklim ve Enerji Analizi

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ABSTRACT

With the technological developments and the increase in population day by day, the need for energy has become greater than before, and this has led to the need to study energy. It is seen that energy consumption and energy use will increase day by day. In the face of this situation, it is important for researchers to work on climate and energy analysis. Within the scope of the study, the degree-day values to be used in calculating the amount of energy required to meet the heating and cooling needs for Erzurum province will be calculated.

This study was carried out using degree-day methods, which are among the building energy analysis methods. The results were obtained by using the heating degree-day and cooling degree-day methods separately within the degree-day methods.

The data obtained within the scope of the study were obtained from the General Directorate of State Meteorological Affairs, and Erzurum province was analysed in terms of temperature, relative humidity, wind, rain, frost, sun, and climate.

As a result of the necessary analyses, it has been determined that the heating need of Erzurum province is felt on most days of the year, and a large part of the energy consumption is used by heating systems. It has been determined that the cooling need is very low in Erzurum province, and it has been determined as a result of the analyses that cooling systems can be operated in an insignificant part of the year.

Keywords: Erzurum, Climate, Energy Analysis, Wind, Solar

ÖZ

Teknolojik gelişmeler ve nüfusun her geçen gün artmasıyla birlikte enerjiye olan ihtiyaç eskisinden daha fazla hale gelmiş, bu da enerji konusunda çalışma yapılması ihtiyacını doğurmuştur. Enerji tüketiminin ve enerji kullanımının her geçen gün artacağı görülmektedir. Bu durum karşısında araştırmacıların iklim ve enerji analizleri üzerine çalışmaları önem arz etmektedir. Çalışma kapsamında Erzurum ili için ısıtma ve soğutma ihtiyacının karşılanması için gerekli enerji miktarının hesaplanmasında kullanılacak derece-gün değerleri hesaplanacaktır.

Bu çalışma, bina enerji analiz yöntemleri arasında yer alan derece-gün yöntemleri kullanılarak gerçekleştirilmiştir. Derece-gün yöntemleri içerisinde ısıtma derece-gün ve soğutma derece-gün yöntemleri ayrı ayrı kullanılarak sonuçlar elde edilmiştir.

Çalışma kapsamında elde edilen veriler Devlet Meteoroloji İşleri Genel Müdürlüğü'nden temin edilmiş olup, Erzurum ili sıcaklık, bağıl nem, rüzgâr, yağmur, don, güneş ve iklim yönünden analiz edilmiştir.

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Gerekli analizler sonucunda Erzurum ilinin ısıtma ihtiyacının yılın çoğu gününde hissedildiği ve enerji tüketiminin büyük bir kısmının ısıtma sistemleri tarafından kullanıldığı tespit edilmiştir. Erzurum ilinde soğutma ihtiyacının çok düşük olduğu tespit edilmiş olup, yılın önemsiz bir bölümünde soğutma sistemlerinin çalıştırılabileceği analizler sonucunda belirlenmiştir.

Anahtar kelimeler: Erzurum, İklim, Enerji Analizi, Rüzgâr, Güneş

Introduction

With the development of industry around the world, energy demand and consumption are increasing. With the development of factories within the scope of industry, the excessive consumption of electronic tools and equipment, and the introduction of electric cars, which appeal to a significant area of our lives today, it has become inevitable that energy has become the most basic need. As a result of developments in the industrial field, it shows that the quality of welfare in daily life is related to industrialization. With the increasing interest in technological tools in human life and the expansion of the usage area, the need for energy is increasing day by day. Individual energy consumption also shows a visible increase in the world and in our country. With these increases, providing economical and reliable access to energy worldwide can be stated as the most basic desire. With these developments, energy consumption is constantly increasing worldwide.

The amount of energy consumed from the beginning of industrialization until today creates the impression that fossil fuels will run out in the near future. In line with the studies conducted, it is seen that energy consumption worldwide is faster than the formation of fossil fuels. With the decrease in fossil fuels, the need for alternative energy sources has become an important situation. In line with these impressions, the use of energy sources other than fossil fuels should be increased. Solar energy, wind energy, etc. In line with the widespread use of renewable energy sources, this expectation has begun to be included in daily life.

Energy Analysis

The process of determining the energy in a system by checking the input and output values is called energy analysis. There is a high amount of energy consumption in industrial facilities or residences. Energy analysis can be performed on devices in industrial or residential buildings and on residential heating and cooling systems. As a result of energy analysis, input and output energy is taken under control, efficient use of energy is aimed and energy savings are achieved. At the same time, as a result of energy analysis applications, it can be observed how much of the energy entering the system is expelled without being used. As a result of the analysis, areas for improvement and development can be identified (Üçüncü, K., 2016).

Institutional Foundations

Analyses using the degree-day method have been continuing since 1928. Kennard et al. (2022) examined in their study how the degree-day method has been used in the last forty years. In their studies, they stated that degree-day change is due to global population growth and climate change. In their study, Nazan et al. (2018) examined how heating and cooling day temperatures may change as a result of climate change in Turkey. They compared the predicted future heating and cooling day temperatures with historical data. As a result of this comparison, they concluded that there would be a decrease in heating degree-days (HDDs) and an increase in cooling degree-days (CDDs). As a result of the study, it was concluded that HDDs will decrease the most in the upcoming period in Kayseri, Sivas, Mersin, and Kahramanmaraş provinces. In his study, Aslan (2022) examined the change in heating and cooling degree hours (HDH and CDH) at different equilibrium temperatures for Bandırma. In his study, he calculated HDH and CDH values for 21 years of Bandırma data by considering three different equilibrium temperatures. As a result of his study and 21 years of data, he concluded that the outdoor temperature is gradually increasing. (Erdoğan & Yılmaz, 2012) included information about building energy analysis methods in their study. This study includes detailed information about energy analysis methods.

They explained the necessary data about the types and classifications of building energy analyses and how they can be applied. Particularly, degree-day methods and bin methods were emphasized, and all necessary equations were mentioned. In their publication on building energy analysis, Erdoğan and Yılmaz (2012) examined and conveyed the necessary topics about the analysis methods that should be carried out and maintained in order to protect energy resources. They stated why building energy analyses are needed, the factors affecting the energy used in buildings, and the methods required for the selection of building energy analyses. Kayın (2019) carried out the energy performance analysis of the annex building of Namık Kemal University Çorlu Engineering Faculty. As a result of the study, a significant reduction in energy consumption was achieved with the inclusion of renewable energy sources into the system. (Bayraktar, 2003) revealed the degree-day values of station number 2218, which is affiliated with DMI General Directorate, as a result of analysis. He completed degree-day

calculations with specific outdoor and indoor temperatures between 1978 and 1998. Baumert and Selman (2003) calculated HDDs and CDDs for 171 countries. As a result of this calculation, the heating and cooling amounts that should be used per person in the countries were determined.

In their study, Büyükalaca et al. (2001) determined heating and CDDs across Turkey using degree-day methods. They used five different base temperatures in their studies. For the HDD calculation, the base temperature was determined as 22°C, and in the CDD calculation, six different values between 18° and 28°C were used as the base temperature. Calculations for all provinces in Turkey have been completed and tabulated. Bulut (2001) created detailed climate data for Adana province. They determined HDD and CDD values by taking into account different equilibrium point temperatures. They made their calculations by determining 8-hour periods for the bin method, which is among the energy analysis methods.

Heating Degree Days (HDD)

Certain comfort conditions are required in buildings. In order to prevent these comfort conditions from deteriorating, the ambient temperature must not fall below the determined base temperature value. If the ambient temperature falls below the specified base temperature, the environment must be heated in order to prevent the comfort structure from deteriorating. Using HDD data, the amount of energy required to heat the environment is determined (Akbulut, 2019).

Measured daily average temperatures provide certain results about the heating needs of buildings and the amount of energy required for this heating process. While designing and analyzing the building, it should be known how the building behaves in the winter conditions of the region where it is built, so that the heating process can be carried out correctly and with energy efficiency. It is important to know the necessary data about winter conditions before building design and construction, as heating systems must operate in all kinds of difficult conditions (Gültekin, 1995). Monthly HDD Values for 18.3°C Base Temperature between 1970-2020 are given in Table 1.

Cooling Degree Days (CDD)

CDDs, unlike HDDs, are used to determine the amount of energy required to cool and ventilate the environment in order to increase human comfort in hot weather. Necessary cooling equipment and electronic systems are used to cool the environments inside buildings. CDD methods are preferred in order to determine the amount of energy consumed by cooling systems and to increase energy efficiency.

The base temperature value, which is among the parameters required to calculate the CDD index, is accepted as 24°C. This parameter is also used throughout Türkiye. In summer, cooling and ventilation needs increase as the outdoor temperature exceeds 24°C due to hot weather. When the temperature exceeds the specified value, CDDs can be calculated by subtracting the base temperature from the average outdoor temperature value. For example, on a day when the average outdoor temperature is 25°C, the base temperature, which is accepted as 24°C, is subtracted from this value, and the CDD value is stated as 1°C (Gültekin, 1995). Table 1 shows the values related to HDD.

Steady State Methods

The energy analysis method, which is another form of building energy analysis method, is divided into two separate groups depending on whether it is continuous or not. These two groups are called steady-state methods and dynamic methods. Less data is needed in analyses performed with steady-state methods. It is preferred in simple applications. Under this heading, types of steady state methods will be explained. The bin method, the data-based bin method, and the correlation method will be introduced.

Bin Method

While energy analysis is carried out using the Bin method, energy consumption is analyzed on a monthly and annual basis by evaluating time and temperature ranges. Bin values used in the bin method are defined as the number of hours during which temperature ranges are observed within a time period. The Bin method does not depend on daily average outdoor temperature values, as in other methods. Instead, hourly climate values are taken into account. In this way, it provides clearer results than degree-day methods (Ashrae, 2009; Erdoğan, et al., 2012).

Adjusted Bin Method

Maximum loads are taken into account when using the bin method, which is one of the energy analysis methods. Considering the different loads, it appears to be in off-design conditions. By taking these conditions into account, more accurate load profiles are created. The basic logic of the corrected bin method also depends on these parameters (Erdoğan & Yılmaz, 2012).

8760 Hourly Method

In the 8760 hourly method, 8760 hourly calculations are made for each day of the year, taking into account the outdoor temperatures when the residences and systems operate. With this energy analysis method, the amount of annual energy consumption can be determined clearly by performing analyses for all days and hours. At the same time, it is seen that situations that cannot be determined clearly in other analysis methods or that make calculations difficult are eliminated with this method. The reason for this may be the use of clear weather data for each

hour. In addition, when performing energy analysis, the number of people in the building or workplace, the lighting used, hourly and daily usage data of heating and cooling systems, and the energy consumption of the equipment used to increase human comfort are also included in these calculations. The clearest data for determining the amount of energy used can be easily obtained for 8760 hours thanks to this method (Alarko, 2007).

Material and Methods

Erzurum is among the cities located in the Eastern Anatolia Region, with high altitudes and continental climate characteristics. Some districts in Erzurum do not show the same climate characteristics as the center. Oltu, Olur, Tortum, Uzundere, and İspir districts are affected by the Black Sea Region in terms of their climate characteristics due to their proximity to the Black Sea Region. It is known that continental climate conditions are observed in the villages or neighborhoods of the mentioned districts with high altitude values.

When the data received from the General Directorate of Meteorology for the energy analysis of Erzurum province is examined, it is seen that the number of frosty days with monthly temperature values of -0.1°C and below between 1970 and 2020 was highest in December, January, and February. The months with the least number of frosty days are naturally stated as the months in which the summer season occurs. Frosty days, which occur rarely in June, July, and August, were evaluated with the help of data obtained from areas with high altitude.

When the annual rainfall amounts of Erzurum province are examined, the months with the most rainfall are April and May. According to the data, there is an average annual rainfall of 412.2 mm. The month with the least rainfall was determined to be August. In the period from 1970 to 2020, the year with the most rainfall was 2015, and the amount of rainfall was 593.3 mm.

According to annual data for Erzurum, the coldest month is January, and the hottest month is August. From here, the importance of energy analysis can be understood once again. Controlling energy consumption in January, which has an average temperature of approximately -10°C, is possible with energy analysis. HDD and CDD numbers are determined using degree-day methods, and necessary precautions can be taken by taking these numbers into consideration. HDD and CDD numbers are determined based on average temperatures.

Winds are most intense in April, May, and July. The average wind speed in these months was determined to be 3.35 $msec^{-1}$, 3.19 $msec^{-1}$and 3.5 $msec^{-1}$, respectively. According to the data, the months with the lowest wind speeds are December and January.

Impact of Urbanization

Climatic changes are observed in cities with the increase in human population, number of buildings, industrial construction, and energy consumption. It has been explained in the previous headings that with the increase in population, the need for energy is constantly increasing due to the materials people use to increase their living comfort. When we consider the winter season, it can be said that the need for heating is high in cities with a high population, and therefore, a certain amount of heat is transferred to the atmosphere from each house. As heat transitions occur, the air also becomes warmer. When we consider that the number of buildings increases with the population, the warming of the weather cannot be ignored.

As a result of the increase in production along with the development of industry and technology, energy consumption and the temperature created by gases transferred to the environment increase. The gases released into the environment as a result of the fuels used by public transportation vehicles or individual vehicles also increase this value.

Erzurum Province Heating and Cooling Degree Day Values

Within the scope of the thesis study, heating and CDD values were determined for Erzurum province. Average temperature values between 1970-2020 were obtained from MGM (Meteoroloji Genel Müdürlüğü). Degree-day values were created using average temperature values, HDD and CDD equations. The equations in formula 1 and formula 2 below were used when making the calculations.

HDD: Heating Degree Days,
CDD: Cooling-degree-day.
n : Number of Days in Period,
T_t : Base Temperature,
T_{ort} : Daily Average Outdoor Temperature.

$$HDD = \sum_1^n [T_t - T_{ort}] \quad (1)$$

Formula 1.

Heating-degree-day calculation equation.

$$CDD = \sum_1^n [T_{ort} - T_t] \quad (2)$$

Formula 2.

Cooling-degree-day calculation equation.

HDD values are given in monthly periods in the Table 1 created at five-year intervals since 1970. Considering the base temperature of 18.3°C throughout most of the year, it has been observed that the need for heating occurs. The need for heating begins in autumn and continues until the end of spring. Due to the climate structure of Erzurum, the need for heating is felt in the summer months. When the data is examined day by day, the days when heating is needed cover most of the year.

It is known that cooling needs occur at temperatures of 24°C and above. When this value was taken into account as the base temperature and the necessary calculations were made and evaluated over five-year periods, the data in Table 2 was obtained. According to the data, it can be seen that the need for cooling is not felt much in Erzurum.

Table 1.

Monthly HDD Values Between 1970-2020 for Base Temperature 18.3°C

Range Of Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average	Total Days Required For Heating
1970 - 1974	886.56	722.40	592.46	375.60	239.84	123.62	24.70	36.38	105.98	288.30	550.54	801.06	**395.62**	1611.00
1975 - 1979	827.22	680.88	615.38	376.4	252.24	120.04	33.48	15.34	99.06	335.52	490.04	728.96	**381.21**	1578.00
1980 - 1984	821.18	735.48	604.5	395.6	271.96	110.32	19.42	33.98	104.1	315.38	506.36	704.32	**385.22**	1589.00
1985 - 1989	841.92	745.64	671.6	368.14	241.86	112.16	22.64	24.42	132.64	351.42	572.92	771.42	**404.73**	1591.00
1990 - 1994	955.76	859.28	723.68	391.58	267.62	131.28	31.08	21.38	132.1	320.96	597.52	827.30	**438.30**	1638.00
1995 - 1999	818.84	774.86	696.34	418.94	227.5	115.76	27.06	15.68	163.42	348.46	533.18	745.62	**407.14**	1619.00
2000 - 2004	909.38	764.22	646.24	390.34	266.42	120.34	20.28	29.2	132.62	323.66	559.16	839.28	**416.76**	1622.00
2005 - 2009	980.70	770.32	586.04	386.02	237.98	106.04	24.24	18.38	127.52	309.84	525.18	768.80	**403.42**	1593.00
2010 - 2014	822.50	737.06	590.16	354.66	228.88	92.48	16.82	5.88	109.64	320.64	533.16	775.02	**382.24**	1557.00
2015 - 2020	850.43	724.67	554.17	374.52	229.40	86.03	9.03	7.82	88.32	294.08	526.87	756.97	**375.19**	1827.00

** The sum of the temperature differences that will meet the daily heating requirement required to reach 18.30°C.*

Table 2.

Monthly CDD Values Between 1970-2020 for a Base Temperature of 24°C

Range Of Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average	Total Days Required For Cooling
1970 - 1974	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.72	0.00	0.00	0.00	0.00	**0.10**	8.00
1975 - 1979	0.00	0.00	0.00	0.00	0.00	0.00	0.74	0.40	0.00	0.00	0.00	0.00	**0.10**	9.00
1980 - 1984	0.00	0.00	0.00	0.00	0.00	0.00	2.18	0.22	0.00	0.00	0.00	0.00	**0.20**	19.00
1985 - 1989	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.54	0.00	0.00	0.00	0.00	**0.05**	9.00
1990 - 1994	0.00	0.00	0.00	0.00	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00	**0.05**	4.00
1995 - 1999	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.06	0.00	0.00	0.00	0.00	**0.01**	2.00
2000 - 2004	0.00	0.00	0.00	0.00	0.00	0.00	1.38	0.86	0.00	0.00	0.00	0.00	**0.19**	12.00
2005 - 2009	0.00	0.00	0.00	0.00	0.00	0.00	0.14	3.96	0.00	0.00	0.00	0.00	**0.34**	13.00
2010 - 2014	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.34	0.00	0.00	0.00	0.00	**0.07**	8.00
2015 - 2020	0.00	0.00	0.00	0.00	0.00	0.00	0.43	1.12	0.00	0.00	0.00	0.00	**0.13**	11.00

** The sum of the temperature differences that will meet the daily cooling need required to reduce 24°C.*

Research Findings

Within the scope of the thesis study, in light of the data obtained from the General Directorate of Meteorology for Erzurum province between 1970 and 2020, monthly numbers of frost days, average current pressure values, average relative humidity values, average wind speeds, average temperatures, total sunshine durations, total rainfall amounts, and average soil temperatures were examined. As a result of these examinations, HDDs and CDDs in the degree-day method were evaluated, and the necessary analyses were made. Necessary interpretations regarding Erzurum climate and building energy analyses were made by examining the analysis tables.

When the winter and summer seasons in Erzurum are examined, it can be said that most of the year is under the influence of the winter season. It is known that snowfall and icing increase in December, January, and February, when air temperatures are at their lowest values, and the harshest winter conditions are experienced in these months. The highest number of frosty days was determined in the winter of 1992. 207 days of the year were announced as frost days, and all days of December and January were determined as frost days.

When the sunshine duration of the province was examined using 51 years of data, it was determined that the highest sunshine duration was in 2017 with 2870 hours annually, taking into account the deficiencies of the 2009-2011 data. When evaluated monthly, it is seen that July has the highest sunshine duration. The total amount of precipitation was determined to be 412.2 mm on average annually, based on data received from MGM.

Monthly Numbers of Frosty Days in Erzurum Province

The number of frost days in Erzurum province was examined with data from MGM between 1970 and 2020. Erzurum is one of the provinces that has a continental climate and spends most of the year under the influence of winter. Frost events occur due to harsh winter conditions. Frost events occur when the air temperature is -0.1°C or below. Based on the data examined since 1970, it is known that the highest number of frosty days belongs to 1992, with 207 days. The least number of frosty days belongs to 1979, with 135 days. Average, minimum and maximum values of the number of frosty days by month between 1970-2020 are given in Table 3.

Table 3.

Average, Minimum and Maximum Values of the Number of Frosty Days Between 1970 and 2020 by Month

Month/Value	Average Number of Frosty Days	Minimum Number of Frosty Days	Maximum Number of Frosty Days
January	30.6	28	31
February	27.6	24	29
March	26.7	15	31
April	13.8	2	24
May	2.8	1	11
June	0.37	1	3
July	1	1	1
August	1	1	1
September	2.1	1	9
October	12.1	1	27
November	23.5	11	30
December	29.3	22	31

Total Monthly Sunshine Time in Erzurum Province

Monthly average sunshine durations across Erzurum were determined with the data between 1970 and 2020 obtained from MGM. Although Erzurum province has harsh winter conditions, it has a certain amount of sunshine every month of the year. The months with the highest amount of sunshine were observed in June, July, and August. When we look at the months with the least solar energy, it is seen that December, January, and February receive less solar energy on average. As a result of examining 51 years of data, the maximum total sunshine duration was recorded as 392.4 hours in July 1971.

Average, Minimum and Maximum Values of Total Sunshine Times by Month between 1970-2020 are given in Table4

Table 4.

Average, Minimum and Maximum Values of Total Sunshine Times by Month between 1970-2020

Month/Value	Monthly Average Sunshine Time (Hours)	Minimum Average Sunshine Time (Hours)	Maximum Average Sunshine Time (Hours)
January	97.15	43	187
February	118.16	65.7	215.2
March	154.8	94.9	252.1
April	181.4	124.6	285.7
May	235.45	154.9	306.8
June	293.22	258.7	357.2
July	341.48	249	392.4
August	326.7	250.1	379.5
September	266.5	213.2	316.8
October	204.36	144.5	273.5
November	135.6	71.2	210.9
December	89.95	27.8	181.9

Erzurum Province Monthly Total Precipitation

Taking into account the data between 1970 and 2020, the average monthly rainfall amounts for 51 years were calculated. In addition, the minimum and maximum precipitation values for each month are determined and shown in the chart. The highest average rainfall occurs in May. When the data are examined separately for each year, the amount of precipitation gradually increases from January to June and then begins to decrease. The months with the least rainfall are December, January, February, and August. As a result of examining the 51-year data taken into account in the analysis with average values, August is stated to be the month with the least rainfall among other months. Monthly Average, Minimum and Maximum Rainfall Amounts with 1970-2020 MGM Data are given in Table 5.

Erzurum Province Monthly Average Temperature

The lowest average daily temperature recorded in MGM between 1970 and 2020 in Erzurum was determined to be -29.6°C. The highest daily average temperature was recorded to be 28.20 °C. When the data received from MGM was examined, it was determined that the highest monthly average temperature belonged to August, and the lowest monthly average temperature belonged to January with -16.9. In this thesis study, building energy analysis will be carried out using the degree-day method, using daily average temperature values. Monthly General, Minimum and Maximum Temperature Averages According to 1970-2020 MGM Data are given in Table 6.

Erzurum Province Monthly Average Wind Speed

Wind speeds recorded between 1970 and 2020 were examined together with the data received from MGM for Erzurum province. The month with the highest wind speed is July, with an average of 3.43 $msec^{-1}$. Within the data, the lowest monthly wind speed belongs to November, with 0.2 $msec^{-1}$. The highest average wind speed occurred in October at 5 $msec^{-1}$. As a result of 51 years of investigation, the lowest wind speed was determined to be November 1994. The highest wind speed was recorded in 1987. When the wind direction, which is constantly dominant in Erzurum, is examined, western (W) winds are effective throughout the province (Karaca et al., 2013). Monthly General, Minimum, Maximum Wind Speed Averages and Wind Directions According to 1970-2020 MGM Data are given in Table 7.

Table 5.

Monthly Average, Minimum and Maximum Precipitation Amounts with 1970-2020 MGM Data

Month/Value	Monthly Average Precipitation Amount (mm)	Minimum Average Monthly Precipitation Amount (mm)	Maximum Average Monthly Precipitation (mm)
January	18.7	1.7	55.7
February	22.01	1.2	90
March	30.8	1.2	82.2
April	55.3	8.8	150.2
May	70.3	14.9	154
June	44.4	2.9	112.6
July	24.65	0.8	92.6
August	17.52	0	63
September	21.7	0	76.2
October	47.3	2.3	210.8
November	30.7	1.6	81
December	21.07	4.9	52.8

Table 6.

Monthly General, Minimum and Maximum Temperature Averages According to 1970-2020 MGM Data

Month/Value	Monthly Average Temperature (°C)	Minimum Monthly Average Temperature (°C)	Maximum Monthly Average Temperature (°C)
January	-9.8	-16.9	-3.9
February	-8.26	-15.1	-1.9
March	-1.91	-10.4	4.6
April	5.53	1.4	9
May	10.36	7.5	12.6
June	14.72	12.6	17.8
July	19.14	16.8	22.2
August	19.32	16.6	22.7
September	14.5	11.6	17.6
October	7.95	5.1	11.9
November	0.32	-5.6	4.5
December	-6.59	-14.2	-0.8

Table 7.

Monthly General, Minimum, Maximum Wind Speed Averages and Wind Directions According to 1970-2020 MGM Data

Month/Value	Monthly Average Wind Speed ($msec^{-1}$)	Minimum Average Monthly Wind Speed ($msec^{-1}$)	Maximum Average Monthly Wind Speed ($msec^{-1}$) - Direction	Wind direction
January	1.87	0.4	3.3 - E	SS-W
February	2.21	0.6	3.7 - W	W
March	2.82	0.3	4.2 - WSW	W
April	3.28	0.8	4.2 - WSW	WSW
May	3.13	1.1	4.2 - SSW	WSW
June	2.95	0.5	3.9 - W	E
July	3.43	0.7	4.5 - ESE	ENE
August	3.27	0.9	4.6 - WSW	E
September	2.78	0.5	3.9 - SSW	ENE
October	2.53	0.6	5 - S	WSW
November	2.23	0.2	3.4 - W	WSW
December	2	0.4	3 - ENE	WSW

Conclusions

HDD and CDD values, which are degree-day methods, were determined by using daily average temperature data between 1970 and 2020 from the General Directorate of Meteorology for Erzurum province. Calculated degree-day values can be used to determine the amount of energy that needs to be used to meet the heating and cooling needs of Erzurum province.

In addition to monthly average degree-day values, annual average degree-day values and the number of days requiring annual heating or cooling processes were determined. In Erzurum, which has a continental climate, the need for heating is greater than cooling. The fact that winter is felt throughout most of the year also highlights this situation. The winter seasons in Erzurum are cold and snowy. When we look at the daily average temperature values obtained, it is seen that daily temperatures are generally below 0°C in winter. In these situations, it is inevitable that the need for heating will increase.

Due to harsh winter conditions throughout Erzurum province, the number of frosty days is quite high. It has been determined that frost occurs in many months of the year, except for the months of summer.

It may be possible to make industrial and technological investments in areas where the cold climate is an advantage. Storage areas can be created for natural gas. As technological investments, cooling for data centers creates a serious cost, and in this respect, data centers can be established in large areas.

Heat pump technologies are developing rapidly as thermal resources, and an alternative energy source to natural gas consumption can be offered by using deep well systems from geothermal resources. Greenhouse cultivation based on geothermal heat can be expanded for crops affected by agricultural frost.

Another analysis was carried out using the degree-day method for the province of Erzurum, and the cooling was carried out using the degree-day method. To determine the CDD values, temperature values of 18, 19, 20, 21, 22, 23, and 24°C were used as base temperatures. In human life, the need for cooling is felt at outdoor temperatures above 24°C. Average daily temperature values in Erzurum province rarely exceed 24°C at certain times of the year. This rarely encountered situation significantly eliminates the need for cooling. This means that there will be no extra energy consumption for Erzurum province. Every possibility should be taken into consideration in building designs. In this way, energy consumption can be reduced.

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