UTICAJ BRZINE VETRA I INSOLACIJE NA POTROŠNJU ENERGIJE ZGRADE

INFLUENCE OF WIND SPEED AND INSOLATION ON HEAT CONSUMPTION IN BUILDINGS

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Rad uvodi aspekt pravilnog izbora podataka eksploatacije vezanih za toplotu isporučenu jednoj zgradi radi ocenjivanja uticaja brzine vetra, insolacije ili nivoa oblačnosti na potrošnju energije. Posmatrana zgrada ima tradicionalan sistem centralnog grejanja sa vertikalama i konvektivnim radiatorima u svakom stanu sa grejnim medijumom temperature 80/60 °C. Analizirani su podaci jedne sezone i prizani su rezultati uticaja vetra brzine ispod 3 m/s, 3–6 m/s i preko 6 m/s na količinu isporučene toplote. Vrlo precizna merenja su vršena više puta danju i noću.

Ključne reči: brzina vetra; insolacija; potrošnja energije

This work introduces the aspects of the proper choice of the exploitation data connected with heat supplied to a building in order to estimate the influence of wind speed, insolation or level of cloudiness on energy consumption. The analyzed building had a traditional, central heating installation with vertical risers in each flat and convective radiators and supplied with the heating medium (80/60 °C). The exploitation data from one heating season were analyzed and the influence of the wind speed within the range below 3 m/s, 3÷6 m/s and above 6 m/s on the value of the heat power delivered to the building was presented. Different times of the day and night were taken into account and the attention to the accuracy of obtained results was paid.

Key words: wind speed; insolation; energy consumption

1. Introduction

Heat consumption in existing residential buildings accounts for approximately 40% of the total heat consumption in the European Union [1]. That is why, it is so important to determine the impact of the main external factors (outdoor air temperature, wind speed and solar radiation) on the heat supplied to buildings during their operation under real conditions [2,3]. It may allow for proper control of heat supply, taking into account weather forecast and achieving energy savings while maintaining the thermal comfort of residents [4,5]. Therefore, this paper introduces the aspects of the proper choice of the exploitation data connected with heat supplied to a building in order to estimate the influence of wind speed and insolation.

2. Materials and Methods

Experimental research was carried out in one multi-family residential building located in Lublin (Poland) in one heating season, which lasted from the beginning of October until the end of April. The multi-family building under test is a building after thermomodernization (with heat transfer coefficients below 0.3 W/(m²·K) for external walls and below 2.0 W/(m²·K) for windows) and has a traditional heating installation with vertical risers in each flat and convective radiators). The heating medium parameters are 80/60°C. The heat source for the building is an individual thermal station for heating and hot water purposes, which is supplied from a high temperature district heating network. The calibrated heat meter measures hourly heat consumption used in the heating system.

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The tests, apart from measuring the heat supplied to the analyzed building, also included the measurement of outdoor parameters (outdoor air temperature, wind speed (average and maximum), insolation), which prevail in the immediate vicinity of the analyzed building, every one hour. The analysis includes various hourly ranges for the analyzed data (all day: 0.00–23.59, 6.00–18.00, 18.00–6.00, 23.00–4.00), in order to show the impact of this aspect on the accuracy of the equations being developed.

3. Results and Discussion

First of all, the impact of wind speed on heat supplied to the analyzed building was investigated, which is shown in Figures 1–3. Therefore, linear equations correlating the value of outdoor temperature and heat supplied to the building at wind speed below 3 m/s, in the range of 3–6 m/s and over 6 m/s were developed.

Figure 1. Heat delivered to the building between hours 0.00 and 23.59 by average wind speed.

On the basis of the results presented in Figures 1–3, it can be seen that the logical dependence of the influence of the wind on the heating power delivered was obtained because the heat delivered to the building increases with increasing wind speed. For example, in Figure 1, linear matches to the results are presented, grouped according to the average wind speed in the ranges of 0–3, 3–6, and above 6 m/s. The range covering the lowest wind speeds of 0–3 m/s is characterized by a high correlation ($R^2 = 0.78$) of the heat supplied and the outdoor air temperature. Values of correlation coefficients decrease along with the increase of wind speed reaching moderate level ($R^2 = 0.49$) for wind speed over 6 m/s.

However, it should be emphasized that dependencies of this type should always be developed individually for a given building, because each object reacts in an individual way to the weather conditions in the field of wind speed. Additionally, in order to clearly underline the impact of the range of

hours during the day, from which the data is taken to develop the above discussed relationships, the correlation coefficients obtained for the analyzed cases in Table 1 were summarized. Based on the obtained results, it can be seen that higher values of correlation coefficients for developed dependencies are obtained using the maximum wind speed and data from 23.00–4.00 hours. It is related to the fact of minimizing other external factors (in particular insolation) as well as internal factors (user behavior) during the night hours.

Figure 2. Heat delivered to the building between hours 0.00 and 23.59 by maximum wind speed.

Figure 3. Heat delivered to the building between hours 23.00 and 4.00 by maximum wind speed.

In addition to the influence of wind speed on the heat supplied to the analyzed building, the influence of insolation (J/cm^2) was also investigated, as shown in Figure 4 for four different ranges of insolation (0–35, 35–100, 100–200, above 200 J/cm^2).

It can be noticed that logical dependencies were obtained for the analyzed building, because with the increase of insolation, the value of heat supplied to the building decreases. In turn, when analyzing the obtained values of regression coefficients for the analyzed variants (Table 2), it can be concluded

that the developed equations have higher correlation coefficients at lower wind speed (less than 3 m/s) than at higher ones. In addition, it is better to take into account the maximum (instead of the average) wind speed. This is due to the fact that when determining the effect of insolation on the thermal power delivered to a building, one should try to minimize the simultaneous effect of wind speed on the heat consumption.

Table 1. The regression coefficients for analyzed cases for wind speed

Time	Wind speed	v < 3m/s	3-6 m/s	v > 6m/s
0.00-23.59	average	0.7818	0.4051	0.4864
	maximum	0.8004	0.7799	0.5472
6.00-18.00	average	0.7681	0.4393	0.4136
	maximum	0.7823	0.7579	0.5867
18.00-6.00	average	0.8092	0.3538	0.9248
	maximum	0.8253	0.8176	0.4663
23.00-4.00	average	0.8168	0.3927	-
	maximum	0.8251	0.8396	0.4287

Figure 4. Heat delivered to the building for different levels of insolation by maximum wind speed

4. Conclusion

Currently, the important issue is to determine the impact of major external factors (outdoor air temperature, wind speed and solar radiation) on the heat supplied to buildings. Therefore, this paper presents various methodological aspects that affect the accuracy of the obtained results. It was noted that the linear regression of developed equations for wind speed have the highest correlation coefficients, taking into account (by calculations) only the data from night hours (23.00-4.00).

In turn, when determining the influence of insolation on thermal power, it is recommended to take into account the data at the lowest possible value of wind speed.

Table 2. The regression coefficients for analyzed cases for insolation

Insolation	Wind speed	v < 3 m/s	3-6 m/s	v > 6 m/s
0-35 J/cm²	average	0.7948	0.3589	0.6361
	maximum	0.9145	0.7997	0.4991
35-100 J/cm²	average	0.7811	0.4777	0.6773
	maximum	0.8675	0.7920	0.6017
100-200 J/cm²	average	0.7743	0.7504	-
	maximum	0.7954	0.8685	0.8448
>200 J/cm²	average	0.4226	0.3460	-
	maximum	0.6834	0.5270	0.5548

A detailed description of these methodological aspects and the methodology for determining the equivalent value of the outdoor air temperature, which takes into account the impact of wind speed and solar radiation or cloud cover, will be presented in the extended version of this paper.

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