proceedings

Investment Costs of Heating in Poland and Spain—A Case Study †

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Abstract: Heating a room or a building is a basic annual operating cost. This paper presents typical heating systems in Poland and Spain. Based on the calculations made for lecture rooms located in different climate zones in Poland and Spain, the design heat loss and energy demand for heating are compared and analyzed. Additionally, the paper includes a statement about selected radiators and a comparison of their purchase costs for individual locations.

Keywords: heating system; heat loss; radiators; central heating

1. Introduction

The construction of buildings is undoubtedly a fundamental and costly investment. One of the main decisions, which has to be made by the investor and has an impact on comfort of usage, is choosing a suitable heating system.

The major task of heating systems is providing the proper amount of heat energy to individual rooms, thereby maintaining optimal temperature conditions. Heating is one of the largest annual operating expenses. The final cost of heating in public buildings like schools depends on a variety of factors, for instance, the type and size of the thermal insulation, the profile of usage, indoor temperature, regulation, and distribution, which have been discussed by Krawczyk [1].

Due to continuous technological development in the field of the heating devices, the investor has a wide range of solutions, products, and materials, with different properties, advantages, and disadvantages. Moreover, in recent years, decisions and actions of the European Union have aimed to increase the environmental awareness of society and standardize regulations concerning energy consumption in residential and public objects in European Union member states. Examples of analysis of energy consumption for heating in different types of buildings have been presented in [2–5].

Having high standards of building energy efficiency has many advantages, such as low operating costs. From the point of view of the owners, it is a very important issue, due to rising energy prices. In addition, the above-mentioned requirements are used to prevent climate change and reduce carbon dioxide production in energy processes, which are the main threats to contemporary Europe.

The aim of this paper is to analyze and compare typical heating systems in Poland and Spain, as well as to assess energy consumption and investment costs for the chosen system.

Based on calculations made for the lecture room located in eight cities in different climate zones in Poland and Spain, the design heat loss and energy demands for heating are compared and analyzed.

2. Description of the Object

The analyzed room is located in the building of Civil and Environmental Engineering Faculty of the Bialystok University of Technology, on the ground floor. The building has three over-ground floors and is entirely composed of basement. The facility was built on a reinforced concrete structure and put into use in 1988. In the years 2014–2015, it was comprehensively thermo-modernized using renewable energy sources. Modernization included also building insulation improvement as well as modernization of ventilation, air conditioning and central heating systems [6]. Figure 1 presents the analyzed room.

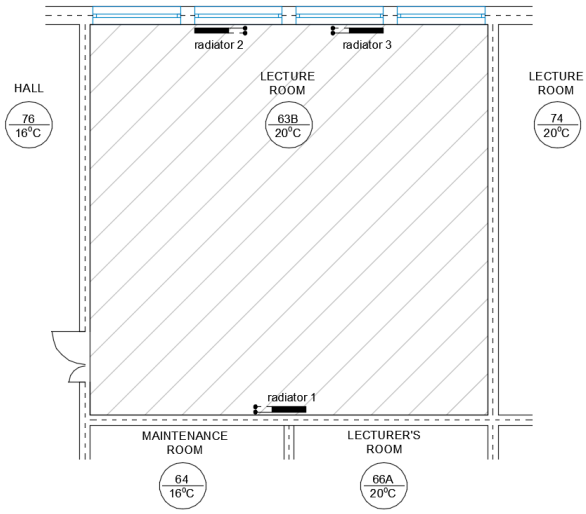

Figure 1. The plan of the analyzed room.

3. Methodology

"U" values for individual building partitions have been taken from [7]. The comparative analysis of heat loss from this room was carried out for eight cities located in different climate zones. Four cities were selected in Poland (Bialystok, Wroclaw, Warsaw, and Gdansk), and four in Spain (Cordoba, Madrid, Barcelona, and Burgos). The division into climatic zones was made on the basics of the PN-EN 12831 standard [8] for Poland and Documento Basico HE Ahorro de Energia, Septimbre 2013 [9] for Spain.

The calculations were performed using the program Purmo OZC 6.7.

For the purposes of this analysis, the indoor temperature was set at 20 °C in both locations, as the obligatory design temperature in Poland [10]. This value was also included in the recommended indoor temperature range in winter in Spain [11–13].

4. Calculations and Results

The results of the heat loss calculations of different locations in Poland and Spain are presented in Table 1 below.

Table 1. Heat loss from the room depending on the location.

Location	Heat loss [W]	Transmission Heat Loss [W]	Ventilation Heat Loss [W]
Bialystok	3475	2411	1064
Wroclaw	3167	2205	963
Warsaw	3321	2308	1013
Gdansk	3013	2101	912
Cordoba	1805	1291	514
Madrid	2067	1466	600

Location	Heat loss [W]	Transmission Heat Loss [W]	Ventilation Heat Loss [W]
Barcelona	1690	1213	476
Burgos	2213	1564	649

Table 2 shows the selected radiators: panel convector radiators Purmo Ventil Compact, equipped with built-in thermostatic valves.

Table 2. Selection of radiators.

Location	Selected Radiators	Total Cost [€]
Bialystok	3 x CV21S-60 1,0 m	727
Wroclaw	3 x CV21S-60 0,9 m	687
Warsaw	3 x CV21S-60 1,0 m	727
Gdansk	3 x CV21S-60 0,9 m	687
Cordoba	3 x CV11-60 0,7 m	451
Madrid	3 x CV11-60 0,8 m	646
Barcelona	3 x CV11-60 0,7 m	451
Burgos	3 x CV11-60 0,9 m	501

Figure 2 below shows the comparison of energy demand in different locations in Poland and Spain. The energy demand depends on the design heat load, the number of heating degree days, and the difference between the average maximum and minimum temperature of the year.

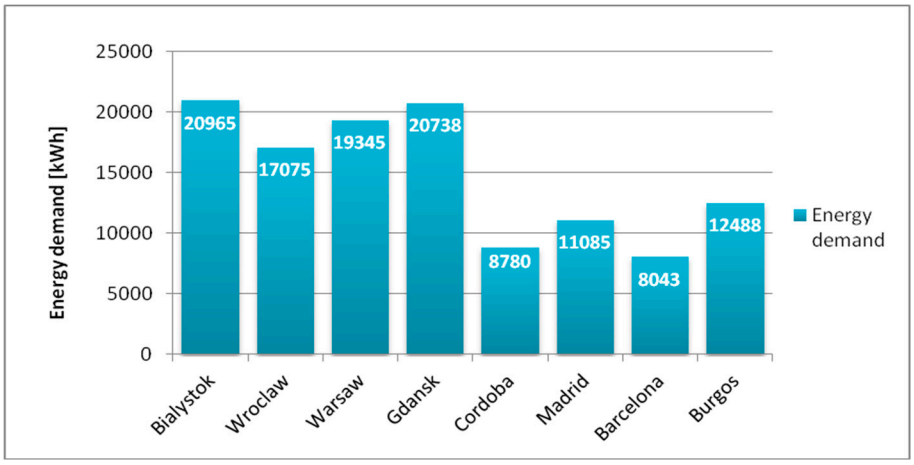

Figure 2. Comparison of the energy demand in different locations.

The highest energy demand was recorded in Bialystok (Poland) (20,965 kWh), while the lowest (8043 kWh) was recorded in Barcelona. The difference between energy demand in Bialystok and Barcelona was 12,922 kWh, which means that energy demand in Bialystok was more than 2.5 times higher than in Barcelona. In addition, the average energy demand achieved in Polish cities was 19,531 kWh, while in cities located in Spain it was almost two times lower (10,099 kWh).

5. Analysis and Conclusions

On the basis of the obtained results of the calculations, a comparative analysis of the total design heat loss of the building located in different climate zones was conducted. The results are presented on the Figure 3.

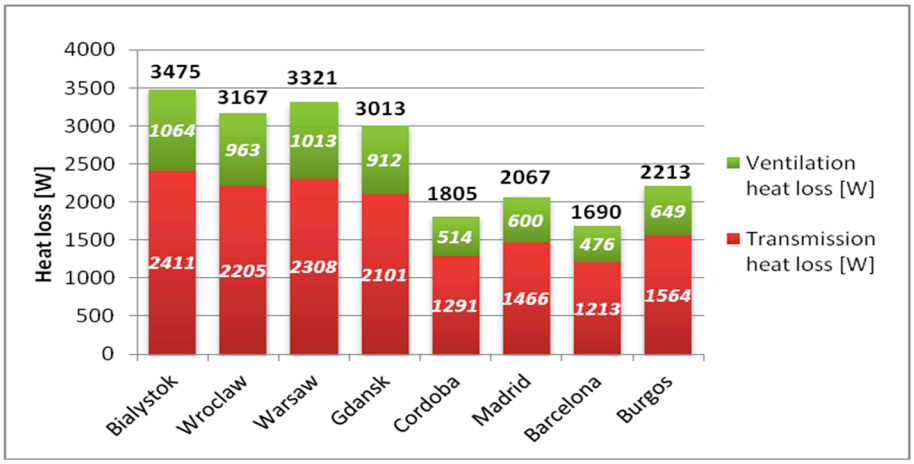

Figure 3. Comparison of the total design heat loss in different locations.

The highest total heat loss was recorded in Bialystok (Poland) (3475 W), while the lowest (1690 W) was recorded in Barcelona (Spain). The difference between the total design heat loss in Bialystok and Barcelona was 1785 W, more than 50%. In each case, both ventilation and transmission heat loss of places located in Poland were higher than in Spain. Additionally, the average result achieved by all Spanish cities were 1300 W lower than the result achieved by Polish cities.

The main differences between radiators selected for the analyzed room located in different climate zones were their dimensions, type, and cost. In Bialystok, Wroclaw, Warsaw, and Gdansk, radiator type 21S with a length of 0.9 or 1.0 m was chosen, while in Cordoba, Madrid, Barcelona, and Burgos, radiator type 11 with length between 0.7 and 0.9 m was chosen.

In every variance of the location, the differences in the total design heat loss, ventilation heat loss, and transmission heat loss were caused by the differential in the average annual temperatures and outdoor design temperatures. The bigger the difference between inside and outside temperature, the more intense were the heat transfer processes. Additionally, as can be noticed, the climate zone had a significant impact on the heat loss obtained by room.

Author Contributions: D.A.K. and A.R. conceived and designed the experiments; A.W. performed the experiments and analyzed the data; D.A.K. and A.R. contributed analysis tools; and A.W. and D.A.K. wrote the paper.

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Conflicts of Interest: The authors declare no conflict of interest.

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