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GENERATION AND VALIDATION OF TYPICAL METEOROLOGICAL YEAR (TMY) TO ANALYSIS THE PSYCHOMETRIC CHART TO EVALUATE THE THERMAL COMFORT CONDITIONS IN BUILDINGS (CASE STUDY: KERMANSHAH, IRAN)

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Statement of the problem. Exact selecting the climatic data is an important and infrastructure factor for computing and simulating the energy consumption in buildings. In this study by using Sandia method which is a statistical method, TMY sample data of weather as a climatic file of real measured data for a period of 10 years (2005 to 2015) were produced for synoptic aerology stations of Kermanshah airport. The data are generated by using the Meteonorm software in order to validation, and the results of Sandia and output data of this software has been compared with average values of real three main climatic data including temperature, relative humidity and wind direction in the period to prepare TMY.

Results. The results show that the Sandia method has better compliance with the actual data of synoptic aerology station of Kermanshah airport while the TMY data of Meteonorm software have not good agreement with data which obtained from the mean of whole period.

Conclusions. checking out the graph of thermal comfort (psychometric) from the output of climate consultant software for Kermanshah city that drawn by using the TMY prepared with Sandia methodin this reaserch, shows that 17 percent of the time in terms of thermal comfort has been established in the city of Kermanshah but the overall condition of climate is becoming warmer.

Keywords: thermal comfort, Typical Meteorological Year, building energy simulation, energy consumption.

Introduction. The existence of climate data of the study area with the maximum proximity rate to the climate reality of that area is one of the most important conditions of validity for any simulation in the field of building energy. Climatic conditions in outdoors throughout the year are an important part of desirable and intended data which is provided on an hourly basis for the whole year. To simulate the exchange of energy in buildings usually 10 to 13 climatic parameters (such as solar radiation, temperature, humidity rate and altitude, speed and direction of the wind and pressure) are needed. These climate data should not be on average per year or only for the part of year but also should be determined on a daily basis and for total 8760 hours of a year [3, 5, 6]. Several studies were conducted by the researchers to provide TMY data for different parts of the world. From 1970 to 1983, ASHRAE conducted three RP projects 100, 239 and 364 for providing weather data and provided the new plan called TRE; these data in simulation are known as WYEC and have the same format to TRE. The difference between them is that the solar radiation data (measure or calculate on the basis of cloud and its type) are also available in the new one. In early 1990, ASHRAE updated WYEC data and presented its new version that has the TMY format and also calculated data of brightness. The next updates are involved to calculate radiation data. The updated version of the WYEC is known as WYEC 2 (version 2) and 77 versions have created until now. In 1997, ASHRAE made another project called RP to develop worldly WYEC; this project has been completed in 2001 and its weather data were obtained for 227 stations in America and Europe [1, 2]. The type of data file in different softwares of course is different. For example, the Plus Energy Program data accepts input data in the form of EPW [4]. Some of the most important formats used in simulation programs include: TMY, TRY, DET. Thus, preparation of climatic data banks in different cities of Iran seems necessary for accurate estimation of energy consumption in buildings. In this study, weather data generated and compared with the format of TMY by Sandia method and Meteonorm software in Kermanshah city. According to the actual average data of the synoptic stations in Kermanshah for a 10-years statistical period (2005—2015), results were compared with the real data mean of three main parameters including drying temperature, relative humidity and wind direction, and the above TMY file have been validated.

1. Introducing the case study. Kermanshah city with a height of 1318.6 meters above sea level is located at 34 degrees, 23 minutes northern latitude and 47 degrees eastern longitude in the center of Kermanshah province and it is known as the center of Kermanshah province. Kermanshah is located in West of Iran and it neighbors from the north with Kurdistan province, from the East with Hamadan province, from the South and the South-East with Ilam and Lorestan provinces, and from the West with Iraq. A climatic region of Kermanshah is classified into cold and mountainous according to Kasmaee and his colleagues' climate division. The average annual temperature and precipitation of Kermanshah is 14.3 °C and 445 mm respectively Fig. 1 shows the location of the study area in Iran.

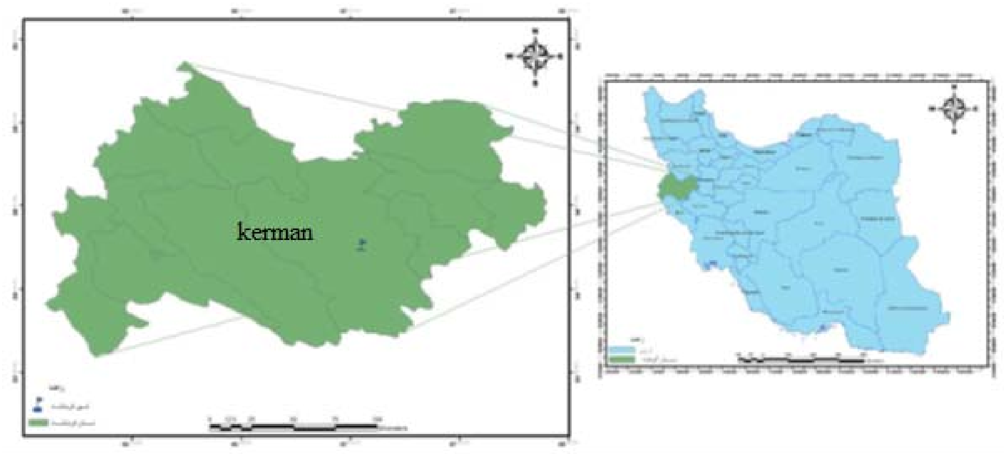

Fig. 1. The location of the study area in Iran

2. Sandia method. Some comprehensive information on meteorological data of the study area should collect before any software simulation in the field of energy. These data must be prepared and processed hourly in the whole of year in order to increase the accuracy and reliability of any simulation. To simulate building energy usually nine to thirteen climatic parameters such as temperature, humidity, solar radiation, barometric pressure, wind speed and direction and altitude and etc. are more important; these data should not be determined for a part of the year or as an annual average but must daily and for total 8760 hours a year [14].

The measured data for each of the months is selected out of the measured data in a few years (the statistical period). For each 12 months of the statistical year, five main climatic characteristics are selected by studying measured data which are: total solar radiation, solar direct radiation, dry air temperature, dew point temperature or (relative humidity) for availability as well as wind speed. The correct selection of these data is critical for the accuracy of TMY file. Statistical monthly average can be also used for other required data [7, 8, 9, 10, 11, 12].

Sandia method usually is used to provide the required data for the TMY files from the measured climatic data. Sandia is experimental method which selects the data for each of the year months from the measured data in several years [16, 17]. For example, if 30-years data are available for June, all information will compared by using a statistical method and the data for a month out of the entire period is selected as data for June to create TMY file, and it goes on for other months. Since it is possible that data related to different years is used to create TMY, between two consecutive months which have been selected from different years, matching process is conducted for 6 hours from each side. In Sandia method, each of the months of the year is selected on the basis of the 9 daily parameters (maximum, minimum and average of air temperature, dew point temperature, maximum and average of wind speed and the total amount of radiation received by a horizontal plane). The procedure steps will explain in the following: The first step: for each of the months of the year, five months are selected out of the statistics of the long-term period years (e.g. 30 years) in which cumulative distribution function of their daily indexes is closer to the cumulative distribution function of the intended month in the statistical long-term period. For each month of the statistical long-term period, cumulative distribution function is calculated on a daily basis for each of the above nine parameters as well as for the entire period. The method of calculating the cumulative distribution function is as follows:

$$S_N(x) = \begin{cases} 0 & x < x_1 \\ (k - 0.5)/n\ , & x_i \le x \le \ x_{1+1}, \\ 1 & x \ge x_n \end{cases}$$

where X variable of climatic data (nine data), *Sn* (X) the value of cumulative distribution function for the x variable, n number of elements and k is equal to 1, 2, 3, ..., n – 1 (cumulative distribution function value is between 0 and 1). Comparing the cumulative distribution functions of selected months and statistical long-term period is done by using FS[2] statistical method. The selection is the results of other steps which are described below. It should be noted that since some indicators are more important than others, the weight factor (ws) is used in FS method to select the five months and we have:

$$\{FS = (1/n) \textstyle\sum_{i=0}^{n} \delta_i\}.$$

Where δ_i is absolute value of the difference between the total cumulative distribution function and cumulative distribution function of the period for x_i parameter in one day and n is the number of days in the month. So the FS value is calculated for each month of different years by this equation.

The second step: since some indicators are more important than others, the weight factor (ws) is used as follows:

$$\{WS = \textstyle\sum w_i FS_i\},$$

where w_i and i are weight factor for the parameter and index for nine parameters respectively.

Now, for every month from different years, the month which has the lowest WS select as elected month (five months) to compare.

The third step: five selected months are sorting depending on how close (compliance) to the GPA and average of statistical long-term period.

The fourth step: the durability of two parameters of drying temperature average and approved energy on horizontal surfaces is evaluated based on how much higher or lower the percentage of their repeat and adaptation is, in comparison of the percentage of statistical long-term period. For the dry temperature daily average, repeat and adaptation of hot consecutive days and cold consecutive days are determined more than 67 percent and less than 33 % respectively. For approved energy on horizontal surfaces, repeat and adaptation is determined less than 33 % (consecutive days with low solar energy). Determined percentages is used for selecting the most appropriate years out of the five years (for the month statistics) to use in TMY file (above percentages is related to Sandia method). The statistics of month in a year which has the closest percentage to durability factor based on the obtained results in the Phase 2, are selected as useable statistics in TMY file. For example, this part can be summarized as follows for the average of daily dry temperature.

a) All of the data for daily average dry temperature per month as a long-term statistical period (for all of the period, for example, for ten years) sorted, and 0 and 100 is advocated to the minimum and the maximum value respectively.

b) The data of daily average dry temperature per month of the five selected years compared with the long-term statistical period, and the its location into the long-term statistical period and thus its percentage was determined; If its value will greater than 67 or less than 33 %, it gets the number 1, otherwise zero is advocated.

c) Part b is conducted for all of the data in each month (the average of daily dry temperature) in order to the number of days, and the total amount of per month is achieved 1. Now, the month out of total period which has more number 1, was been used in TMY.

The fifth step: To complete the annual statistics of each of the parameters, the 12-month statistics which determined as above connect to each other. For this purpose, after the selection of 12 months, unification is done between different months for 6 hours by using curve fitting.

The weight coefficients for each data have an important role for selecting data of TMY file. Weight coefficients represent the degree of importance and sensitivity of any of the data for selecting TMY data. Weight coefficient of Sandia method is given in the table 1.

Table 1

The weight coefficients of Sandia method

Aerial parameter name	The weight coefficient value of the Sandia method
The maximum of drying temperature	1.24
The minimum of drying temperature	1.24
The average of drying temperature	2.24
The maximum of dew point temperature	1.24
The minimum of dew point temperature	1.24
The average of dew point temperature	2.24
The maximum of wind speed	2.24
The average of wind speed	2.24
The total radiation	12.24
The total perpendicular radiation	—

The fitted curve is used for two months which were selected out of the different year, for six hours on each side of the data including dry air temperature, dew point temperature (or percentage of moisture), wind speed, wind direction, atmospheric pressure, water content percentage in the air. The moisture percentage can be calculated by the equations after calculation of the dry air and dew temperature.

The measured data may not be reported for some months and hours. Thus, these unreported data should be calculated and updated when choosing the TMY data [15]. In this study, we used the following method to correct them, Unreported value = (the value of three hours later + the value of three hours ago)/2.

3. Providing TMY file for the city of Kermanshah. As we said, the data of dry air temperature, relative humidity, total radiation and direct radiation as hourly, and wind speed and direction as every three hours recorded in order of importance is required to provide TMY file for Kermanshah based on Sandia method. Therefore, the above statistics profile was related to statistical period (2005—2015) of Kermanshah airport synoptic station of which was measured for every three hours in the day, also measured data of total radiation on the same period which is as daily average (measured in watts per square meter of horizontal plane) were collected from this station [18, 19, 20, 21]. Since hourly data must be available for the preparation of the TMY file by the above method, the following measured data placed in Excel software as hourly in the TMY file by using interpolation [22]:

a) dry air temperature, b) relative humidity, c) Total radiation, d) Direct radiation.

According to that collected data of radiation for above statistics period was related to total radiation and also obtained as daily average in Kermanshah meteorological station, and the amount of direct and scattered radiation received on the surface is not available, therefore, Watanabe or other valid methods can be used to calculate these values. In this study due to the unavailability of direct and scattered radiation values, Watanabe method — which was provided for Japan climates — has been used to calculate these data [24]. To validate the calculations, actual total radiation amounts collected by Pyranometer of Kermanshah meteorological station were compared with total radiation values estimated by Watanabe method. It should be noted that according to extensive studies conducted by Iranian researchers in this field, direct radiation value calculated by this method are compared to measured results of other Iran cities, and satisfactory results have been obtained.

In this study, according to that the measured data of total radiation received by the horizontal surface is available as daily average; these data were converted to hourly radiation data by using the following method.

a) Calculating the amount of radiation received to the surface from the perpendicular direction (Gen) as hourly. Following equation is used to calculate the amount of radiation received to the surface from the perpendicular direction on a daily basis:

$$G_{en} = G_{sc}(1.00011 + 0.034221 Cos B + 0.00128 Sin B + 0.000719 Cos 2B + 0.000077 Sin 2B),$$

$$B = 6.283185 \frac{n-1}{365},$$

where G_{sc} is solar constant and equal to 1367W / m2 (n is the number of days from the January first).

b) Solar radiation received to horizontal surface outside the atmosphere (Geh)Geh is calculated by using the zenith angle (θz) and the following equation: { $G_{eh} = G_{en} Cos\theta_z$ }.

The zenith angle is the angle between the sun rays and perpendicular to the horizon in radians which is calculated by using the following equation (by spherical trigonometry in degree):

$$Cos\theta_z = Sin\delta Sin\varphi + Cos\,\delta Cos\varphi Cos\omega.$$

∅, δ and ω are latitude, deviation angle and hour angle respectively.

c) Total solar radiation received on a horizontal surface on Earth (Gh).

To calculate the Gh, first, the actual amount of the monthly clearance coefficient is calculated by having actual measured data for solar radiation from meteorological station. The hourly clearance coefficient is calculated with the actual amount of monthly clearance coefficient, by using Duffie method that will explain in the following [13], then by having the clearance coefficient, the amount of solar radiation received on a horizontal surface is calculated on an hourly basis. It should be noted that there is a need for total solar radiation on a horizontal surface per day in the Sandia method for the each year of the entire statistical period. So the daily total amount of solar radiation received on a horizontal surface is calculated for each year by using monthly radiation data and Duffie method, and Sandia method is used to select the appropriate month. After the selection of appropriate month, solar radiation received on surface is selected by Sandia method and placed to the TMY data as hourly form. Air clearance coefficient in any point of the earth with the given latitude and longitude is as the ratio of intake energy by the horizontal plane at the same point during a given time (daily, monthly or hourly) to the amount of radiation received on the same horizontal plane during at the same time, if the point is located outside the Earth's atmosphere. Air clearance coefficient can be calculated for any day, hour or month:

$$\{K_{th} = \frac{G_h}{G_{eh}}\}.$$

In this equation, G_h and G_{eh} are the total radiation received on the Earth's horizontal surface and the total radiation received on the horizontal surface outside the Earth's atmosphere, respectively. If the air clearance coefficient and G_{eh} calculate correctly, it can be said that the amount of radiation received on the horizontal surface at Earth will also calculate correctly. Duffie in 1980 had offered following equation to calculate the hourly amount of the clearance coefficient from its monthly amount.

$$K_{th} = \left[a + bCos\frac{\pi}{12}(h - 12)\right] K_{tm},$$
$$a = 0.409 + 0.5016Sin(\omega_s - 60),$$
$$b = 0.06609 - 0.4767Sin(\omega_s - 60).$$

H and ωs represent time in hours and the hour angle for sunrise or sunset, respectively (in this equation (ωs – 60) must be converted to radians).

d) Solar direct radiation received on the surface in the perpendicular direction at the earth surface (G_{bn}).

If the value of direct radiation on a horizontal plane is determined, Gbn is calculated by using the following equation:

$$\{G_{bh} = G_{bn}Cos\theta_z\}.$$

In this equation, the zenith angle is in radians. If the value of direct and scattered radiation received on the horizontal surface is not available, Watanabe method or other valid methods can be used to calculate it. In this study due to the unavailability of direct and scattered radiation, Watanabe method — which is provided for Japan climates — has been used to calculate these data. In extensive studies that have been done in this field as well as previous studies of some researchers, calculated Gh amount by this method and measured results for different cities of Iran were compared and satisfactory results have been obtained. In comparative chart 1—4, values of the total radiation calculated based on Watanabe method are compared with the actual total radiation statistics of Pyranometer at Kermanshah airport station for the period (2005—2015), and as indicated in the chart, it shows good agreement with the actual statistics especially in the second half of the year.

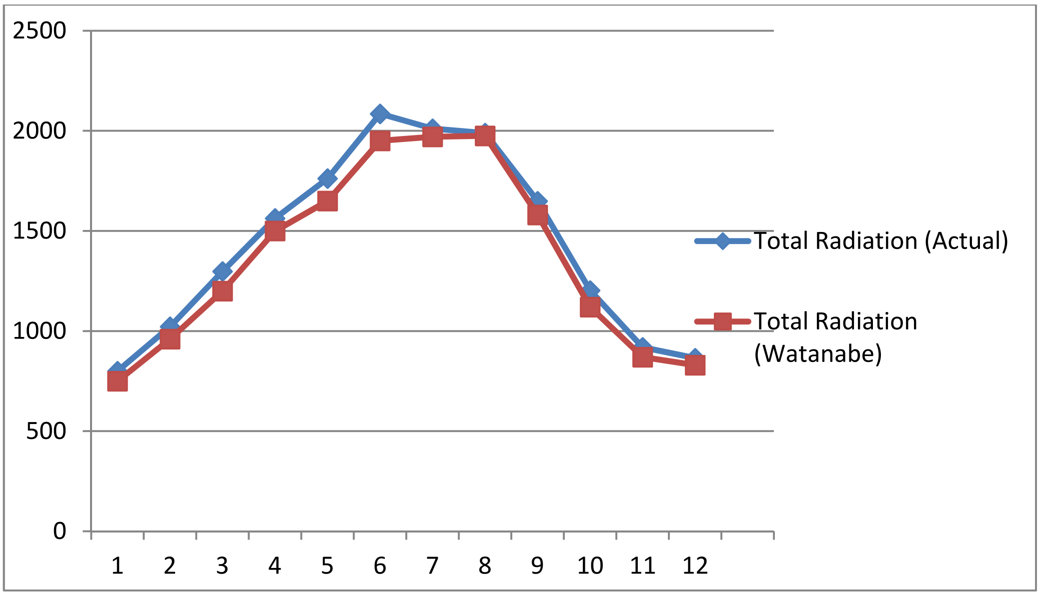

Chart. 1. Comparative chart of total radiation (in watts per square meter) based on the actual statistics of Pyranometer Kermanshah airport aerology station and total calculated radiation based on Watanabe method during (2005—2015)

In this part, the direct radiation is calculated by using Watanabe method and the following formula in (W/m2).

$$K_{rc} = 0.4268 + 0.1934 Sin\alpha_s,$$

$$K_{DS} = K_{th} - (1.107 + 0.03569 Sin\alpha_s + 1.681 Sin^2\alpha_s)(1 - K_{th})^2, \quad If\ K_{th} \geq K_{rc},$$

$$K_{DS} = (3.9963.862 Sin\alpha_s + 1.54 Sin^2\alpha_s) K_{th}{}^3, \quad If\ K_{th} < K_{TC},$$

$$G_{bh} = G_{en} K_{DC} \frac{1 - K_{th}}{1 - K_{DC}} Sin\alpha_s.$$

G_{bh} direct radiation, K_{th} air clearance coefficient as hourly and α_s is pitch angle in radians.

e) Solar scattered radiation received on a horizontal plane on the earth (G_{dh}). The scattered radiation rate in Watanabe method is calculated by the following formula in (W/m2) G_{bh} direct radiation, K_{th} air clearance coefficient as hourly and α_s is pitch angle in radians. As mentioned before, the data about the wind direction and speed during the period (2005—2015) in Kermanshah aerology station were placed into TMY file every three hours.

4. Validation of climatic factors in Kermanshah according to TMY file. In this section, first, the TMY file for Kermanshah was produced by using the Meteonorm software [23] to check validation of TMY file which provided in the previous step by Sandia method, then the profile of above TMY file outputs under the Climate Consultant software were compared with TMY outputs provided in this thesis by Sandia method both of which have the same period (2005—2015). The results of the three main parameters including dry air temperature, relative humidity and wind direction were compared with actual profile of the above three parameters in Kermanshah aerology station; thus the rate of closeness to actual statistics indicates the validation of each of the relevant TMY files.

Table 2

Summary of weather data in Kermanshah on the basis of TMY file provided by Sandia

WEATHER DATA SUMMARY

LOCATION: Kermanshah-IRIMO-station-40766, Kermanshah, Islamic Republic of Iran
Latitude/Longitude: 34.31° North, 47.07° East, Time Zone from Greenwich 3
Data Source: IRIMO-40766 40766 WMO Station Number, Elevation 1311 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	341	385	361	566	577	576	513	501	494	400	362	331	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	617	568	360	679	624	648	509	536	617	548	656	639	Wh/sq.m
Diffuse Radiation (Avg Hourly)	83	106	150	121	137	122	147	133	115	109	83	84	Wh/sq.m
Global Horiz Radiation (Max Hourly)	664	766	919	1024	1037	1036	1011	961	912	820	712	605	Wh/sq.m
Direct Normal Radiation (Max Hourly)	967	984	1014	962	921	931	913	894	932	968	984	952	Wh/sq.m
Diffuse Radiation (Max Hourly)	266	369	544	426	446	457	432	416	386	492	303	296	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	3412	4121	4272	7310	7975	8217	7200	6631	6035	4453	3703	3234	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	6182	6047	4251	8757	8625	9242	7144	7089	7524	6091	6701	6227	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	835	1151	1775	1561	1898	1740	2062	1775	1412	1211	845	824	Wh/sq.m
Global Horiz Illumination (Avg Hourly)	36243	41322	39608	60848	62019	61644	55404	54132	53204	43217	38495	35154	lux
Direct Normal Illumination (Avg Hourly)	56712	54007	34565	66039	61165	63036	49956	52672	59677	52111	60274	57696	lux
Dry Bulb Temperature (Avg Monthly)	2	4	9	14	19	26	29	28	23	17	9	4	degrees C
Dew Point Temperature (Avg Monthly)	-3	-1	0	3	4	0	0	0	-1	0	1	-2	degrees C
Relative Humidity (Avg Monthly)	67	62	49	50	40	19	15	15	19	33	60	59	percent
Wind Direction (Monthly Mode)	130	120	140	110	180	240	220	230	240	80	80	80	degrees
Wind Speed (Avg Monthly)	2	2	3	3	3	3	3	2	2	2	1	1	m/s
Ground Temperature (Avg Monthly of 3 Depths)	16	15	15	17	21	25	28	29	28	26	22	19	degrees C

Table 3

Summary of weather data in Kermanshah based on TMY file provided by using the Meteonorm software

WEATHER DATA SUMMARY

LOCATION: Kermanshah, -, -
Latitude/Longitude: 34.317° North, 47.117° East, Time Zone from Greenwich 3
Data Source: MN7 407660 WMO Station Number, Elevation 1322 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	292	359	399	452	510	558	537	545	493	399	327	287	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	430	460	410	444	497	605	551	596	604	537	467	489	Wh/sq.m
Diffuse Radiation (Avg Hourly)	106	127	156	163	166	134	154	131	117	112	106	85	Wh/sq.m
Global Horiz Radiation (Max Hourly)	668	836	976	1093	1120	1071	1063	1032	1018	833	748	616	Wh/sq.m
Direct Normal Radiation (Max Hourly)	987	1010	1004	1004	1023	984	982	1003	1019	1000	1007	984	Wh/sq.m
Diffuse Radiation (Max Hourly)	291	388	416	443	504	470	471	451	414	384	302	256	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	2912	3843	4720	5819	7059	7964	7537	7218	6038	4427	3344	2805	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	4287	4908	4828	5707	6870	8635	7743	7882	7389	5941	4781	4777	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	1065	1371	1852	2104	2296	1914	2163	1748	1436	1251	1087	834	Wh/sq.m
Global Horiz Illumination (Avg Hourly)	31376	38489	43023	48903	55264	60072	58200	58875	53047	43305	35521	31025	lux
Direct Normal Illumination (Avg Hourly)	39487	43010	38347	42083	47455	58652	52867	58193	58558	51607	43967	45354	lux
Dry Bulb Temperature (Avg Monthly)	1	4	9	13	19	25	29	29	23	17	9	4	degrees C
Dew Point Temperature (Avg Monthly)	-3	-3	-2	3	4	1	4	3	-2	0	0	-1	degrees C
Relative Humidity (Avg Monthly)	67	57	45	52	39	23	22	21	21	34	56	66	percent
Wind Direction (Monthly Mode)	220	200	210	210	200	290	210	260	240	200	110	290	degrees
Wind Speed (Avg Monthly)	2	2	3	3	2	2	2	2	2	2	1	1	m/s
Ground Temperature (Avg Monthly of 1 Depths)	12	9	8	9	12	15	19	22	23	22	19	15	degrees C

Tables 2 and table 3 shows the summary of weather data in Kermanshah airport aerology station during the period (2005—2015) according to the TMY file provided by Sandia and based on TMY file provided by using the Meteonorm software based on output of climate consultant software, respectively.

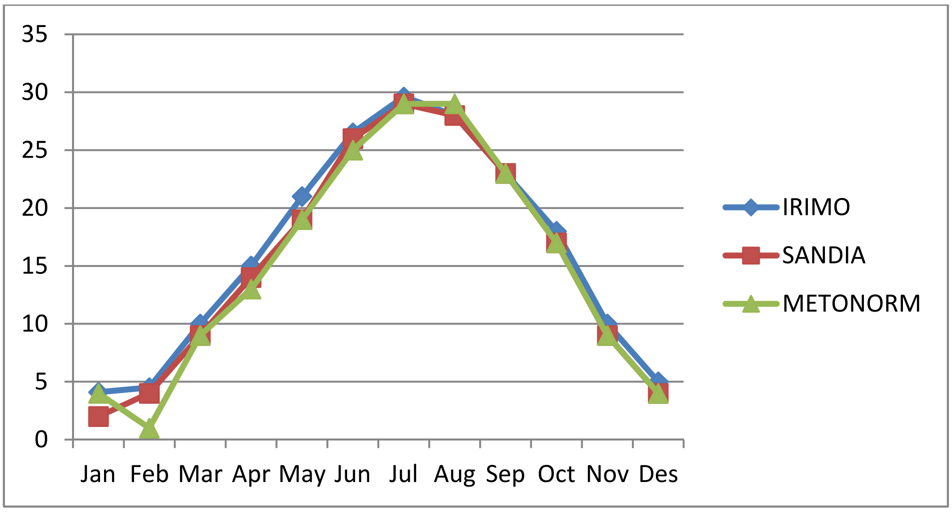

Chart. 2. Comparative chart of monthly average of dry temperature from output of Sandia, Meteonorm and actual statistics of Kermanshah weather station during (2005—2015)

To validate the TMY file provided by Sandia method in this thesis, three main parameters including dry air temperature, relative humidity and wind speed and direction of each of TMY files which presented as monthly average were compared with actual monthly average of above three parameters statistics during the same period in Kermanshah aerology station, and the results can be verified in comparative diagrams of 2 and 3 and 4.

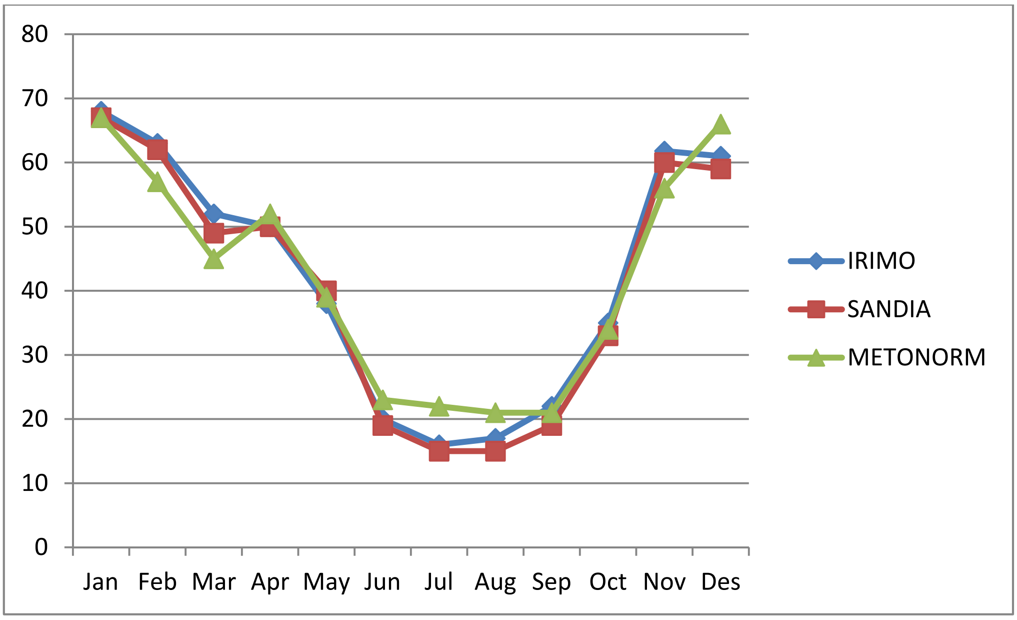

Chart. 3. Comparative chart of monthly average of relative humidity from output of Sandia, Meteonorm and actual statistics of Kermanshah weather station during (2005—2015)

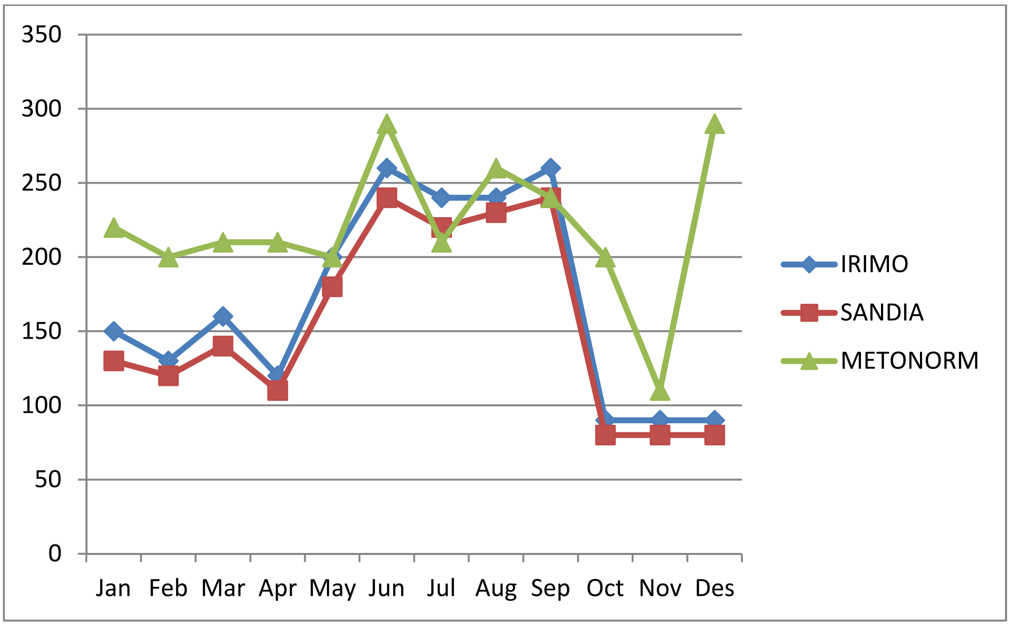

Chart. 4. Comparative chart of monthly average of wind direction from output of Sandia, Meteonorm and actual statistics of Kermanshah weather station during (2005—2015)

As it is clear in comparative charts of 2, 3 and 4, most conformity of three main parameters of TMY file with actual statistics of Kermanshah weather station during the period (2015—2005) has been observed in outputs of TMY file provided by Sandia in the study, this suggests the accuracy of the method for providing the file and its credit.

5. Analysis of Bioclimatic (psychometric) graph for Kermanshah City. There is need to draw the data about temperature, the monthly minimum and maximum of relative humidity on the graph because of selecting the building bioclimatic comfort criteria for analyzing the weather state of site. For this purpose, the temperature and humidity of hottest and coldest time of a day of each month is determined on the graph. The connection of two points, by a straight line, that is related to the day and night condition of each month shows the situation of the month on the *Givoni* building bioclimatic criteria. Crossing the line from different parts of the graph represents the all-day conditions of the month. Obviously, in situations where there is a short line and passes through fewer regions, it represents the thermal conditions fixity in a day. In contrast, the long line and passing through different parts of the graph represents the diversity of thermal conditions during a day and night and consequently there is a need to various spaces with different micro-climates to accommodate climatic conditions.

Chart 5 shows the building bioclimatic (psychometric) graph of Kermanshah weather station based on TMY file provided in previous steps and by using graphic outputs of climate consultant software. As mentioned in the previous sections, the data of Kermanshah synoptic station including dry temperature, relative humidity, total and direct solar radiation, and wind direction and speed were been used as hourly form and over the period of 10 years (2005—2015); After converting the above data to TMY file by Sandia method and the validation in the previous steps, in this section, climatic parameters listed in the climate consultant software extracted graphically, and then analyzed and compared with other available climate indicators such as *Givoni* thermal comfort models according to the country climatic zoning studies to specify the variation of climatic trends and thermal comfort requirements in Kermanshah than previous studies. According to the results obtained in psychometric charts in Kermanshah, generally comfort conditions have not significant difference compared to other models such as *Givoni* model which prepared based on the country climatic zoning map shown in the chart 5, and as it can be seen in the chart, thermal comfort conditions are established in the city of Kermanshah more than 17 % of the year. But just partially in January, at days the use of active solar systems and at night the use of heaters and exothermic mechanical systems is required to provide comfort within building. In February and December, at days for a sense of comfort the use of passive solar systems is needed, also at nights of these months Kermanshah is seen in the area of conventional heating where there is a need to use heaters. In March, April and November, during the day internal heat and at night using a conventional heating system for April and active solar systems for the March and November provides comfort conditions inside the building. In May and October, comfort conditions are provided in the natural way, at night the use of passive solar systems is effective (the use of capacitor materials and solar spaces based on the received solar radiation and absorb and store heat in the building during the day, and excrete the heat into inside at night). June, July, August and September are the warmest period in the city of Kermanshah and in these months due to high temperature, the relative humidity is low thus thermal comfort conditions is not desirable, and a sense of comfort in buildings is require to supply humidity inside the buildings which this can be done by the water cooler; also indoor air can be in the comfort zone by using suitable construction material properties to the climatic conditions, therefore, we should prevent the entry of hot air into the building by selecting and using heavy and heat-resistant materials which have the maximum delay time as well. In September, the use of passive solar system is also useful at night.

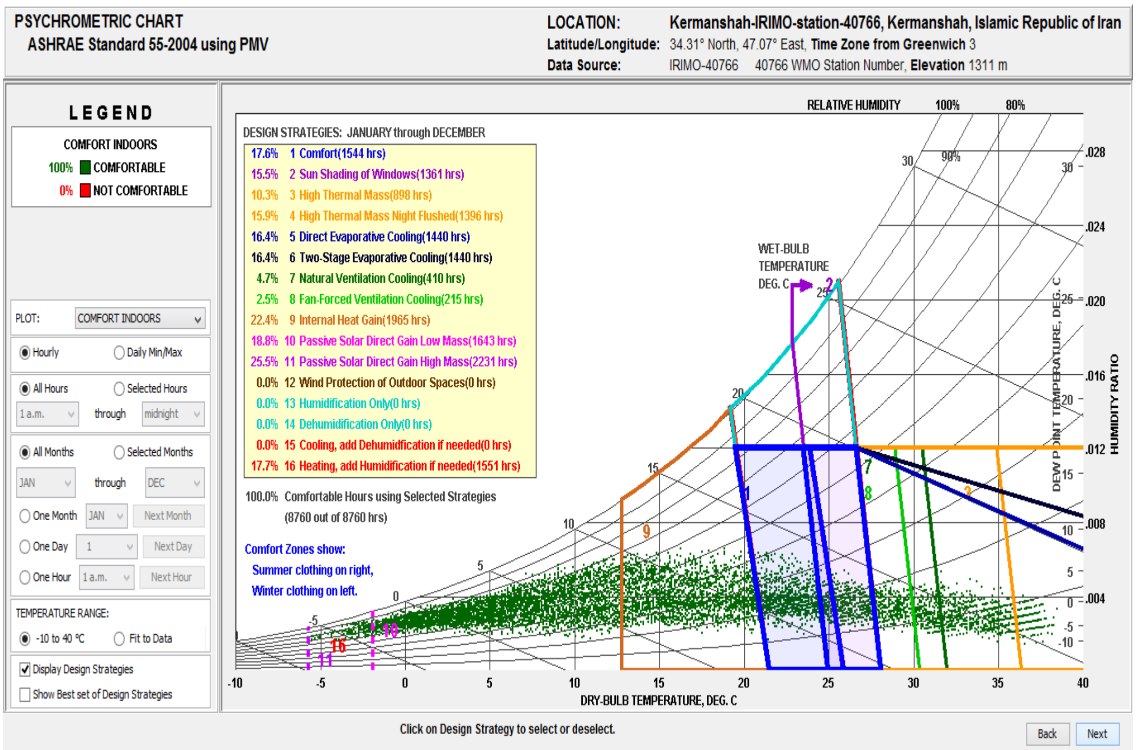

Chart. 5. Bioclimatic chart (psychometric) of Kermanshah based on the Kermanshah TMY file from the graphical outputs of climate consultant software

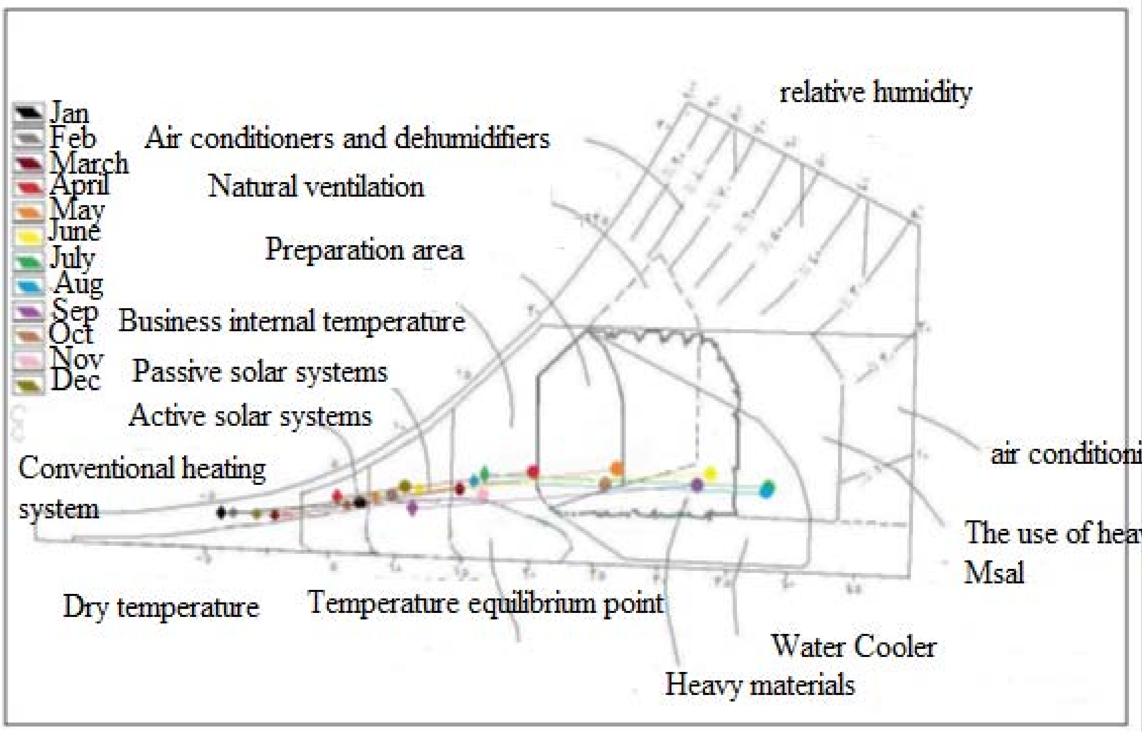

Chart. 6. Building bioclimatic chart of Kermanshah by using Givoni method from Iran climatic zoning (housing and residential environments)

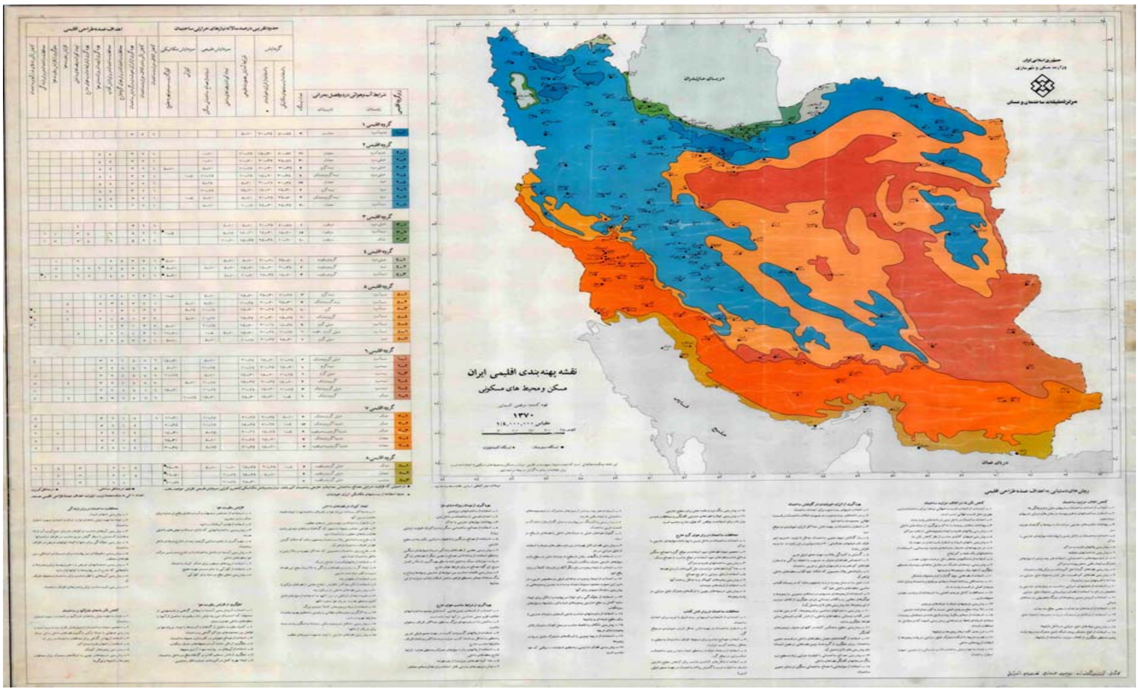

Fig. 2. Iran climatic zoning (housing and residential environment)

6. Conclusion. Table 4 compares bioclimatic chart of Kermanshah based on the country climatic zoning studies during the period (1966—1982) with psychometrics chart of Kermanshah in accordance with TMY file provided in Kermanshah aerology station at previous steps and graphic output of climate consultant software during the period (2005—2015). This means that first it determined the range of time when comfort conditions have been established in the natural way or by using heating or cooling systems on the basis of climatic zoning map. Then we addressed to complete this information by using psychometric table of climate consultant software which was set for all months of the year. The sum of the maximum predicted values in the above charts is shown at the rows of the table. As it is clear according to the values, generally, despite an increase in the comfort conditions range in the city of Kermanshah in recent years, the need for mechanical heating and mechanical cooling are reduced and increased, respectively which represents that Kermanshah becomes warmer than previous years.

Table 4

Comparing the range of heat required in Kermanshah based on two climatic zoning maps (Givony chart) and psychometric chart based on the TMY file

Title			Climatic zoning map (*Givoni* chart)(Percent)	TMY file (Percent)
Comfort conditions as naturally			5—10	17.6
Heating	Mechanical systems		35—40	17.7
	Solar Energy		20—25	22.4
Cooling	Natural	Creating the storm at indoors	—	4.7
		The use of heavy construction materials	5—10	10.3
	Mechanical	Water Cooler	0—5	16.4
		Air-conditioners	—	—
Total Including overlapping			90	89.1

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