COMPARISON OF UNTYPICAL METEOROLOGICAL YEARS (UMY) AND THEIR INFLUENCE ON BUILDING ENERGY PERFORMANCE SIMULATIONS

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ABSTRACT

Three versions (type 1, 2 and 3) of untypical climate data based on the Weather Year for Energy Calculations 2 (WYEC2) methodology were calculated. The following parameters were altered in comparison with standard WYEC2 year: the average value of a total daily amount of solar radiation; the average and maximum wind speed; the average, minimum and maximum dry bulb temperature; the average, minimum and maximum dew point temperature. These new meteorological years were used for energy simulation of well-known building types used for ANSI 140 standard tests – Building Energy Simulation Test (BESTEST). Results of energy simulations were compared with base typical meteorological years to determine the influence of each meteorological parameter, that was altered while determining new climate data.

The calculations were made for four orientations (north, south, east and west) for cases: 600, 610, 900 and 910 of BESTEST. Cases were located in the centre of Poland. It is important that the simulations with new meteorological years were not compared with BESTEST simulations output. The results were obtained with an hourly time step and include: total annual heating and cooling energy demands and transient heat fluxes. In addition, the effects of various types of meteorological years on the criterion of comfort - Percentage People Dissatisfied (PPD) parameter were analysed.

Comparison of the results computed for Untypical Meteorological Years (UMY) with typical meteorological year shows that the UMY files have strong application potential, especially in building performance simulations of energy and power demands for heating. In simulations of cooling energy and power demands, UMY files assure comparable results to typical weather files.

INTRODUCTION

A lot of research work was devoted to analysis of climate change and its impact on energy efficiency. Based on the interpretation of the past measurement data, it is stated in many scenarios that the climate is constantly warming up. On the other hand, it is important not only to reflect on trends and predictions of climate change, but also on how to interpret recorded meteorological data. Data interpretation is especially important for choosing methods for determining typical meteorological years, such as TMY, TRY, WYEC, CWY, HSY or ISO. As an example, indices for WYEC2 calculation may be alternated to change the influence of meteorological parameters on the calculated year for energy simulations. Therefore, determination of the weighting factors assigned to the attributes of various climate parameters sets and their impact on energy simulation results were considered as the thematic scope of presented paper.

PROBLEM DEFINITION

In the literature of issue, a few notes about selecting the appropriate type of calculation climate files for building performance simulations can be found. For example, one author compares in the article (Drury B. Crawley, 1998) the results from simulations carried out for a following types of climate files: WYEC2, TMY2, CWEC, and CTZ2. Based on a comparative analysis the author draws inter alia the following conclusions:

1. Annual variation in weather files mostly affects energy consumption in heating-dominated locations. Annual weather variations in climatic data have the least impact on energy consumption in cooling-dominated locations. Where heating and cooling loads are more balanced, the impact is more variable.
2. Variations in power demands, similarly to energy consumption, have the least variation for a cooling-dominated location. Unlike energy consumption, peak demand varies considerably for locations with relatively mild, but variable weather conditions.

Despite well illustrated impact of the above-described types of climate files on the results of building performance simulations, still opened issue is: to what extent it is possible to adjust the selected type of climate data (in this case a WYEC2 file) for the more complicated computational tasks and what energy effect will it cause for a building simulation? For instance, in simulation of low mass buildings with highly glazed facade – the greater importance in the composite index for selecting the most „typical" year could be attributed to the daily total solar radiation (*DTSR*). In the other case, for example, in estimating by simulation methods the impact of natural ventilation and infiltration into the building's energy demands for cooling and heating, the greater importance should be attributed to the weights of the average and maximum wind speed, etc.

To answer for the formulated issue, the procedure for constructing typical & untypical weather data files is described in details below, together with the results of buildings performance simulations conducted on the basis of worked out files (ISO, WYEC2 and three types of UMY – v1, v1 & v3).

WEATHER DATA FOR ENERGY CALCULATION

Source IMGiW data for the typical and untypical meteorological years

The typical and untypical meteorological years were derived from the IMGiW (Instytut Meteorologi i Gospodarki Wodnej – Poland). The IMGiW meteorological data used for that calculation contains 3-hour (synoptic) values of measured meteorological parameters (SYNOP FM-12) and measured or modelled solar radiation for 61 stations for the 30-year period from 1971-2000. There are two types of stations in the data: primary and secondary. The 43 primary stations measured parameters for all the 30-year period. The remaining 19 stations, designated as secondary stations, measured the 30-year period partially (from 11 to 29 years). Both primary and secondary stations are National Weather Service stations that collected meteorological data for the period 1971-2000.

Selection procedure

Construction of ISO reference year

The ISO reference year contains hourly values of at least meteorological parameters, taken from a location representative of the climate concerned:

- dry bulb air temperature;
- direct normal solar irradiance and diffuse solar irradiance on a horizontal surface;
- relative humidity, absolute humidity, water vapour pressure or dew point temperature;
- wind speed at a height of 10 metres above the ground.

As temperature, radiation, and humidity are the key parameters for cooling and heating calculations, they are used to construct the ISO reference year.

In principle, if a year existed within the long term data in which each month was representative of the long term conditions, that year could be used as a reference year. However, that is unlikely and in practice the most appropriate months are selected from a number of different years and joined together, with smoothing at the joins, to construct a complete year.

The procedure specified below is designed to construct a year of hourly values in which the mean value of individual variables, their frequency distribution and correlations between the different variables within each month are as close as possible to the corresponding calendar month of the long-term data set.

The procedure therefore has two stages. In the first stage, the best month is selected from the multi-year record for each calendar month. In the second stage, the hourly values in the selected month are adjusted to provide a smooth transition when the different months are joined to form a year. In those procedures correlations between variables are retained.

The procedure for constructing ISO reference year assumes that dry bulb temperature, solar radiation and humidity are taken as the primary parameters for selecting the „best” months to form the reference year, with wind speed as a secondary parameter. Other combinations of primary and secondary parameters can be used to develop reference years for special purposes as for example for calculation of highly glazed and ventilated facades of buildings. The variables chosen as the basis for the untypical meteorological reference year shall always be stated in the accompanying documentation. To construct ISO reference year for each climatic parameter p (where p is dry bulb temperature, solar radiation or humidity) calculate (ISO 15927-4.2, 2005):

a. from at least 10 years (better 20 or 30 years) of hourly values of p, calculate the daily means of parameter p,

b. for each calendar month - m, calculate the cumulative distribution function of the daily means over all years in the data set, $\Phi(p,m,i)$, by sorting all the values in increasing order and then using equation (1):

$$\Phi(p,m,i) = \frac{K(i)}{N+1} \qquad (1)$$

c. for each year - y of the data set, calculate the cumulative distribution function of the daily means within each calendar month - m, $F(p,y,m,i)$ by sorting all the values for that month and that year in increasing order and then using equation (2):

$$F(p,y,m,i) = \frac{J(i)}{n+1} \qquad (2)$$

d. for each calendar month - m, calculate the Finkelstein-Schafer statistic $FS(p,y,m)$ for each year - y of the data set, using equation (3):

$$FS(p,y,m) = \sum_{i=1}^{n} \left| F(p,y,m,i) - \Phi(p,m,i) \right| \qquad (3)$$

e. for each calendar month - m, rank the individual months from the multiyear record in order of increasing size of $FS(p,y,m)$,

f. for each calendar month - *m* and each year - *y* add the separate ranks for the three climate parameters,
g. for each calendar month, for the three months with the lowest total ranking, calculate the deviation of the monthly mean wind speed from the corresponding multi-year calendar month mean.

The month with the lowest deviation in wind speed is selected as the „best" month to be included in the reference year. Further parameters can be investigated if necessary. All twelve chosen „best" months combined together create ISO reference year. As the adjacent months come in most cases from different years, the parameters at contact should be adjusted. Parameters in the last eight hours of each month and the first eight hours of each month should be corrected using cubic spline interpolation to ensure a smooth transition of joined months. This adjustment should include the last eight hours of December and the first eight hours of January so that the reference year could be used repeatedly in simulations.

Construction of WYEC2 reference year

The following is quoted from the Watsun Simulation Lab paper that states (Siurna, D.L. et al., 1984):

„Canadian Weather for Energy Calculations (CWEC) files are typical year sets of meteorological data in WYEC2 format; they include such quantities as solar radiation (global, diffuse, direct), dry-bulb and dew point temperatures, wind speed and direction, atmospheric pressure, etc., on an hourly basis. They were developed by the Watsun Simulation Laboratory". The WYEC2 months are chosen by statistically comparing individual monthly with long-term monthly means for daily total global radiation, monthly mean, minimum and maximum dry bulb temperature, monthly mean, minimum and maximum dew point temperature, and monthly mean and maximum wind speed. The composite index used to select the most „typical" months uses the following weights (in %), shown in Table 1.

Table 1 Typical meteorological year – WYEC2 – months' selection weights

PARAMETER	Dry Bulb Max	Dry Bulb Min	Dry Bulb Mean	Dew Point Max	Dew Point Min
WEIGHT (%) - *W*	5	5	30	2,5	2,5
PARAMETER	Dew Point Mean	Wind Speed Max	Wind Speed Mean	Daily Solar Rad.	
WEIGHT (%) - *W*	5	5	5	40	

The Sandia Laboratories method is an empirical approach that selects individual months from different years of the period of record. For example, if multi-year meteorological data contains 30 years of data, all 30 Januaries are examined and the one judged most typical is selected to be included in the reference year. The other months of the year are treated in a like 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 or 8 hours on each side.

This method selects a typical month based on nine daily indices consisting of the maximum, minimum, and mean dry bulb and dew point temperatures; the maximum and mean wind velocity and the total global horizontal solar radiation. Final selection of a month includes consideration of the monthly mean and median and the persistence of weather patterns. The process of month selection may be considered as series of four steps.

1. For each month of the calendar year, five candidate months with cumulative distribution functions (CDFs) for the daily indices that are closest to the long-term (30 years) 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)* statistic equation (4) for each index.

   $$FS = \frac{1}{n}\sum_{i=1}^{n}\delta_i \quad (4)$$

   Because some of the indices are judged more important than others, a weighted sum *(WS)* of the *FS* statistics is used to select the 5 candidate months that have the lowest weighted sums, using equation (5).

   $$WS = \sum_{j=1}^{9} w_j FS_j \quad (5)$$

2. The 5 candidate months are ranked with respect to closeness of the month to the long-term mean and median.
3. 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 (consecutive warm days) and below the 33rd percentile (consecutive cool days) were determined. For global horizontal radiation, the frequency and run length below the 33rd percentile (consecutive low radiation days) were determined. The persistence data are used to select from the five candidate months the

month to be used in the reference year. The highest ranked candidate month from step 2 that meets the persistence criteria is used in the reference year. The persistence criteria exclude the month with the longest run, the month with the most runs, and the month with zero runs.

4. The 12 selected months were concatenated to make a complete year and smooth discontinuities at the month interfaces for 6 hours each side using splines curve fitting techniques.

Typical and untypical meteorological years were calculated according to the presented ISO and WYEC2 procedures. The "Typowy Rok Meteorologiczny" (TRM) application was developed to make it easier to prepare different types of reference meteorological years with different weighting indices based on source data.

Data format

The reference years calculated by TRM application consists of twelve „typical" meteorological months selected from the calendar months in a multi-year weather database. Combined together, they form „typical" or „untypical" meteorological year. This form of reference meteorological year contains exactly the same parameters as the IMGiW source data. As the source data are in 3-hours synoptic measurements, the reference years were interpolated to hourly data and additional meteorological parameters were determined on the measurements basis. Table 2 shows all calculated meteorological parameters.

Table 2 Meteorological parameters for hourly time step data determining

FIELD	PARAMETER	UNIT	FORMAT
1	Year	-	I4
2	Month	-	I2
3	Day	-	I2
4	Hour UTC	-	I2
5	Dry bulb temperature	°C	F8.3
6	Wet bulb temperature	°C	F8.3
7	Dew point temperature	°C	F8.3
8	Relative humidity	%	F6.1
9	Humidity ratio	g/kg	F7.3
10	Air density	kg/m^3	F6.3
11	Barometric pressure	hPa	F7.1
12	Wind speed	m/s	F5.1
13	Wind direction (36 sectors)	-	I3
14	Cloud cover 0 - 8	-	I2
15	Rain flag (0 or 1)	-	I1
16	Snow fall flag (0 or 1)	-	I1
17	Precipitation type	-	I1
18	Total horizontal solar irradiance	W/m^2	F6.1
19	Direct horizontal solar irradiance	W/m^2	F6.1
20	Diffused horizontal solar irradiance	W/m^2	F6.1
21	Sky radiation temperature	°C	F8.3

Raw reference ISO and WYEC2 meteorological year were interpolated by IDM application, developed for this purpose. This application uses the model of Erbs, Klein, and Duffie (Erbs, D. G. et al., 1982) for splitting total solar radiation into direct and diffuse parts. Calculated with IDM hourly reference ISO and WYEC2 text files contain 8760 records of meteorological parameters for each local meteorological station in Poland.

UNTYPICAL METEOROLOGICAL YEARS

Untypical meteorological years are the WYEC2 reference years calculated with different than standard weighting indices, e.g. different parameters are more important during calculation of weighted sums. This leads to choosing different „typical" months that compose reference years. Three untypical meteorological years (UMY v1, UMY v2 and UMY v3) were calculated with weighting indices presented in tables below (Table 3, Tab. 4 & Tab. 5).

Weather indices

Composite indices for the months' selection were determined based on methodology of three sets of WYEC2 weight parameters. Among the 9 parameters, the most important to determine composite index for UMY files were the following 4: minimum and maximum dry bulb temperature, maximum wind speed and daily total solar radiation. On that basis, three kinds of meteorological reference years were composed.

In the first type of UMY year, the following meteorological parameters were recognized as the most important: maximum and minimum temperatures of dry bulb thermometer, daily total solar radiation and maximum wind speed. For these parameters approximately the same equal importance was used in determining the composite index. Table 3 shows the values of weighting indices for the first type of reference meteorological year – *UMY v1*. The remaining two types of UMY years for building performance simulations were determined as the extreme years due to the values of the daily total solar radiation and due to the wind speed.

Table 3 Untypical meteorological year v1 – months' selection weights

PARAMETER	Dry Bulb Max	Dry Bulb Min	Dry Bulb Mean	Dew Point Max	Dew Point Min
WEIGHT (%) - *W*	15	15	10	1	1
PARAMETER	Dew Point Mean	Wind Speed Max	Wind Speed Mean	Daily Solar Rad.	
WEIGHT (%) - *W*	1	15	5	37	

The second type of UMY year can be characterized by the months, for which the most important parameters are: the temperatures of dry bulb thermometer (in particular minimum and maximum values) and the intensity of solar radiation. Table 4 shows the values of weighting indices for the second type of reference meteorological year – *UMY v2*.

Table 4 Untypical meteorological year v2 – months' selection weights

PARAMETER	Dry Bulb Max	Dry Bulb Min	Dry Bulb Mean	Dew Point Max	Dew Point Min
WEIGHT (%) - *W*	15	15	10	1	1
PARAMETER	Dew Point Mean	Wind Speed Max	Wind Speed Mean	Daily Solar Rad.	
WEIGHT (%) - *W*	1	1	1	55	

For the third type of UMY year, it was assumed to obtain a year of extreme wind speeds. Therefore, the half of total weight sum was assigned to the wind speed indices. Table 5 shows the values of weights for the third type of reference year – *UMY v3*.

All three types of reference meteorological years for building performance simulations were resolved for the analysed location.

Table 5 Untypical meteorological year v3 – months' selection weights

PARAMETER	Dry Bulb Max	Dry Bulb Min	Dry Bulb Mean	Dew Point Max	Dew Point Min
WEIGHT (%) - *W*	15	15	10	1	1
PARAMETER	Dew Point Mean	Wind Speed Max	Wind Speed Mean	Daily Solar Rad.	
WEIGHT (%) - *W*	1	25	25	7	

Weather data analysis

For the assumed input parameters of composite index weights, five reference meteorological years were determined for specified location - 4 according to WYEC2 methodology and 1 according to ISO methodology. Figures 1-3 show the statistical values of the following climate parameters: the monthly mean values of total solar radiation, the minimum and average monthly temperatures.

With few exceptions of winter months, the highest values of monthly mean total horizontal radiation (Fig. 1) occurred in the three types of UMY weather data files. For the winter months, the observed differences are relatively small. Over the time of the year however, these differences amount from 10% to 20%. The maximum values of solar radiation were observed for the standard type of WYEC2 file and it amounts to 998 W/m^2, whereas for other types of climate files the maximum values fall within the scope from 918 W/m^2 (UMY v1) to 986 W/m^2 (ISO). On that basis, it can be preliminary concluded that in terms of amounts of solar radiation and the extreme values of radiation, the results of building simulations for different types of presented climate files will be much the same. Considerably greater differences were observed comparing the minimum (Fig. 2) and mean (Fig. 3) monthly temperatures - especially for the winter months.

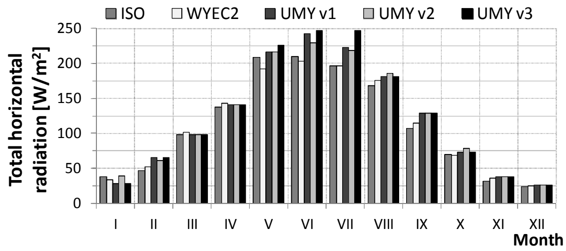

Figure 1 Monthly mean values of total horizontal radiation – comparison of climates

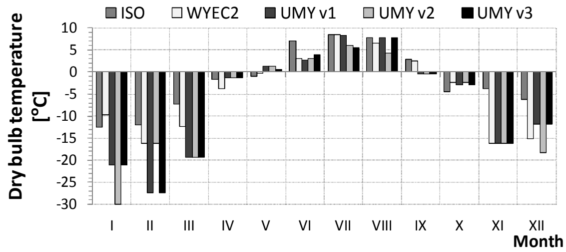

Figure 2 Monthly minimum values of dry bulb temperature – comparison of climates

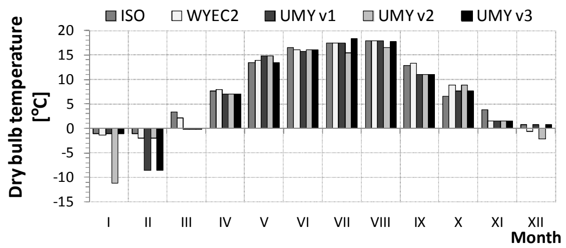

Figure 3 Monthly mean values of dry bulb temperature – comparison of climates

The lowest temperatures were recorded for the months of January & February and attained values up to -30ºC. Extreme sub-zero temperatures occurred for the file type UMY v2 and it is worth noting that for the specified location such low temperatures appear to be extremely rare. For the summer months, minimum values of temperatures attained a value in the range 3°C - 8°C. In the case of short-lived incidence of such low temperatures in the summer it may lead to a noticeable impact on energy simulation results for buildings with low thermal mass. The monthly mean temperatures are shown in Figure 3. For the summer months, no significant differences are observed for monthly mean temperatures, while the winter and interim months have many discrepancies in values. The extreme values of mean temperatures recorded for the untypical files in the months of January and February (reaching up to -12ºC in case of UMY v2 file) may in turn influence the seasonal increasing in energy demands for heating. The typical meteorological years (ISO & WYEC2) are characterized for the winter months by comparable mean values and moderate temperatures (approximately -1°C). For the cooling season, the differences in extreme temperatures are minor and on that basis its analysis was abandoned. It can be added that maximum result temperatures reached values close to 35°C, which very well reflects the historical recorded maximum temperatures in the analysed region.

Wind speed analysis shown in Table 6 revealed that the longest occurrence of period with light and calm air movement (wind speed ≤ 1m/s) characterizes the climate files ISO and UMY v3 (with the number of windless hours approximately equalling to 1720h). Despite very comparable mean values of wind speed (falls within the scope from 3.3 to 3.7 m/s) the minimum number of windless days was recorded for the file type UMY v1. On the other hand, the longest periods with high wind speeds were recorded for the file types UMY v2 and WYEC2 (approximately 650 hours with wind speed exceeding 8m/s). Extreme wind speeds in any of the cases did not exceed the value of 16 m/s (recorded for the file UMY v3).

Table 6 Wind speed (WS) analysis

NO. OF HOURS /WIND SPEED	TYPE OF CLIMATE				
	ISO	WYEC 2	UMY v1	UMY v2	UMY v3
Hours ≤ 1m/s	1719	1518	1368	1487	1722
Hours ≥8 m/s	360	642	419	655	357
Max [m/s]	13	14	12	14	16
Mean [m/s]	3,5	3,7	3,6	3,7	3,3

CASE STUDIES

Presented analysis describes the modelling methodology and results of testing done for building performance simulations. The simulations were used to identify and diagnose differences in building performance that may possibly be caused by applying different boundary conditions - typical and untypical meteorological data. Four ASHRAE/ BESTEST cases were performed for four orientations (north, south, east and west): base case 600 (low mass building) and basic cases - 610 (low mass building with shading device), 900 (high mass building) and 910 (high mass building with shading device). All of mentioned cases are well described by (Judkoff, R. and Neymark, J, 1995) and have the same geometry. The example of base case 600 geometry is shown in Figure 4. Cases 610 and 910 have added a 1 m horizontal overhang across the entire length of wall with windows at the roof level.

The cases are characterised with the equivalent heat transfer coefficient that equals to 0,514 $W/m^2 \cdot K$ for walls; 0,318 $W/m^2 \cdot K$ for roofs and 0,039 $W/m^2 \cdot K$ for floors. Infiltration was assumed on a constant level at 0,5 air changes per hour. Internal gains were constant and the value was 200 W (60% radiative, 40% convective; 100% sensitive, 0% latent). The control was assumed to be ideal: there was no limitation neither in cooling nor heating capacity - the heating start point was 20°C and the cooling start point was 27°C (for both, considering dry bulb temperature as an actuator). Thermal inertia of the plant system was not taken into account. Sensible cooling only and 100% convective air system were assumed.

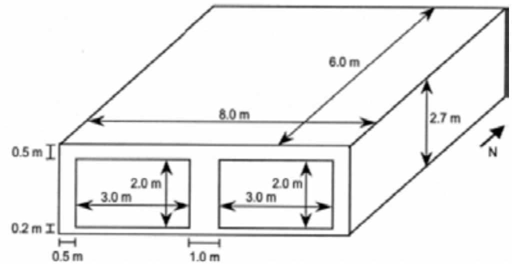

Figure 4 Geometry of BESTEST case 600

Thermal model of the building was created using a finite-volume heat balance discretisation method. The influence of solar radiation was considered by way of direct solar-tracking processor combined with the distribution of diffused radiation (Clarke 2001).

RESULTS

The results are presented in the figures 5 - 8 and in the tables 7 – 10. The tables 7 to 10 show the maximum and minimum values together with the standard deviation (std. dev.) and mean values for made simulations. All obtained results are characterised with comparable features of the charts, thus results presented in the tables and figures were selected as the most representative for analysed cases. Figures 5 to 8 are shown additionally to the tables to highlight graphically the differences in the results.

Annual heating and cooling

Table 7 indicates the highest annual heating demand for climate type UMY v2. In three analysed cases (600,610 & 910) this energy approached to approx. 7500 kWh and in case 900 reached the value of almost 7000kWh. The lowest energy demands were recorded for climate type ISO. Results obtained with basic climate file WEYC2 were closer to ISO results. The rest of untypical climate files gave results a bit lower from the most severe UMY v2 climate.

Table 7 Total annual heating demands for north oriented cases and different climate files

CLIMATE DATA	ANNUAL HEATING – NORTH ORIENTATION FOR CASE [kWh]			
	600	610	900	910
ISO	6142	6445	5699	6076
WYEC2	6389	6687	5962	6312
UMY v1	6982	7300	6579	7103
UMY v2	7407	7732	6955	7504
UMY v3	6997	7311	6585	7113

Figure 5 shows for each of the month that UMY files gave higher values of heating energy consumption than standard ISO and WYEC2 files. The highest value of monthly heating energy demand was noted for the month of January and UMY v2 climate file and reached to approx. 1800kWh. Small energy consumption for heating was also noted in each case in the summer months. No significant difference was noted between the results for different cases.

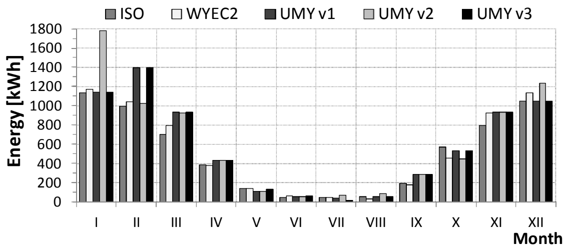

Figure 5 Monthly energy heating demands for north oriented case 600 and different climate files

Table 8 indicates the highest annual cooling demand for climate type UMY v3. In the analysed cases the energy varies depending on case from 801 kWh (case 910) to 2967kWh (case 600). The lowest energy demands were recorded for climate type ISO. Results obtained with basic climate file WEYC2 were very close to ISO. The most comparable results for untypical climates were noted for UMY v1 and UMY v3 files.

Table 8 Total annual cooling demands for south oriented cases and different climate files

CLIMATE DATA	ANNUAL COOLING – SOUTH ORIENTATION FOR CASE [kWh]			
	600	**610**	**900**	**910**
ISO	2568	1347	951	801
WYEC2	2557	1407	1010	840
UMY v1	2879	1448	1220	1041
UMY v2	2781	1364	1014	925
UMY v3	2967	1462	1286	1147

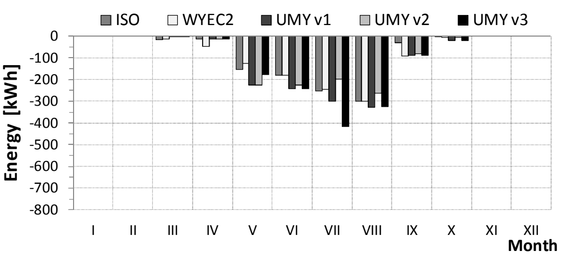

Figure 6 Monthly energy cooling demands for south oriented case 900 and different climate files

Figure 6 shows the highest monthly cooling energy demands recorded in most cases for untypical climates. However, in August, results for ISO and WYEC2 files almost reached the values obtained for UMY files. The highest value of monthly cooling demand was noted for the month of July and UMY v3 climate file and reached to approx. 420kWh. Small energy consumption for cooling was also noted in each case of the interim months (March, April and October). A significant difference was noted between the results for different cases.

Table 9 indicates, without noticeable differences, the highest peaks in heating power demand for all climates type UMY. The highest peaks in cooling power demand were recorded for standard files type ISO and WYEC2 (as well without noticeable differences). In the analysed cases the power demands for heating vary depending on case from 2,39kW (case 910) to 3,94kW (case 600) and for each case results do not differ significantly. The power demands for cooling vary depending on case from 2,59kW (case 910) to 7,26kW (case 600), thus each case should be examined separately. For the most power demanding case 600, the difference between the highest (7,26kW) and the lowest (4,68kW) peaks for typical (ISO) and untypical (UMY v1) years reaches 55%.

Table 9 Peaks in heating and cooling for west oriented cases and different climate files

CLIMATE DATA		PEAK HEATING & COOLING FOR CASE [kW]			
		600	**610**	**900**	**910**
ISO	Heating	2.66	2.66	2.40	2.39
	Cooling	7.26	5.91	3.55	2.94
WYEC2	Heating	3.10	3.10	2.78	2.67
	Cooling	7.24	6.28	3.83	3.25
UMY v1	Heating	3.94	3.94	3.54	3.45
	Cooling	4.68	4.19	2.73	2.48
UMY v2	Heating	3.93	3.93	3.51	3.56
	Cooling	5.09	4.44	3.03	2.59
UMY v3	Heating	3.94	3.94	3.54	3.45
	Cooling	5.15	4.65	3.20	2.93

Table 10 Total annual amount of hours above or below specified value

CLIMATE DATA		NUMBER OF HOURS FOR SOUTH ORIENTED CASE [h]			
		600	**610**	**900**	**910**
$T_R > 27$ºC	ISO	1616	1255	1538	1307
	WYEC2	1628	1292	1698	1441
	UMY v1	1688	1358	1878	1631
	UMY v2	1700	1341	1673	1448
	UMY v3	1710	1385	1869	1647
$T_R < 20$ºC	ISO	4975	5268	4139	5033
	WYEC2	4853	5145	4115	4793
	UMY v1	4810	5107	4124	4896
	UMY v2	4835	5124	3988	4869
	UMY v3	4802	5097	4125	4911

Table 10 indicates the highest value of number of hours when the resultant temperature (T_R) drops below 20ºC or raises above 27ºC. The number of hours when $T_R > 27$ºC depends on the considered case, but in general is the greatest for UMY v3 file and the lowest for ISO file. The number of hours when $T_R < 20$ºC as well depends on the considered case and in general is the greatest for UMY v3 file and the lowest for ISO file.

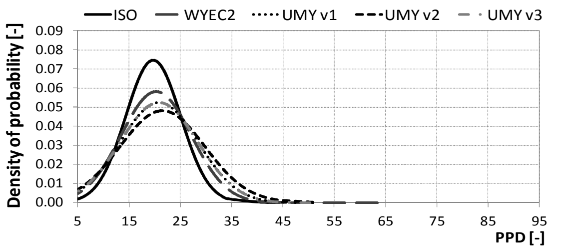

Figure 7 Normal distribution of PPD – case 900 west oriented

Figure 7 and show the normal distribution of PPD comfort parameter over the whole year. The assumptions for evaluation of PPD were adopted as follows:

- MET = 1,2 (metabolic rate as for sedentary activity);
- in the cooling season clothing level (CLO) = 0,5 & air velocity (A_V) = 0,19 m/s;
- in the heating season CLO = 1,0 & A_V = 0,16 m/s.

The highest uncertainty in PPD (Fig. 7) is revealed for UMY v2 file and the smallest uncertainty is revealed for ISO file. That stays in good comparison with the presented normal distribution of temperature (Fig. 8).

CONCLUSION

The difference between the lowest and the highest annual heating energy demands reached roughly value of 24% (in comparison to the results for north oriented cases in tab. 7). The highest peaks in power demands for heating were also recorded in the results for UMY files. It can be concluded that untypical climate files could be useful in prediction of maximum cost of building operation during severe winters. These should be also used to predict the size of systems of heating power supply. However, for representative predictions of heating energy demands the typical weather files will be sufficient. Taking into consideration the lowest dry bulb temperatures, some heating energy consumption was recorded also during the summer time. The building operation in moderate climate of analysed location shows that in practice such necessity does not occur.

The difference between the lowest and the highest annual cooling energy demands reached roughly value of 43% (in comparison to the results for south oriented cases in tab. 8). Additionally, the percentage differences for ratio max/min cooling demands occurred as well between the analysed cases. It can be concluded that untypical climate files could be useful in prediction of maximum cost of building operation during hot summers. What is the most important, the highest peaks in power demands for cooling were recorded for the typical ISO and WYEC2 weather data files. For the most power demanding case, the difference between the highest and the lowest peak reached 55%. Thus, typical meteorological years can be more adequate for predicting the cooling power demands.

Results obtained for the PPD analysis leads to conclusion that the smallest uncertainty will be assured by the climates determined with standard ISO or WYEC2 methodology.

NOMENCLATURE

FS_j – Finkelstein- Schafer statistic for parameter,

$J(i)$ - the rank order of the *i-th* value of daily means within that month and that year,

$K(i)$ - the rank order of the *i-th* value of daily means within that calendar month in the whole data set,

n - the number of daily readings in a month,

w_j – weighting for parameter (from Table 1)

δ_i - the absolute difference between the long-term CDF and the candidate month CDF at x_i.

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