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A method for generation of typical meteorological year

Abdulsalam Ebrahimpour [a,*], Mehdi Maerefat [b]

[a] Departament of Mechanical Engineering, Science and Research Branch, Islamic Azad University, Tehran, P.O. Box 14515-775, Iran
[b] Departament of Mechanical Engineering, Tarbiat Modares University, Tehran, P.O. Box 14115-111, Iran

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A B S T R A C T

The correct selecting of typical meteorological year is an important factor for accurate building energy simulation. In this study, the Sandia method has been applied to analyze the measured weather data of a 14-year period (1992–2005) in Bandarabass and to select the proper data for the typical meteorological year. Also, typical meteorological year has been generated by using Meteonorm and Weathergenrator softwares. Then the results of Sandia method and the two mentioned softwares have been compared with long-term average measured data for main parameters in the weather data file. Finally, those results which have the minimum difference in every month with the long-term average measured data and have best meet the persistence criterion of Hall's have been used to select the typical meteorological year. It is found that, the results of Sandia method and Meteonorm software have good agreement with the long-term average measured data during the year and have best meet with the persistence criterion of the Hall's.

1. Introduction

The information about weather data, HVAC systems, equipments and temperature control system are the important parameters necessary for building energy simulation. The weather data is the most important factor. The hourly amounts of about 10–13 meteorological parameters such as solar radiation, dry bulb temperature, relative humidity, wind speed, atmospheric pressure and etc. are usually needed for energy simulation.

Many methods have been suggested to provide the typical meteorological year. Typical meteorological year has been presented in different types for examples TMY2 (NREL 1995) and WYEC2 (ASHRAE 1997) in the United States and Canada and TRY (CEC 1985) in the Europe. The TMY2 and WYEC2 typical weather years contain more solar radiation and illumination data than older formats such as TMY (NCDC 1983), WYEC (ASHRAE 1985) and TRY (NCDC 1981).

From 1970 to 1983, Ashrae commissioned three research projects to represent weather year data for energy calculations (WYEC), which used the TRY format but included solar data (measured data, if available or calculated based on cloud cover and type). In the early 1990s, Ashrae began to update the WYEC data set. New WYEC data sets were listed in TMY format, and calculated hourly illuminance data, data quality as well as source flags, were included. Other major changes included updating the calculated solar radiation data and adjusting the data from solar time to local time. The updated WYEC data sets were known as WYEC2 [1].

Typical meteorological year has been obtained in various types and for different cities in the earth's surface which some investigations in this field have been briefly discussed. Chan et al. [2] reviewed various types of typical weather data sets in a paper and then the Finkelstein–Schafer statistical method applied to analyze the hourly measured weather data of a 25-year period (1979–2003) in Hong Kong. Kalogirou [3] presented the generation of a type two typical meteorological year (TMY2) for Nicosia, Cyprus. Also, Lam et al. [4], Zhang et al. [5] and Anderson et al. [6] in the different researches, provided the various typical meteorological years based on different year periods and in many places of the Earth's surface.

In spite of this fact, the majority energy simulation softwares use typical meteorological year, so the exact values are necessary in order to correct estimation of the building energy consumption at the year. In this study, the Sandia method [7] has been used to analyze the measured weather data of a 14-year period (1992–2005) in Bandarabass, and to select typical meteorological year. Also, typical meteorological year has been generated using Meteonorm [8] and Weathergenrator [9] softwares and then the results of Sandia method and the two mentioned softwares have been compared with long-term average measured data for main parameters in the weather data file. Finally, those results which have the minimum difference in every month with long-term average measured data and have best meet the persistence criterion of the Hall's have been used to select the typical meteorological year. So, the TMY months have been selected a mixture of

* Corresponding author.
E-mail address: salam_ebr@yahoo.com (A. Ebrahimpour).

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Nomenclature

E	equation of time, min
G	irradiance, W/m^2
m	day number of year
t	time, h
B	day angle,°
x	parameter (such as mean dry bulb temperature)
n	the number of daily readings in a month
CDF	cumulative distribution functions
FS	Finkelstein–Schafer parameter
w_i	weighting for index
k_t	hourly clearance index
Greek symbols	
α_s	solar altitude,°
δ	declination angle,°
T_z	time zone, h
φ	latitude angle,°
L	longitude angle,°
ω	hour angle,°
θ_z	zenith angle,°
Subscripts	
b	beam, beam horizontal
bn	direct normal
d	diffuse, diffuse horizontal
t	total global, horizontal
o	total extraterrestrial, horizontal
on	direct normal extraterrestrial
sc	solar constant, 1367 W/m^2
h	hourly
d	daily
m	monthly

months from the Sandia method and the results of applying the two softwares.

2. Sandia method

The Sandia method is an empirical approach that selects individual months from different years of the period of record. For example, in the case that contains 30 years of data, all 30 Januarys are examined and the one judged most typical is selected to be included in the TMY. The other months of the year are treated in a similar manner, and then the 12 selected typical months are concatenated to form a complete year. Because adjacent months in the TMY may be selected from different years, discontinuities at the month interfaces are smoothed for 6 h on each side. The Sandia method selects a typical month based on nine daily indices consisting of the maximum, minimum, and means dry bulb and dew point temperatures; the maximum and mean wind velocity; and the total global horizontal solar radiation. For each month of the calendar year, five candidate months with cumulative distribution functions (*CDFs*) for the daily indices that are the closest to the long-term *CDFs* are selected. The *CDF* gives the proportion of values that are less than or equal to a specified value of an index. Candidate monthly *CDFs* are compared to the long-term *CDFs* by using the following Finkelstein–Schafer (*FS*) statistics for each index.

$$FS = (1/n)\sum_{i=1}^{n}\delta_i \tag{1}$$

where, δ_i is absolute difference between the long-term *CDF* and the candidate month *CDF* at x_i and n is the number of daily readings in a month.

Because some of the indices are judged more important than others, a weighted sum (*WS*) of the *FS* statistics is used to select the five candidate months that have the lowest weighted sums. The weighting factors listed in Table 1 for TMY type.

$$WS = \sum w_i FS_i \tag{2}$$

where w_i is weighting for index and FS_i is *FS* statistic for index.

All individual months are ranked in ascending order of the *WS* values. A typical month is then selected by choosing from among the five months with the lowest *WS* values the one with the smallest deviation from the long-term *CDF*. In Hall's original method, persistence structures characterized by frequency and run length of days are included. The persistence of mean dry bulb temperature and daily global horizontal radiation are evaluated by determining the frequency and run length above and below fixed long-term percentiles. For mean daily dry bulb temperature, the frequency and run length above the 67th percentile and below the 33rd percentile are determined. For global horizontal radiation, the frequency and run length below the 33rd percentile are also determined. The persistence data are used to select, from the five candidate months, the month to be used in the TMY. The highest ranked candidate month in ascending order of the *WS* values that meet the persistence criterion is used in the TMY. Then, the 12 selected months were concatenated to make a complete year and smooth discontinuities at the month interfaces for 6 h each side using curve-fitting techniques [10,11].

3. TMY selection procedure

The 3-h of dry bulb temperature, dew point temperature, wind speed, wind direction and monthly average global solar radiation, were been measured by IRIMO, have been used to provide TMY. In this part, the procedure based on 3-h data has been presented to select the TMY.

3.1. Weather data in Sandia method

In Sandia method, the 3-h measured data of dry bulb temperature, dew point temperature and wind speed have been used to select the TMY. So, calculating the maximum, minimum, and mean dry bulb and dew point temperatures and the maximum and mean wind velocity during a day have been based on 3-h measured data in Sandia method. Also, the total global horizontal solar radiation during a day was calculated as following procedure.

Table 1
Weighting factors for TMY type.

TMY (Sandia)	Weather index
1/24	Maximum dry bulb temperature
1/24	Minimum dry bulb temperature
2/24	Mean dry bulb temperature
1/24	Maximum dew point temperature
1/24	Minimum dew point temperature
2/24	Mean dew point temperature
2/24	Maximum wind speed
2/24	Mean wind speed
12/24	Total horizontal solar radiation

3.1.1. Solar angles

We need to define several parameters to calculate the global solar radiation. These parameters have been explained as follow [12].

3.1.1.1. Declination angle δ. Declination angle is the angle between sun direction and equatorial plane. Positive declination angle (sun above equator) to a maximum of 23.45° characterize the summer in northern hemisphere, negative declination angles to −23.45° the winter. This angle can be calculated by a Fourier series:

$$\delta = \frac{180}{\pi}(0.006918 - 0.399912\cos B + 0.070257\sin B - 0.006758\cos 2B + 0.000907\sin 2B - 0.002697\cos 3B + 0.00148\sin 3B) \tag{3}$$

$$B = 6.283185\frac{m-1}{365}$$

where m is day of the year that is the number of days spent since January.

3.1.1.2. Hour angle ω and equation of time E. The hour angle is defined as angle between local longitude and the longitude at which the sun is at its zenith. In order to calculate the hour angle, the local time must be corrected by temporal deviation equation of time E and also the time zone (T_z) must be calculated.

$$E = 229.18(0.000075 + 0.001868\cos B - 0.032077\sin B - 0.014615\cos 2B - 0.040849\sin 2B) \tag{4}$$

$$Tz = (L + 7.5)/15 \tag{5}$$

$$\omega = 15\left(t - 12.5 + \frac{E}{60} + \frac{L}{15} - Tz\right) \tag{6}$$

where L is the longitude (°) and t is the hour.

3.1.1.3. Zenith angle θ_z. The zenith angle is defined as the angle of incidence of direct solar irradiance on a horizontal surface.

$$\cos\theta_z = \sin\delta\sin\phi + \cos\delta\cos\phi\cos\omega = \sin\alpha_s \tag{7}$$

where ϕ is the latitude (°) and α_s is the solar altitude.

3.1.2. Extraterrestrial solar radiation

3.1.2.1. Extraterrestrial solar radiation on a normal surface G_{on}. Daily value of G_{on} can be calculated from a Fourier series expansion, as follows:

$$G_{on} = G_{sc}(1.000110 + 0.034221\cos B + 0.001280\sin B + 0.000719\cos 2B + 0.000077\sin 2B) \tag{8}$$

where G_{sc} is the radiation outside the terrestrial atmosphere, known as the solar constant and equal to 1367 W/m^2.

3.1.2.2. Extraterrestrial solar radiation on a horizon surface G_o. After calculating the G_{on}, the hourly value of G_o can be calculated as follows:

$$G_o = G_{on}\ \cos\theta_z \tag{9}$$

3.1.3. Global solar radiation G_t and clearness index k_t

The clearness index is the solar irradiance on a horizontal surface in the Earth (global solar radiation) divided by the extraterrestrial solar irradiance on the same surface, during a characterized time. Clearness index is usually calculated monthly (K_{tm}), daily (K_{td}) or hourly (K_{th}). The hourly clearness index can be calculated using the following equation [13].

$$K_{th} = \frac{G_t}{G_o} \tag{10}$$

where, G_t is the global solar radiation at the Earth's surface.

In this study, the monthly clearness index has been calculated of monthly average global solar radiation in Bandarabass which have been measured by *IRIMO* [14] and then hourly clearness index has been estimated using Duffie and Beckman [15] method, as follows:

$$K_{th} = \left[a + b\cos\frac{\pi}{12}(t-12)\right]K_{tm} \tag{11}$$

$$a = 0.409 + 0.5016\sin\left[(\omega_s - 60)\frac{\pi}{180}\right]$$
$$b = 0.6609 - 0.4767\sin\left[(\omega_s - 60)\frac{\pi}{180}\right]$$

where, ω_s (°) is the hour angle at sunrise or sunset and t is the hour in the day.

After calculating the hourly clearness index, the hourly global solar radiation can be calculated by Eq. (10) for each year of the 14-year periods (1992–2005) in Bandarabass. So, the total daily global horizontal solar radiation which will be needed by Sandia method can be calculated.

4. Other data in the TMY

After selecting the typical months in the year by Sandia method, other data such as hourly direct or diffuse solar radiation have been calculated to employ in the TMY.

4.1. Direct and diffuse horizontal radiation

In pervious study, several methods have been compared for predicting the global solar radiation [16]. It found that the adopted method by Watanabe et al. [17] is in good agreement with daily and monthly measured data of the global solar radiation for cities of Iran. For example Fig. 1 shows the comparative result of global solar radiation between monthly measured long-term average data and predicated result by Watanabe method. So, hourly direct and diffuse horizontal radiation has been calculated to be used in the TMY by Watanabe method. The Watanabe method has been presented to calculate global, diffuse and direct solar radiations on a horizontal surface in Japan using following equations [17].

$$\begin{aligned} &K_{TC} = 0.4268 + 0.1934\sin\alpha_s \\ &K_{DS} = K_{th} - (1.107 + 0.03569\sin\alpha_s + 1.681\sin^2\alpha_s)(1 - K_{th})^2 \quad \text{if } K_{th} \geqslant K_{TC} \\ &K_{DS} = (3.996 - 3.862\sin\alpha_s + 1.54\sin^2\alpha_s)K_{th}^3 \quad \text{if } K_{th} < K_{TC} \end{aligned} \tag{12}$$

$$\begin{aligned} &G_d = G_{on}\frac{K_{th} - K_{DS}}{1 - K_{DS}}\sin\alpha_s \\ &G_b = G_{on}K_{DS}\frac{1 - K_{th}}{1 - K_{DS}}\sin\alpha_s \\ &G_t = G_b + G_d \end{aligned} \tag{13}$$

where, G_d is the horizontal diffuse solar radiation and G_b is the horizontal direct solar radiation.

4.2. Direct normal radiation G_{bn}

After calculating the hourly direct horizontal radiation from Eq. (13), the hourly direct normal radiation can be calculated of the following equation.

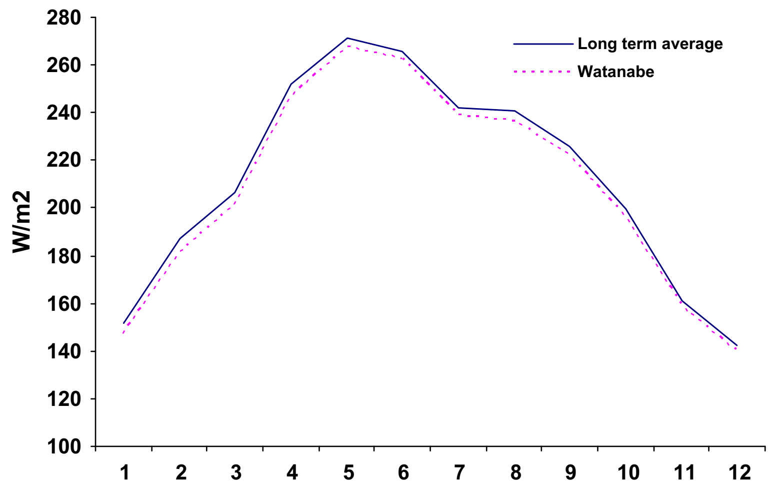

Fig. 1. Comparative results of monthly global solar radiation between Watanabe method and long-term average measured data (Bandarabass).

$$G_{bn} = \frac{G_b}{\cos\theta_z} \tag{14}$$

4.3. Other remained weather data

Other remained data in the TMY weather file has not been calculated and the default values of Energyplus document software have been used [18].

5. Generating the hourly value data

At final process, the hourly value data have been calculated from the 3-h selected data of Sandia method using proposed interpolating method by Lagrange for required parameters [19].

First the total 3-h measured data was arranged during the year (Table 2) and then data between them was calculated by Lagrange method. For example, it was employed to calculate the data of 4 and 5 h (F_4 and F_5), an interpolation between data of 3, 6 and 9 (F_3, F_6 and F_9) or to calculate the data of hours 1 and 2 (F_1 and F_2), an interpolation between data of hours 3, 6 and 8760 (F_3, F_6 and F_{8760}). This method was similarly used at all hours during the year. The interpolating Lagrange method is for three data as follows.

Hour	Value
x_0	F_0
x_1	F_1
x_2	F_2

$$p(x) = L_0F_0 + L_1F_1 + L_2F_2$$

$$L_0(x) = \frac{(x-x_1)(x-x_2)}{(x_0-x_1)(x_0-x_2)}, \quad L_1(x) = \frac{(x-x_0)(x-x_2)}{(x_1-x_0)(x_1-x_2)}, \quad L_2(x) = \frac{(x-x_0)(x-x_1)}{(x_2-x_0)(x_2-x_1)} \tag{15}$$

Table 2
Description of interpolating method.

Hour	Value	Hour	Value	Hour	Value
1	F1	5	F5	9	**F9**
2	F2	6	**F6**	10	F10
3	**F3**	7	F7	11	F11
4	F4	8	F8	12	**F12**

5.1. Abstract of procedure

The abstract of procedure and parameters that have been employed to provide the TMY for Bandarabass have been presented in Table 3.

6. Creating the TMY by available softwares

In this study, the TMY for Bandarabass has been generated by Meteonorm and Weathergenrator softwares and then the results together with Sandia method's result; have been compared with long-term average measured data for four main parameters in the weather data.

7. Results and discussion

Fig. 2 shows the selected months that have been used to create the TMY of Bandarabass by Sandia method. Obviously, data of several years have been used to select the typical months and data of year 2001 have been more used than other years in TMY.

After providing the TMY with Sandia method and also with Weathergenrator and Meteonorm softwares, the best results have been selected for TMY using the following described procedure.

Those results which have the minimum differences with long-term average measured data in every month and have best meet the persistence criterion of the Hall's have been used to select the typical meteorological year. So, the TMY months have been selected from a mixture of months from the Sandia method and the results of applying the two softwares.

1. For three mentioned methods (Sandia, Weathergenrator and Meteonorm) the daily mean values of dry bulb temperature, dew point temperature, wind speed and sum of daily global solar radiation have been compared with daily mean long-term average measured data of the same parameter using *RMSE* (the root mean square error).
2. The sum monthly values of *RMSE* (*SMRMSE*) of the four mentioned parameters have been calculated for every month and for every method. Also mean yearly of sum monthly values (*MYRMSE*) of *RMSE* have been calculated. Then for every month the results of three methods have been ranked with respect to minimum of the *ERMSE* parameter as following:

Table 3
Description of parameters in TMY.

Dry bulb temperature	For selected month from Sandia method the hourly values have been calculated from Eq. (15)
Dew point temperature	For selected month from Sandia method the hourly values have been calculated from Eq. (15)
Relative humidity	For selected month from Sandia method the hourly values have been calculated from Eq. (15)
Atmospheric pressure	For selected month from Sandia method the hourly values have been calculated from Eq. (15)
Extraterrestrial horizontal radiation	The hourly values have been calculated by Eq. (9)
Extraterrestrial direct normal radiation	The hourly values have been calculated by Eq. (8)
Global horizontal radiation	The hourly values have been calculated by Eq. (10)
Direct normal radiation	The hourly values have been calculated by Eq. (14)
Diffuse horizontal radiation	The hourly values have been calculated by Eq. (12)
Wind direction	For selected month from Sandia method the hourly values have been calculated from Eq. (15)
Wind speed	For selected month from Sandia method the hourly values have been calculated from Eq. (15)
Global horizontal illuminance	The default values of Energyplus software document have been used (999999)
Direct normal illuminance	The default values of Energyplus software document have been used (999999)
Diffuse horizontal illuminance	The default values of Energyplus software document have been used (999999)
Zenith luminance	The default values of Energyplus software document have been used (9999)
Total sky cover	The default values of Energyplus software document have been used (5)
Opaque sky cover	The default values of Energyplus software document have been used (5)
Visibility	The default values of Energyplus software document have been used (777)
Ceiling height	The default values of Energyplus software document have been used (77777)
Present weather observation	The default values of Energyplus software document have been used (9)
Present weather codes	The default values of Energyplus software document have been used (999999999)
Precipitable water	The default values of Energyplus software document have been used (0)
Aerosol optical depth	The default values of Energyplus software document have been used (0)
Snow depth	The default values of Energyplus software document have been used (0)
Days since last snow	The default values of Energyplus software document have been used (88)

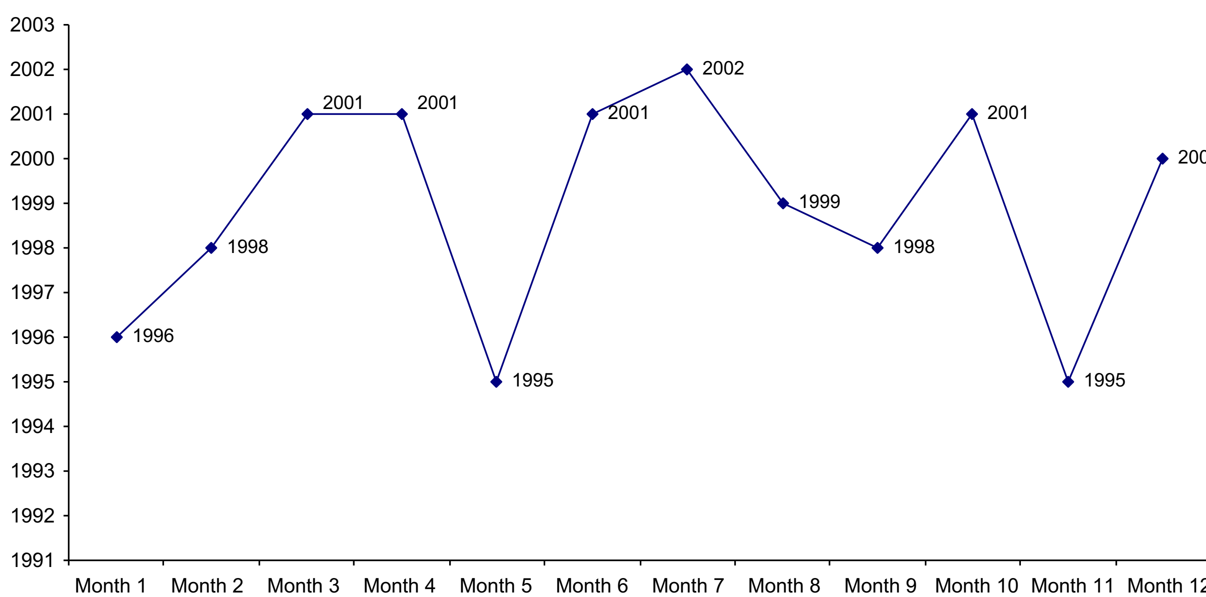

Fig. 2. The selected years for each month of the year.

$$ERMSE^i = \frac{SMRMSE_1^i}{MYRMSE_1} + \frac{SMRMSE_2^i}{MYRMSE_2} + \frac{SMRMSE_3^i}{MYRMSE_3} + \frac{SMRMSE_4^i}{MYRMSE_4}$$

where i is month number, $SMRMSE_1^i$ is sum monthly values of *RMSE* for parameter 1 and in month i, $MYRMSE_1$ is mean yearly of sum monthly values of *RMSE* for parameter 1, and parameters are:

Parameter 1: the daily mean values of dry bulb temperature.
Parameter 2: the daily mean values of dew point temperature.
Parameter 3: the daily mean values of wind speed.
Parameter 4: the sum daily global solar radiation.

3. Using the final step of Hall's original method as follow, the best method have been obtained to select TMY in every month of the year.
4. All individual months are ranked in ascending order of the *ERMSE* values. A typical month is then selected by choosing from among the three months with the lowest *ERMSE* values. In Hall's original method, persistence structures characterized by frequency and run length of days are included. The persistence of mean dry bulb temperature and daily global horizontal radiation are evaluated by determining the frequency and run length above and below fixed long-term percentiles. For mean daily dry bulb temperature, the frequency and run length above the 67th percentile and below the 33rd percentile are determined. For global horizontal radiation, the frequency and run length below the 33rd percentile are also determined. The persistence data are used to select, from the three candidate months, the month to be used in the TMY. The highest ranked candidate month in ascending order of the *ERMSE* values that meet the persistence criterion is used in the TMY. Naturally, the long-term values in this part have been created of the three mentioned method values for every month of the year.

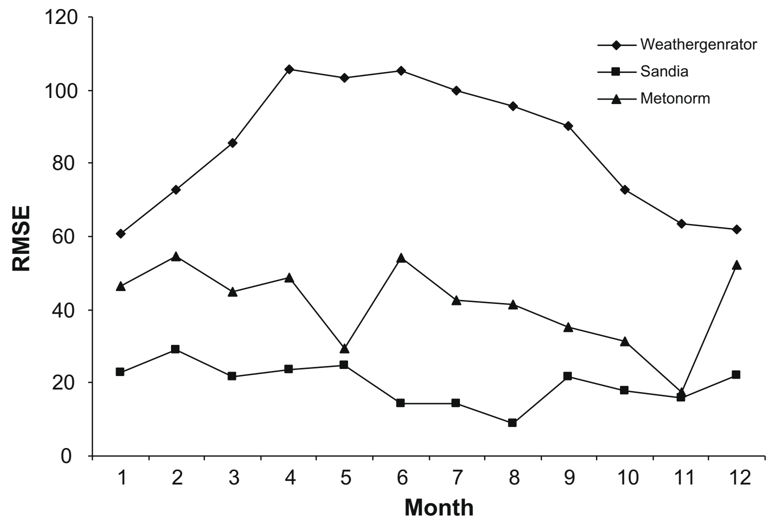

Fig. 3. The monthly RMSE results of global solar radiation for several methods.

Figs. 3–6 shows the monthly results of *RMSE* from several methods and for various main parameters of weather data in Bandarabass. Consequently, the minimum *RMSE* for the global solar radiation has been obtained from Sandia method for every month of the year. Also, the results of dry bulb temperature and wind speed of Sandia method have more suitable agreement with their long-term average measured data than those of Weathergenrator and Meteonorm softwares for most months of the year. So the dew point temperature result of Meteonorm software has better agreement with it long-term average measurement data than the dew point temperature results of Weathergenrator software and Sandia method for some months at the year.

Also, the sum monthly *RMSE* of the four parameters for every month in the year from several methods have been presented in Fig. 7 and it can be concluded that the results of every method have agreement with long-term average measured data in such month of the year. The selected method for every month has been presented in Table 4 based on minimum values of *ERMSE*. This Table shows that the Sandia method have minimum difference with long-term average measured data for five months and also the Meteonorm method has minimum difference with long-term average measured data for other five months of the year. Weathergenrator method has minimum difference with long-term average measured data for two remained months in the year.

After applying the step 4, the selected method for every month has been presented in Table 5 based on minimum values of *ERMSE* and best meet the persistence criterion of the Hall's. It can be seen that the Sandia and Meteonorm methods are best methods in 5 and 6 months of the year respectively and the data of Weathergenrator software has been used only in 2 months of the year.

8. Conclusions

In this study, the new method has been presented to select the TMY data between results of Sandia method and two mentioned softwares results. The following procedures are suggested to provide the TMY:

(a) Using measured (or predicted) weather data, the typical meteorological year will be selected by Sandia method.
(b) Typical meteorological year will be generated using Meteonorm and Weathergenrator softwares.

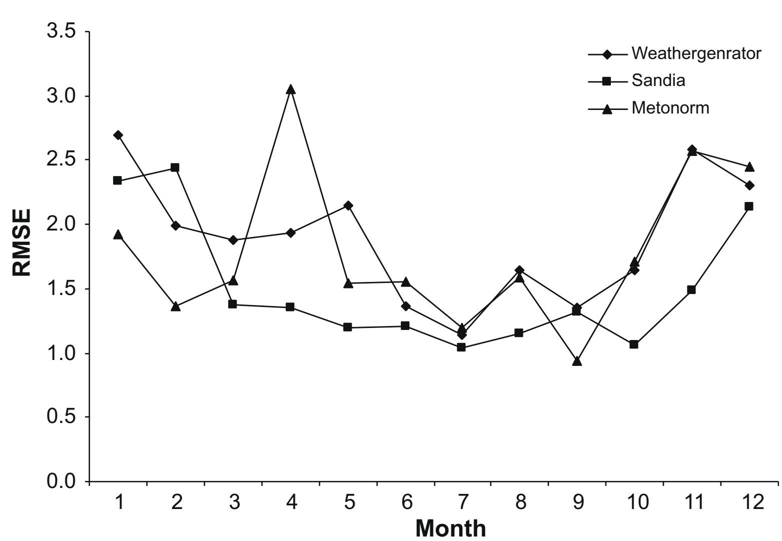

Fig. 4. The monthly RMSE results of dry bulb temperature for several methods.

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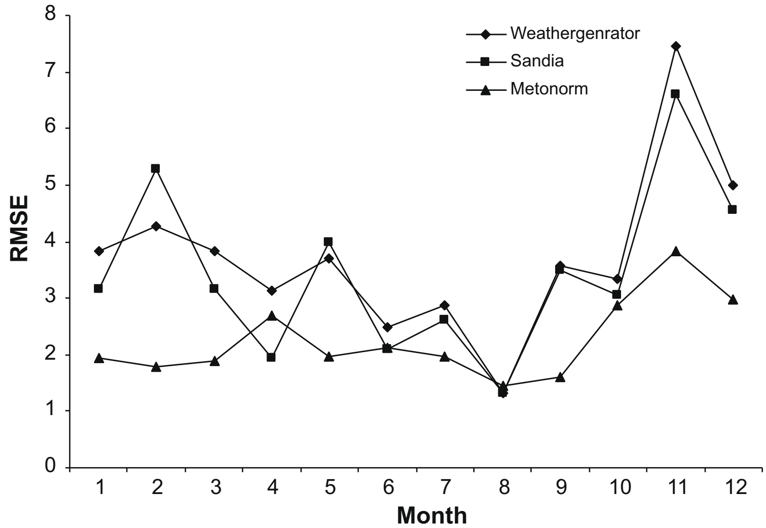

Fig. 5. The monthly RMSE results of dew point temperature for several methods.

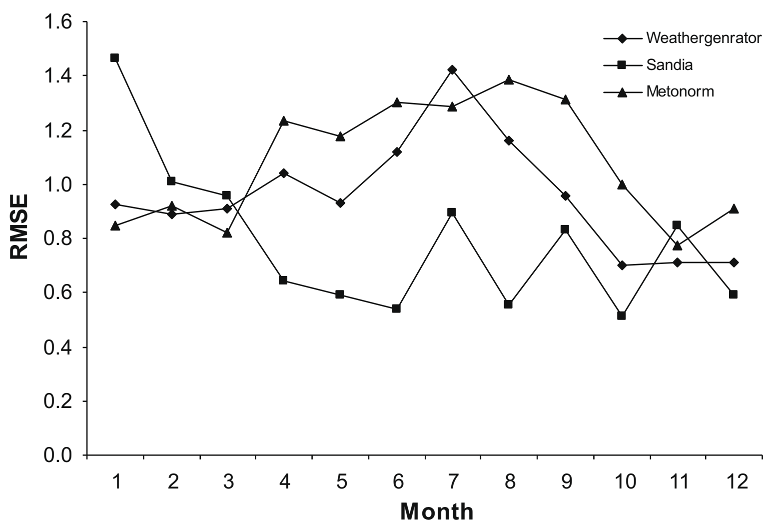

Fig. 6. The monthly RMSE results of wind speed for several methods or several methods.

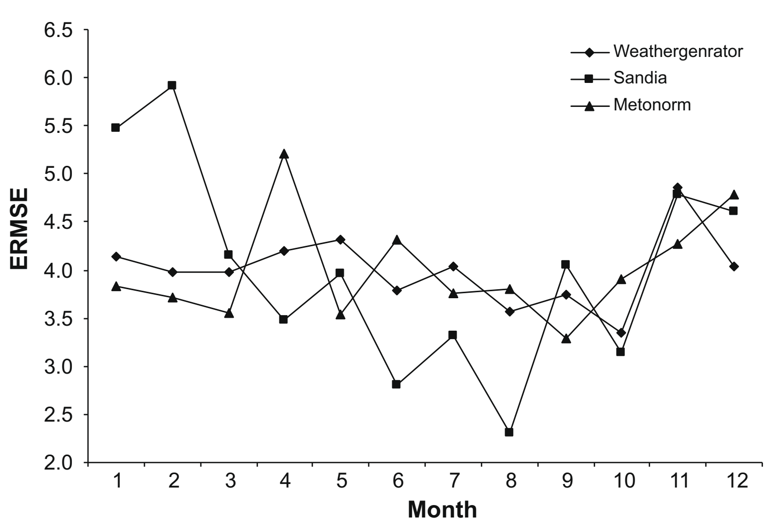

Fig. 7. The sum monthly ERMSE results of several methods.

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Table 4
The best method with minimum *ERMSE* in every month.

Month	Method
1	Metonorm
2	Weathergenrator
3	Metonorm
4	Sandia
5	Metonorm
6	Sandia
7	Sandia
8	Sandia
9	Metonorm
10	Sandia
11	Metonorm
12	Weathergenrator

Table 5
The best method for every month.

Month	Method
1	Metonorm
2	Weathergenrator
3	Metonorm
4	Metonorm
5	Metonorm
6	Metonorm
7	Metonorm
8	Weathergenrator
9	Sandia
10	Sandia
11	Sandia
12	Sandia

(c) The results of Sandia method and mentioned softwares will be compared with long-term average measured data for main parameters (dry bulb temperature, dew point temperature, wind speed, global solar radiation) for all months of the year using *ERMSE*.
(d) All individual months are ranked in ascending order of the *ERMSE* values for the three mentioned methods.
(e) Using the final step of Hall's original method, the best method has been obtained to select TMY in every month of the year.
(f) Those results which have the minimum difference with long-term average measured data in every month and have best meet the persistence criterion of the Hall's have been used to select the typical meteorological year.
(g) The 12 selected months were concatenated to make a complete year and smooth discontinuities at the month interfaces for 6 h each side using curve-fitting techniques.

References

[1] Crawley D, Hand J, Lawrie L. Improving the weather information available to simulation programs. Washington, DC: US Department of Energy.
[2] Chan LS, Chow TT, Fong KF, Lin Z. Generation of a typical meteorological year for Hong Kong. Energy Convers Manage 2006;47:87–96.
[3] Kalogirou A. Generation of typical meteorological year (TMY-2) for Nicosia, Cyprus. Renew Energy 2003;28:2317–34.
[4] Lam C, Hui CM, Chan LS. A statistical approach to the development of a typical meteorological year for Hong Kong. Architect Sci Rev 1986;39:201–9.
[5] Zhang Qingyuan, Joe Huang, Lang Siwei. Development of Chinese weather data for building energy calculations. In: 4th International conference on indoor air quality, ventilation and energy conservation in buildings, Changsha, Hunan, China, 2–5 October, 2001. p. 1211.
[6] Anderson TN, Duke M, Carson JK. A typical meteorological year for energy simulations in Hamilton, New Zealand. IPENZ engineering treNz 2007-003, ISSN 1177-0422.
[7] Finkelstein JM, Schafer RE. Improved goodness-of-fit tests. Biometrika 1971;58(3):641–5.
[8] Meteonorm documentation software version 5.102. <http://www.meteonorm.com>.
[9] Degelman Larry O. A statistically based hourly weather data generator for driving energy simulation and equipment design software for building. Department of Architecture Texas A&M University, College Station, TX 77843-3137, USA.
[10] Hall I, Prairie R, Anderson H, Boes E. Generation of typical meteorological years for 26 SOLMET stations, SAND78-1601. Albuquerque, NM: Sandia National Laboratories; 1978.
[11] Marrion William, Urban Ken. User's manual for TMY2s typical meteorological years. National Renewable Energy Laboratory, US Department of Energy; 1995.
[12] Maxwell EL. A Quasi-physical model for converting hourly global insolation to direct normal insolation. Solar Energy Research Institute (National Renewable Energy Laboratory), US Department of Energy; 1987.
[13] Mehdi B, Abbas M. The clearness index for various Iran cities. In: The 3rd conference on fuel conservation in building, Tehran, Iran; 2003.
[14] IRIMO. Islamic Republic of Iran Meteorological Office, Data Center, Tehran, Iran. <http://www.weather.ir/>.
[15] Duffie JA, Beckman WA. Solar energy of thermal processes. New York: John Wiley; 1980.
[16] Abdulsalam E. New equations for designing windows based on minimum energy consumption for Iran. PhD thesis, Modares University, Iran, Tehran; 2008.
[17] Watanabe T et al. Procedures for separating direct and diffuse insolation on a horizontal surface and prediction of insolation on tilted surfaces. Transactions, no. 330. Architectural Institute of Japan, Tokyo, Japan; 1983.
[18] EnergyPlus documentation, software. <http://apps1.eere.energy.gov/buildings/energyplus/>.
[19] Mehri B. Computational mathematics. Tehran, Iran; 2005. ISBN 964-6096-13-1.

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