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Detailed weather data for the provinces covered by the Southeastern Anatolia Project (GAP) of Turkey

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Abstract

The Southeastern Anatolia Project (GAP) of Turkey is a multi-faceted and integrated regional development project based on the concept of sustainable development. The project area covers nine provinces (Adıyaman, Batman, Diyarbakır, Gaziantep, Kilis, Mardin, Siirt, Şanlıurfa and Şırnak) in the Euphrates–Tigris basins and Upper Mesopotamia plains. In this study, detailed weather data are presented for these provinces (except Şırnak). The data consist of new outdoor design conditions for heating and cooling according to the format recommended by the American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc. (ASHRAE), the heating and cooling degree-days for different base temperatures and the bin data for dry-bulb temperatures from −21 °C to 45 °C with 3 °C increments, in six daily 4-h shifts. These data are determined by using long-term recently-measured data.

Keywords: Degree-day; Bin; Design data; Southeastern Anatolia Project (GAP)

1. Introduction

Energy is essential to economic and social development and improved quality of life in Turkey, as in other counties. Turkey is an energy-importing country. More than half of energy requirement is supplied by imports because of its limited energy resources [1]. In 2000, primary-energy consumption was 79.67 million tons of oil

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Nomenclature

DB	Dry-bulb
DMİ	The State Meteorological Affairs General Directorate
FL	Annual frequency level
GAP	Southeastern Anatolia Project (Güneydoğu Anadolu Projesi)
Max	Maximum
Min	Minimum
MMO	Turkish Chamber of Mechanical Engineers
MWB	Mean coincident wet-bulb
N_{bin}	Number of hours (h)
NOH	Average number of hours
S.D.	Standard deviation
T_{b}	Base temperature (°C)
WB	Wet-bulb
Δ	Difference

equivalent, while production was only 27.59 million tons of oil equivalent, and approximately 35% of demand was met by domestic sources [2]. The country expects a very large growth in energy demand as its economy expands, especially for electricity and natural gas [3]. The energy demand will depend on imported energy in the future more than at present: for instance 72% in 2010 and 76% in 2020 [4]. Therefore, in addition to investigating new domestic energy-resources and focusing on increasing domestic production by utilizing public, private and foreign investment, every means to use energy in a much more rational way should be taken into consideration.

Approximately 25–30% of the total annual energy consumed in Turkey is used by the building sector [5]. The amount of energy consumed for air-conditioning is increasing in steady parallel to the increase in the standard of living and use of air-conditioning equipment. Although a comprehensive study does not exist, it is estimated that more than half of the energy consumed in residential and commercial buildings is used for air-conditioning [5–9].

Turkey, which has 81 administrative provinces, is divided into seven geographical regions, and one of them is Southeast Anatolia Region (Fig. 1). The Southeastern Anatolia Project (GAP) is Turkey's largest and most multifaceted development project, and also, one of the largest development projects of its kind in the world [10]. The project area covers nine provinces (Adıyaman, Batman, Diyarbakır, Gaziantep, Kilis, Mardin, Siirt, Şanlıurfa and Şırnak) of the Southeastern Anatolia Region, which is a relatively underdeveloped region in Turkey. The provinces are mainly located in the Euphrates-Tigris basins and Upper Mesopotamia plains, and have an area extending over 75,358 km^2, which corresponds to 9.7% of the total area of Turkey [11]. The population of the region is approximately 6.6 million (according to the 2000 census), which corresponds to 9.73% of the total population of the country [12].

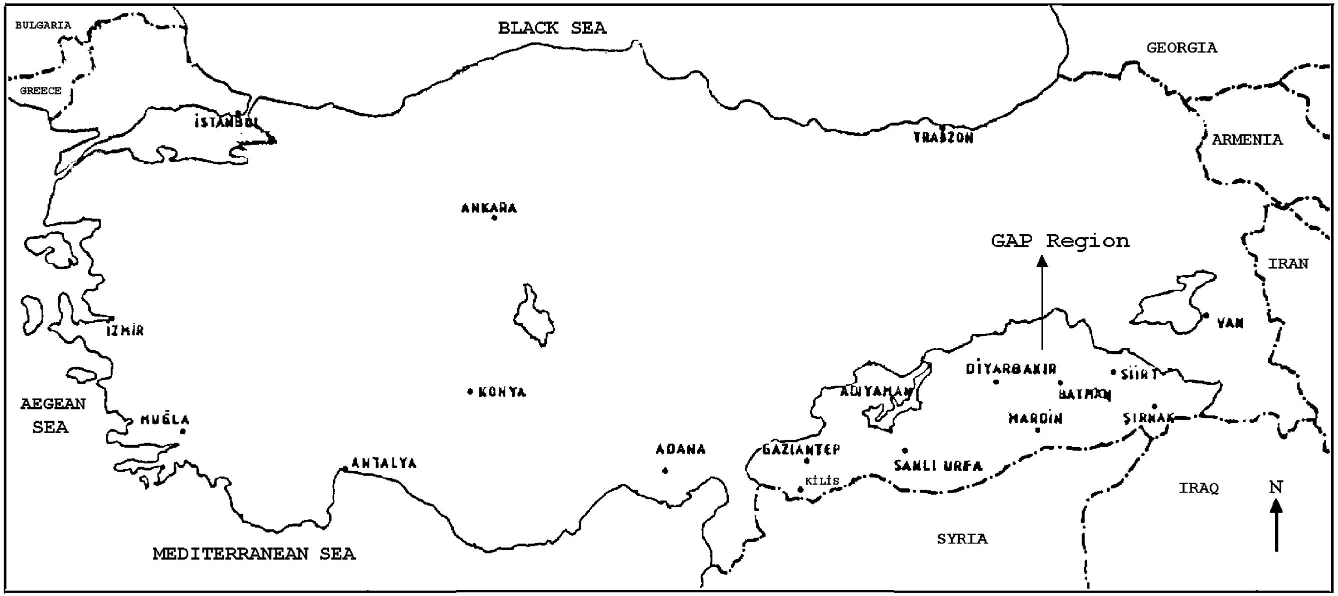

Fig. 1. The region of Turkey covered by the Southeastern Anatolia Project (GAP).

The project covers such sectors as irrigation, hydraulic-energy production, agriculture, urban, rural and agricultural infrastructure, transportation, industry, forestry, tourism, education and health. Its water-resources program envisages the construction of 22 dams and 19 power plants and irrigation schemes on an area extending over 1.7 million hectares. It will be possible to produce 27 $\times 10^{12}$ kWh energy at an installed capacity of 7460 MW annually. The planned irrigation area corresponds to 20% of total irrigable land in Turkey, while annual energy production will have a share of 22% of total energy-production capacity of Turkey [11].

The total cost of the project is US\$ 32 $\times 10^{9}$, of which about \$14 $\times 10^{9}$ was actually spent as of the end of 1999 for the realization of the project. So far, 12.8% of the agricultural, 75.4% of the energy, 97.6% of the mining, 40.5% of the manufacturing, 30.7% of the transportation-communication, 24.3% of the tourism, 34.5% of the housing, 74.6% of the education-health and 55.5% of the other public services projects have been made completed. Today, GAP's share in total energy production (thermal and hydraulic) of the country is 20% [11].

It is expected that high agricultural and industrial potential to be generated by GAP will increase the total economic output of the region 4.5 times and generate employment for 3.5 million people in a region whose population is projected to be over 9 million in 2005. The GAP project will increase the income level of the region 5-fold [11]. Parallel to this development, an intensive investment is expected in the region; not only new, modern buildings will be built, but also many new industrial establishments for manufacturing, processing, etc. will be installed. Therefore, new, reliable and detailed weather data for thermal design, energy analysis and simulation is of great importance for the region.

The climatic weather data given in the 1997 edition of ASHRAE Handbook—Fundamentals [13] are incomplete for Turkey; only eight Turkish localities are considered and none of them is in the GAP region. The number of studies concerning weather data for the design of heating, ventilating and air-conditioning (HVAC) systems [9,14–16] and energy-consumption calculations [9,14,17–19] is very limited in Turkey. The subject has been considered seriously only in recent years and it is not complete yet. A comprehensive analysis of the data for degree-days [20], temperature bins [21] and cooling design data [22] was presented by the present authors. In this study, new weather data are provided for the provinces located in the GAP region.

2. New weather design data

Calculation of heating and cooling loads of a building that depend on its characteristics, the indoor conditions to be maintained and on outside weather conditions is very important in the design of air-conditioning systems. If the air-conditioning system is expected to provide the indoor conditions required at all times, it should be designed for peak conditions that are determined by the most extreme weather data recorded for the locality in which the building is located. This approach, however, will result in oversized air-conditioning equipment, which, in turn, will increase the initial equipment cost and the operating cost. The latter is due to the reduced system efficiency of air conditioning systems at part-load conditions. Therefore, in practice, a risk of slight discomfort under rare extremes of weather is taken, and by doing so, both the initial and operating costs of the air conditioning equipment are reduced considerably [23]. The American Society of Heating, Refrigeration and Air-Conditioning Engineers Inc. (ASHRAE) publishes climatic design-conditions corresponding to different levels of probability for several locations in the United States and around the world [13,24].

For heating, the design data are provided at 99.6 and 99 annual percentile frequency of occurrence in the 1997 edition of the ASHRAE Handbook—Fundamentals [13]. In the case of cooling, annual percentile values are 0.4, 1 and 2. Design values corresponding to the various annual percentiles represent the value that is exceeded on average by the indicated percentage of the total number of hours in a year (8760 h). For example, outside dry-bulb temperature falls below the 99.6% and 99% heating design values on average 35 and 88 h in a year, respectively. The 0.4, 1 and 2% cooling design values are exceeded on average 35, 88 and 175 h in a year, respectively.

2.1. New heating and cooling design data for the GAP region

In this study, heating and cooling design conditions were provided for the provinces (except Şırnak) covered by the GAP using the raw data measured by The State Meteorological Affairs General Directorate (DMİ). The hourly dry bulb temperatures measured during at least 15 years between 1981 and 1998 were used in the calculations. Since, hourly weather data measurements are not available for Şırnak, this province was excluded in the analysis. Table 1 provides information for the weather stations and the periods of the data considered.

Tables 2 and 3 show recommended heating and cooling design dry-bulb (DB) temperatures for the GAP region, respectively. Two annual frequency levels (99.6% and 99%) for heating and three annual frequency levels (0.4%, 1% and 2%) for

Table 1
Weather database and basic information for the weather stations

Province	Longitude (°E)	Latitude (°N)	Elevation (m)	Hourly dry-bulb temperatures (°C)		Daily extreme temperatures (°C)	
				Period	Total years	Period	Total years
Adıyaman	38.17	37.45	678	1981–1998	18	1981–1998	18
Batman	41.10	37.52	540	1983–1998	15	1983–1998	16
Diyarbakır	40.12	37.55	660	1983–1998	16	1981–1996	16
Gaziantep	37.22	37.05	855	1983–1998	16	1981–1996	16
Kilis	37.05	36.44	638	1981–1998	17	1981–1998	18
Mardin	40.44	37.18	1080	1983–1998	16	1983–1998	16
Siirt	41.56	37.56	875	1981–1998	18	1981–1998	18
Şanlıurfa	38.46	37.08	547	1983–1998	16	1980–1993	14

Table 2
Heating design-conditions for the provinces covered by the GAP

Province	Heating DB (°C)		Min DB (°C)	
	99.6%	99%	Mean	S.D.
Adıyaman	−2.6	−1.3	−5.2	2.5
Batman	−6.5	−4.7	−9.8	4.4
Diyarbakır	−8.7	−6.4	−12.1	5.2
Gaziantep	−4.5	−3.1	−7.9	2.4
Kilis	−0.8	0.2	−4.4	2.4
Mardin	−4.5	−3.2	−8.3	2.9
Siirt	−5.7	−3.8	−8.6	4.0
Şanlıurfa	−1.6	−0.3	−4.6	2.4

Table 3
Cooling design-conditions for the provinces covered by the GAP

Province	Cooling DB/MWB (°C)						Max DB (°C)		Daily range of DB (°C)
	0.4%		1%		2%		Mean	S.D.	
	DB	MWB	DB	MWB	DB	MWB			
Adıyaman	39.4	21.5	38.3	21.3	37.2	21.1	42.0	1.6	14.4
Batman	40.8	23.9	39.7	23.7	38.5	23.3	43.4	1.4	18.2
Diyarbakır	39.7	22.3	38.7	22.0	37.5	21.7	42.1	1.2	17.1
Gaziantep	36.7	21.0	35.8	20.9	34.7	20.7	39.6	1.2	14.9
Kilis	37.7	19.6	36.5	19.5	35.3	19.2	40.8	1.7	15.3
Mardin	36.5	20.5	35.5	20.4	34.4	20.1	39.4	1.1	10.4
Siirt	38.1	21.2	37.1	21.0	36.1	20.7	40.7	1.3	13.5
Şanlıurfa	40.0	22.1	39.1	21.7	38.0	21.4	42.5	1.2	14.2

cooling are offered for each location as suggested by the 1997 ASHRAE Handbook—Fundamentals [13].

As can be seen from the tables, the region has a relatively uniform climate. 99.6% and 99% heating design dry-bulb temperatures for the locations within the region vary between −8.7 °C (Diyarbakır) and −0.8 °C (Kilis) and, −6.4 °C and 0.2 °C, respectively (Table 2). In the case of cooling, 0.4, 1 and 2% design temperatures are between 40.8 °C (Batman) and 36.5 °C (Mardin), 39.7 and 35.5 °C, and 38.5 and 34.4 °C, respectively.

Table 3 also shows mean coincident wet-bulb (MWB) temperatures. Coincident wet-bulb temperature is the mean of all wet-bulb temperatures occurring at the design dry-bulb temperature. In Turkey, wet-bulb temperature and relative humidity are recorded only at 07:00, 14:00, and 21:00 h. Therefore, it is not possible to obtain coincident wet-bulb temperatures directly. An approach given by Bulut et al. [22] was used for determining the coincident wet-bulb temperature.

In this study, design wet-bulb temperatures were not presented due to the lack of hourly wet-bulb temperature measurements. However, in cooling-load calculations, the use of design dry-bulb temperature with the design wet-bulb temperatures produce cooling loads significantly greater than the actual loads. Therefore, design dry-bulb temperatures should be used with the coincident wet-bulb temperatures in computing cooling-loads for cooling applications, especially in air-conditioning [13,24].

The probability of occurrence of very extreme conditions can be required for the operational design of equipment to ensure continuous operation and serviceability [13]. The mean and standard deviation (S.D.) of the annual extreme minimum (Min DB) and maximum (Max DB) dry-bulb temperatures are given in Tables 2 and 3, respectively. These data are based on the daily minimum and maximum temperature observations.

Another parameter needed in the calculation of thermal loads is the mean daily range of dry-bulb temperature, which is the mean of the difference between daily maximum and minimum temperatures for the hottest month. The last column of Table 3 presents the mean daily ranges.

2.2. Analysis of currently-used heating and cooling design data for the GAP region

Heating and cooling load calculations in Turkey are generally carried out using the climatic design data provided by the Turkish Chamber of Mechanical Engineers (MMO) in Publication No. 84 [25], which is based on the data given in Turkish Standard No. 2164 [26], and Publication No. 115 [27] and by the Turkish Ministry of Reconstruction and Settlement in Technical Publication No. 9 [28].

The heating and cooling design data given in these publications are not detailed for design evaluations and building energy analyses. They are based on old weather observations that were taken with the limited instrumentation of the past, which raise doubts about the accuracy of the measurements and they have not been updated for the last 35 years. Therefore, a possible change in the climatic conditions during the recent decades cannot have been taken into consideration in load calculations. Lack of data for various frequency levels is one of the main drawbacks of the existing design-data that are based on only one level of probability (frequency of occurrence). Therefore, designers do not have the opportunity to choose different risk levels desired for the project in hand. The same level of risk factor is assumed for all types of buildings because of the lack of design data for different frequencies of occurrence. Therefore, some designers tend to adopt their past experience and modify the existing design-data imposed by the official bodies for non-governmental buildings. Whilst the existing heating design-data were determined by averaging the yearly minimum dry-bulb temperatures observed during ten successive years for each location [26], the method used in determining the cooling design data from the observations is not clear. It is also not clear whether the wet-bulb temperature given is the 'design wet-bulb temperature' or the 'coincident wet-bulb temperature'. In addition to all these shortcomings, cooling design-conditions are not available for some locations such as Batman and Kilis.

Table 4 compares the current cooling and heating design-data [25–28] with the data obtained in this study for the GAP region. The annual frequency levels (FL) of

Table 4
The frequency level of current cooling and heating design-conditions and comparison of them with the data obtained in this study

Location	Cooling										Heating				
	Current				Difference with current						Current			Difference with current	
					0.4%		1%		2%					99.6%	99%
	DB (°C)	NOH (h)	FL (%)	WB (°C)	ΔDB (°C)	ΔWB (°C)	ΔDB (°C)	ΔWB (°C)	ΔDB (°C)	ΔWB (°C)	DB (°C)	FL (%)	NOH (h)	ΔDB (°C)	ΔDB (°C)
Adıyaman	38	140	1.6	22	−1.4	0.5	−0.3	0.7	0.8	0.9	−9.0	100	0	−6.4	−7.7
Batman	NA[a]	–	–	NA	–	–	–	–	–	–	−9.0	99.66	29	−2.5	−4.3
Diyarbakır	43	1	0.01	23	3.3	0.7	4.3	1.0	5.5	1.3	−9.0	99.46	47	−0.3	−2.6
Gaziantep	39	6	0.06	23	2.3	2.0	3.2	2.1	4.3	2.3	−9.0	99.97	3	−4.5	−5.9
Kilis	NA	–	–	NA	–	–	–	–	–	–	−6.0	99.99	1	−5.2	−6.2
Mardin	38	13	0.15	23	1.5	2.5	2.5	2.6	3.6	2.9	−6.0	99.65	31	−1.5	−2.8
Siirt	40	8	0.09	23	1.9	1.8	2.9	2.0	3.9	2.3	−9.0	99.78	19	−3.3	−5.2
Şanlıurfa	43	2	0.02	24	3.0	1.9	3.9	2.3	5.0	2.6	−6.0	99.97	2	−4.4	−5.7

[a] NA: not available.

the current cooling and heating design dry-bulb temperatures were calculated using the database (Table 1) on which this study is based. For example, the current cooling design dry-bulb temperature is 38 °C for Adıyaman. Analyzing the hourly dry-bulb temperature records between the years 1981–1998 (Table 1), the average number of hours (NOH) for which the dry-bulb temperature exceeds this value was found to be 140 h. The corresponding annual frequency level was then calculated as 1.6%.

Annual frequency levels of the current design dry-bulb temperatures for the locations within the GAP region are between 0.01 and 1.6% for cooling and 99.46 and 100% for heating (Table 4). The current design-conditions usually overestimate the cooling design dry-bulb temperature and underestimate the heating design temperature. For five of the six locations, the frequency level of the current cooling dry-bulb temperature is smaller than the minimum frequency level (0.4%) proposed by the 1997 ASHRAE Handbook—Fundamentals [13]. Similarly, for seven of the eight locations, the frequency level of the current heating temperature is bigger than the maximum frequency level (99.6%). This means that the outside air dry-bulb temperature will be higher than the heating design temperature (or lower than the cooling design temperature) on average for less than 35 h in a year. Moreover, those hours do not occur in sequence and the thermal inertia of the building attenuates the peak loads if the building is not light structured. Therefore, it can be concluded that the current cooling and heating design temperatures for the locations within the GAP region are stringent and provide total protection. If the current cooling and heating design-data are used, an air-conditioning system will be oversized and will run under part-load conditions most of the time. Furthermore, in practice, an average safety margin of 5–10% is added to the cooling and heating load based on the current design data. As a result of these, both initial and operational costs of the air-conditioning system will be high.

The current design wet-bulb temperatures are also higher than the coincident wet-bulb temperatures presented in this study. Table 4 also shows the temperature difference between the current design data and the design data recommended in this study. Temperature differences are generally positive for cooling and negative for heating, indicating that the current design temperatures are generally higher in cooling and lower in heating than the data obtained in this study.

The current cooling-design data and the design data presented in this study are shown together on a psychrometric chart in Fig. 2 for 0.4% frequency level. A comparison of the envelopes that cover the current design data and the data presented in this study reveals that the current design-data sit further right (i.e., higher

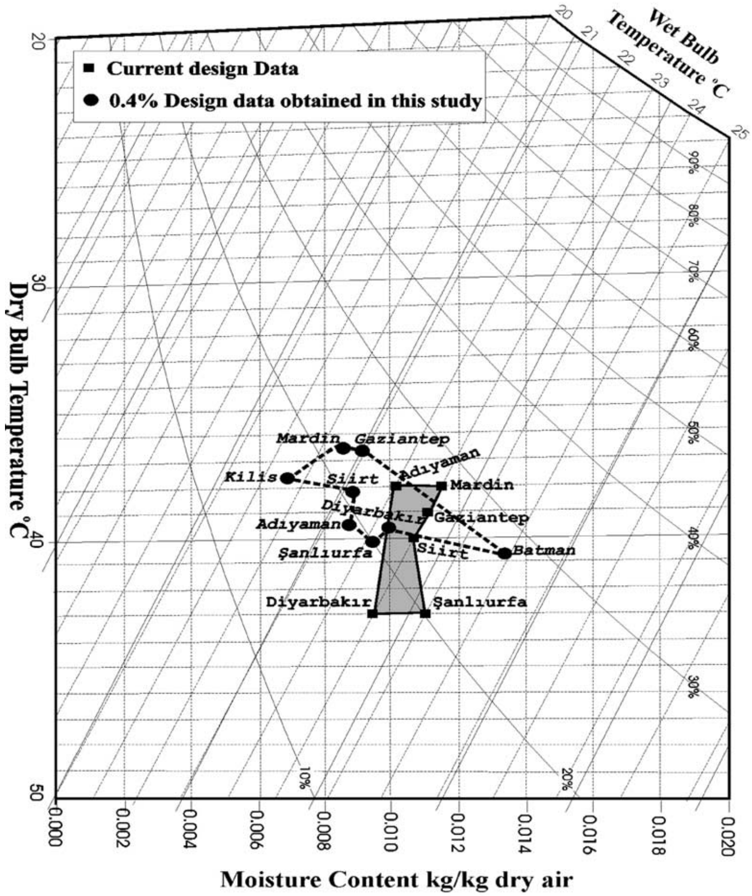

Fig. 2. Comparison of the current cooling-design conditions for the GAP region with the conditions obtained in this study at 0.4% frequency level.

moisture contents) and below (i.e., higher design dry-bulb temperatures) on the chart. These mean that the current design data will produce larger sensible and latent cooling loads than that of the present design data. When comparing the envelopes, it should be noted that current design data do not exist for Batman and Kilis.

3. Degree-days

The degree-day method is one of the well known and the simplest methods used in the HVAC industry to estimate heating and cooling energy requirements. The method is especially useful, if the buildings use, the efficiency of HVAC equipment, indoor temperature and internal gains are relatively constant. The value of degree-days is a measure used to indicate the demand for energy to heat or cool buildings. The method assumes that the energy needs for a building are proportional to the difference between the mean daily temperature and a base temperature. The base temperature is the outdoor temperature below or above which heating or cooling is needed [24,29].

Traditionally, heating degree-days are calculated at a base temperature of 18 °C (or 65 °F) and cooling degree-days are determined at a base temperature of 22 °C (71.6 °F) for a typical uninsulated building. However, the average value of the base temperature varies widely from one building to another, because of differing personal preferences for the thermostat and thermostat setback settings and because of different building characteristics such as thermal insulation, air leakage and solar gains. Hence degree-days, with a base temperature of 18 °C in heating or 22 °C in cooling, must be employed with caution [23].

In this study, based on the database for temperature shown in Table 1, daily minimum and maximum outdoor dry-bulb temperatures of recent years were used in the calculation of the number of degree-days. Daily mean temperatures were obtained by averaging the minimum and the maximum temperatures. Using the daily mean temperatures, monthly and annual heating and cooling degree-days for various base temperatures were obtained for the provinces covered by the GAP.

Tables 5 and 6 show the monthly and annual heating degree-days for 14, 16, 18, 20 and 22 °C base temperatures and the cooling degree-days for the base temperatures of 18, 20, 22, 24 and 26 °C for the GAP region, respectively. As can be seen from the tables, the differences between the degree-days for different provinces are not significant at the same base temperature. The maximum value of annual heating degree-day is 2142 °C-days in Diyarbakır, whilst the minimum is 1503 °C-days in Şanlıurfa. For the annual cooling degree-day at 22 °C base temperature, the maximum value appears in Şanlıurfa (940 °C-days), the minimum is in Gaziantep (520 °C-days).

4. Bin data

The degree-day method can estimate energy consumption very accurately if the heat-loss coefficient of the building, the efficiency of the HVAC system, utilization of

Table 5
The monthly and annual heating degree-days at different base temperatures (T_b) for the provinces covered by the GAP

Province	T_b (°C)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Yearly
	14	276	231	144	30	2	0	0	0	0	4	85	223	995
	16	338	287	202	61	8	0	0	0	0	11	134	285	1326
Adıyaman	18	400	343	263	103	22	0	0	0	0	27	190	347	1695
	20	462	399	325	153	44	1	0	0	1	54	249	409	2097
	22	524	455	387	208	78	4	0	0	3	95	308	471	2533
	14	329	250	148	22	2	0	0	0	0	5	95	265	1116
	16	391	306	207	52	7	0	0	0	0	13	146	327	1449
Batman	18	453	362	268	94	20	0	0	0	0	32	203	389	1821
	20	515	418	330	146	43	1	0	0	1	66	263	451	2234
	22	577	474	392	202	78	3	0	0	5	115	323	513	2682
	14	371	296	187	46	5	0	0	0	0	10	147	313	1375
	16	433	352	248	86	16	0	0	0	0	24	204	375	1738
Diyarbakır	18	495	408	310	136	38	0	0	0	1	53	264	437	2142
	20	557	464	372	193	71	2	0	0	3	97	324	499	2582
	22	619	520	434	252	117	8	0	0	9	151	384	561	3055
	14	318	267	180	47	6	0	0	0	0	11	141	271	1241
	16	380	323	241	86	17	0	0	0	0	28	197	333	1605
Gaziantep	18	442	379	303	135	39	1	0	0	1	58	256	395	2009
	20	504	435	365	191	72	4	0	0	3	103	316	457	2450
	22	566	491	427	249	117	14	0	0	10	157	376	519	2926
	14	246	202	122	25	2	0	0	0	0	3	72	200	872
	16	308	258	178	53	8	0	0	0	0	8	116	262	1191
Kilis	18	370	314	239	93	20	0	0	0	0	20	169	324	1549
	20	432	370	300	141	42	1	0	0	1	43	226	386	1942
	22	494	426	362	194	75	6	0	0	3	79	286	448	2373
	14	335	286	201	54	7	0	0	0	0	10	106	271	1270
	16	397	342	261	93	18	0	0	0	0	22	155	333	1621
Mardin	18	459	398	322	140	36	0	0	0	1	43	210	395	2004
	20	521	454	384	193	63	2	0	0	3	75	269	457	2421
	22	583	510	446	249	99	9	0	0	8	117	329	519	2869
	14	338	277	181	39	5	0	0	0	0	6	112	276	1234
	16	400	333	242	75	15	0	0	0	0	16	165	338	1584
Siirt	18	462	389	303	121	32	0	0	0	1	37	223	400	1968
	20	524	445	365	174	61	2	0	0	2	72	283	462	2390
	22	586	501	427	231	101	6	0	0	5	119	343	524	2843
	14	257	203	110	14	0	0	0	0	0	2	70	196	852
	16	319	259	164	36	3	0	0	0	0	5	113	258	1157
Şanlıurfa	18	381	315	223	71	12	0	0	0	0	16	166	320	1504
	20	443	371	284	117	29	0	0	0	0	36	223	382	1885
	22	505	427	346	171	57	2	0	0	1	68	282	444	2303

Table 6
The monthly and annual cooling degree-days at different base temperatures (T_b) for the provinces covered by the GAP

Province	T_b (°C)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Yearly
	18	0	0	0	15	91	231	377	384	257	85	11	0	1451
	20	0	0	0	6	54	186	324	319	182	35	0	0	1106
Adıyaman	22	0	0	0	2	26	129	262	257	125	14	0	0	815
	24	0	0	0	0	10	80	200	195	73	4	0	0	562
	26	0	0	0	0	3	42	139	133	34	0	0	0	351
	18	0	0	0	14	86	238	390	369	219	47	1	0	1364
	20	0	0	0	5	47	178	328	307	160	19	0	0	1044
Batman	22	0	0	0	2	20	120	266	245	104	6	0	0	763
	24	0	0	0	0	6	70	204	183	55	1	0	0	519
	26	0	0	0	0	1	33	142	122	20	0	0	0	318
	18	0	0	0	3	52	205	362	340	194	29	0	0	1185
	20	0	0	0	0	24	147	300	278	136	11	0	0	896
Diyarbakır	22	0	0	0	0	8	93	238	216	82	3	0	0	640
	24	0	0	0	0	2	49	177	154	39	0	0	0	421
	26	0	0	0	0	0	20	117	94	11	0	0	0	242
	18	0	0	0	7	57	176	307	306	180	28	0	0	1061
	20	0	0	0	2	29	120	245	244	123	11	0	0	774
Gaziantep	22	0	0	0	0	12	70	183	182	70	3	0	0	520
	24	0	0	0	0	4	33	123	122	30	0	0	0	312
	26	0	0	0	0	1	12	69	67	8	0	0	0	157
	18	0	0	0	21	101	207	312	330	244	100	14	0	1329
	20	0	0	0	10	65	160	256	265	176	50	1	0	983
Kilis	22	0	0	0	4	35	104	194	203	118	24	0	0	682
	24	0	0	0	1	17	58	132	141	66	8	0	0	423
	26	0	0	0	0	7	27	74	82	29	2	0	0	221
	18	0	0	0	14	88	223	369	360	232	65	2	0	1353
	20	0	0	0	6	52	165	307	298	174	34	0	0	1036
Mardin	22	0	0	0	2	27	111	245	236	119	15	0	0	755
	24	0	0	0	0	11	67	184	175	71	4	0	0	512
	26	0	0	0	0	4	34	125	116	35	1	0	0	315
	18	0	0	0	11	71	211	366	369	241	65	7	0	1341
	20	0	0	0	4	38	165	314	303	166	20	0	0	1010
Siirt	22	0	0	0	1	16	109	252	241	110	6	0	0	735
	24	0	0	0	0	5	62	190	179	60	1	0	0	497
	26	0	0	0	0	1	28	130	118	24	0	0	0	301
	18	0	0	1	25	118	277	410	398	272	96	4	0	1601
	20	0	0	0	11	73	218	348	336	213	54	1	0	1254
Şanlıurfa	22	0	0	0	4	39	159	286	274	154	24	0	0	940
	24	0	0	0	1	17	105	224	212	98	8	0	0	665
	26	0	0	0	0	5	58	163	151	50	2	0	0	429

Table 7
Yearly total N_{bin} values (h/year) for six separate time periods of the day for the provinces covered by the GAP

Province	Time	Temperature bin (°C) −21/−15	−18/−15	−15/−12	−12/−9	−9/−6	−6/−3	−3/0	0/3	3/6	6/9	9/12	12/15	15/18	18/21	21/24	24/27	27/30	30/33	33/36	36/39	39/42	42/45
	1–4	0	0	0	0	2	12	43	117	177	178	152	125	134	142	149	145	67	16	1	0	0	0
	5–8	0	0	0	0	3	17	54	130	172	169	139	122	130	137	156	135	73	20	3	0	0	0
	9–12	0	0	0	0	0	1	11	50	120	157	138	116	104	98	93	114	132	143	116	58	9	0
Adıyaman	13–16	0	0	0	0	0	1	4	25	66	129	155	133	103	104	91	85	103	127	142	138	49	5
	17–20	0	0	0	0	0	2	13	53	120	162	153	121	103	92	95	102	120	136	117	60	11	0
	21–24	0	0	0	0	1	7	26	89	156	176	150	120	113	116	124	145	146	79	12	0	0	0
	Total	0	0	0	0	6	40	151	464	811	971	887	737	687	689	708	726	641	521	391	256	69	5
	1–4	0	0	2	4	6	24	78	118	150	163	174	136	143	135	153	126	43	5	0	0	0	0
	5–8	0	0	3	6	9	44	88	128	154	166	154	140	139	146	151	98	30	4	0	0	0	0
	9–12	0	0	0	3	6	11	45	94	120	126	115	111	98	100	97	116	128	128	102	51	9	0
Batman	13–16	0	0	0	0	3	5	8	32	83	129	127	110	98	100	85	84	100	109	122	157	98	10
	17–20	0	0	0	2	5	5	11	61	114	139	131	118	107	98	93	88	102	117	126	97	42	4
	21–24	0	0	0	5	5	7	43	107	134	148	146	141	120	108	118	133	139	87	18	1	0	0
	Total	0	0	5	20	34	96	273	540	755	871	847	756	705	687	697	645	542	450	368	306	149	14
	1–4	1	0	2	5	20	54	101	150	161	163	147	130	119	132	139	99	34	3	0	0	0	0
	5–8	0	3	3	8	21	61	102	153	150	146	136	116	118	124	122	100	66	29	2	0	0	0
	9–12	0	1	0	3	6	10	33	88	128	132	121	106	100	92	90	104	116	142	126	55	7	0
Diyarbakır	13–16	0	0	0	1	3	6	14	48	82	130	135	112	104	97	82	81	108	103	140	153	57	4
	17–20	0	0	1	4	5	12	44	96	124	138	122	113	104	92	89	92	105	117	112	74	15	1
	21–24	1	0	3	4	9	34	85	131	142	155	136	124	105	115	122	131	111	45	7	0	0	0
	Total	2	4	9	25	64	177	379	666	787	864	797	701	650	652	644	607	540	439	387	282	79	5
	1–4	0	0	0	1	7	28	86	154	195	170	146	130	140	157	168	72	6	0	0	0	0	0
	5–8	0	0	0	1	9	33	92	157	190	155	141	123	129	153	159	92	24	2	0	0	0	0
	9–12	0	0	0	0	0	3	18	71	130	149	135	115	105	91	100	134	153	156	84	16	0	0

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Table 7 (*continued*)

Province	Time	Temperature bin (°C)																					
		−21/−15	−18/−15	−15/−12	−12/−9	−9/−6	−6/−3	−3/0	0/3	3/6	6/9	9/12	12/15	15/18	18/21	21/24	24/27	27/30	30/33	33/36	36/39	39/42	42/45
Gaziantep	13–16	0	0	0	0	0	0	10	40	84	131	151	131	111	96	85	100	135	153	158	70	5	0
	17–20	0	0	0	0	1	5	28	85	142	172	144	115	101	97	116	140	143	111	51	9	0	0
	21–24	0	0	0	0	3	15	60	131	179	181	140	124	119	145	166	151	43	3	0	0	0	0
	Total	0	0	0	2	20	84	294	638	920	958	857	738	705	739	794	689	504	425	293	95	5	0
Kilis	1–4	0	0	0	0	0	4	22	77	165	210	163	134	144	201	235	88	14	3	0	0	0	0
	5–8	0	0	0	0	0	5	26	91	177	191	151	130	134	203	225	100	23	4	0	0	0	0
	9–12	0	0	0	0	0	1	6	31	95	161	157	129	109	98	114	157	183	142	65	11	1	0
	13–16	0	0	0	0	0	0	1	15	48	121	158	146	120	95	90	86	122	172	178	95	13	0
	17–20	0	0	0	0	0	0	8	29	89	173	176	127	108	105	111	150	165	129	69	19	2	0
	21–24	0	0	0	0	0	2	17	55	139	203	171	128	118	152	209	193	61	11	1	0	0	0
	Total	0	0	0	0	0	12	80	298	713	1059	976	794	733	854	984	774	568	461	313	125	16	0
Mardin	1–4	0	0	0	0	5	25	59	117	164	152	140	107	115	128	146	167	102	31	2	0	0	0
	5–8	0	0	0	0	5	28	64	127	160	148	134	110	112	131	144	161	99	34	3	0	0	0
	9–12	0	0	0	0	3	12	47	95	136	135	127	109	98	91	113	129	146	135	69	15	0	0
	13–16	0	0	0	0	1	6	30	77	120	135	133	109	103	84	84	105	125	150	142	53	3	0
	17–20	0	0	0	0	2	10	43	93	146	149	127	118	91	89	99	115	137	146	80	15	0	0
	21–24	0	0	0	1	3	18	54	104	155	151	137	111	101	108	129	155	154	70	9	0	0	0
	Total	0	0	0	1	19	99	297	613	881	870	798	664	620	631	715	832	763	566	305	83	3	0
Siirt	1–4	0	0	0	4	7	20	70	149	162	150	144	124	114	133	152	158	67	6	0	0	0	0
	5–8	0	0	1	2	9	26	86	152	157	149	133	117	115	130	150	138	74	20	1	0	0	0
	9–12	0	0	0	0	4	9	32	94	140	144	113	106	99	93	95	109	126	156	108	30	2	0
	13–16	0	0	0	0	2	5	14	53	104	149	130	112	104	90	90	85	107	126	157	113	19	0
	17–20	0	0	0	1	4	8	29	92	147	151	125	111	105	91	90	99	116	136	104	47	4	0
	21–24	0	0	0	3	4	11	50	130	159	147	137	115	107	108	128	151	148	58	4	0	0	0
	Total	0	0	1	10	30	79	281	670	869	890	782	685	644	645	705	740	638	502	374	190	25	0

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Table 7 (*continued*)

Province	Time	Temperature bin (°C)																				
		−21/−15	−18/−15	−15/−12	−12/−9	−9/−6	−6/−3	−3/0	0/3	3/6	6/9	9/12	12/15	15/18	18/21	21/24	24/27	27/30	30/33	33/36	36/39	39/42	42/45
Şanlıurfa	1–4	0	0	0	0	1	8	28	82	160	188	158	121	113	129	150	168	122	32	0	0	0	0
	5–8	0	0	0	0	1	9	36	96	172	180	145	116	112	134	162	158	99	36	4	0	0	0
	9–12	0	0	0	0	0	1	8	32	87	149	140	122	108	99	92	112	143	155	133	68	11	0
	13–16	0	0	0	0	0	0	1	16	43	100	147	135	116	105	93	82	100	136	152	156	73	5
	17–20	0	0	0	0	0	1	9	35	89	157	155	126	106	91	92	94	110	141	134	95	25	0
	21–24	0	0	0	0	0	4	17	62	136	177	157	129	102	104	123	142	164	116	26	1	0	0
	Total	0	0	0	0	2	23	99	323	687	951	902	749	657	662	712	756	738	616	449	320	109	5

the building, which affects the internal heat gains, indoor temperature, and the ventilation rate, or the balance-point temperature are sufficiently constant. However, for many applications, at least one of the above parameters varies with time. In such cases, the bin method can be used. This method is based on the calculation of the energy consumption for different values of the outdoor temperature and multiplying it by the corresponding number of hours (N_{bin}) in the temperature interval (bin) centred on that temperature [21,23]. The bin method can be used for predicting both heating and cooling energy requirements and it is more accurate than the degree-day method, since the bin method is based on hourly weather data rather than daily averages [30].

Based on the database shown in Table 1, bin data for dry-bulb temperature from −21 °C to 45 °C with 3 °C increments were calculated in six daily 4-h shifts (1–4, 5–8, 9–12, 13–16, 17–20 and 21–24 h) for the provinces covered by the GAP. The number of hours (N_{bin}) within each temperature interval (bin) was calculated separately for every month of the year. The calculations were performed separately for every year of the period considered. Averaging over the years considered, the numbers of hours were obtained for six separate time periods of the day for each month. Using these data, the monthly total and yearly total number of the hours were calculated.

Although bin data were calculated in this study for each month of the year for the provinces covered by the GAP, it is not practical to present them in this paper due to space limitations. Only yearly total bin values are presented. In Table 7, yearly total N_{bin} values for six separate time-periods of the day are given. Summing up the N_{bin} values for six separate time periods of the day produces the total number of hours within each temperature bin in a year. The results are given in the last row for the each province in Table 7. Analysis of the table reveals that the yearly total temperature bins observed in the region vary between −19.5 °C (−21 °C/−18 °C) and 43.5 °C (42 °C/45 °C). The maximum N_{bin} value occurs in 6/9 °C (7.5 °C) temperature bin and its frequency is 10.6% for the GAP region. As can be seen from Fig. 3, there are not significant differences between the provinces in terms of the yearly total temperature bins.

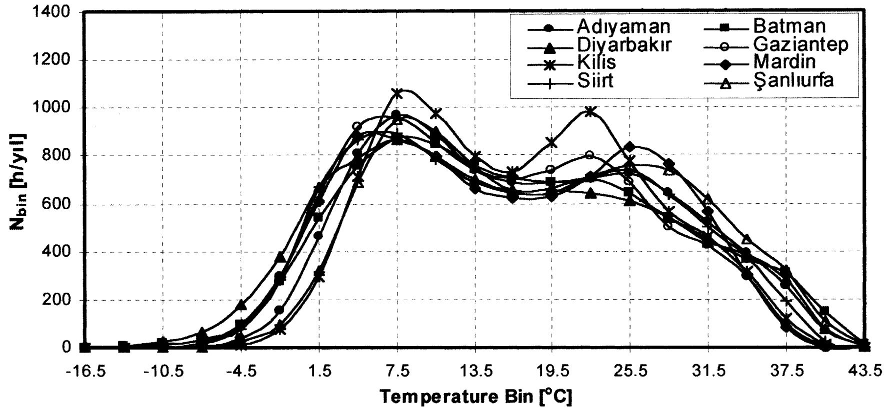

Fig. 3. Variation of yearly total bin data for the provinces in the GAP region.

5. Conclusion

Detailed weather data used in the heating and cooling load calculations and in energy estimating methods were determined for the cities (Gaziantep, Kilis, Şanlıurfa, Adıyaman, Diyarbakır, Batman, Siirt and Mardin) located in GAP region. New outdoor design the conditions were developed both for cooling and heating according to the format recommended by ASHRAE. The heating and cooling design data found in this study were compared with the existing design data. The comparison showed that the current design temperatures are generally stringent and provide total protection. Variable base degree-days were determined both for heating and cooling. It was seen that the differences between the degree-days for different provinces are not significant at the same base temperature. The bin data for dry-bulb temperature with 3 °C increments were calculated in six daily 4-h shifts. The most repeated temperature bin in the region is 6/9 °C.

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