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Economic indicators of a heating system of a building in Ukraine and Poland

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Abstract: In this article the economic indicators of a two-pipe water heating system of a residential building in Ukraine and Poland are identified. It was established that the requirements for the premises in which the heating system is designed in Poland are stricter than the requirements in Ukraine. Most notably, in Poland, the maximum heat transfer coefficient of enclosing structures and the value of indoor air temperatures in residential premises, which should be maintained by the heating system, is lower. This allows the design of heating systems for residential buildings in Poland with a lower heating capacity. However, due to the higher cost of heating equipment and workers' salaries, the economic indicators of a water heating system in Poland is higher than in Ukraine.

Keywords: heating system, economic indicators, capital investments, operating costs

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Introduction

The purpose, design and operating conditions of a building determines the features of the thermal regime of the premises, and accordingly the design, parameters and mode of operation of heating systems (Lis, 2019; Lis & Lis, 2019). The thermal regime of some buildings is maintained constant throughout the heating period, in other buildings, to save thermal energy, there is maintained a variable thermal regime during the non-working period of the day or weekends by reducing indoor air temperature (Yurkevych & Savchenko, 2010) In residential buildings, the thermal regime on the premises should be constant throughout the heating period.

To maintain the thermal regime in residential buildings water heating systems with radiators are most common in Ukraine and Poland. An autonomous gas, solid fuel or electric boiler, and a central heat source, boiler room or CHP can be used as a heat source (Zhelykh et al., 2015; Wojdyga & Chorzelski, 2017; Szkarowski, 2019). At present renewable fuels are becoming popular in district heating systems (Savchenko et al., 2018; Millar et al., 2019).

Before designing a heating system, a feasibility study is carried out, which analyzes all components of the investment project and determines the terms of return on investment. In an economic comparison of heating systems, indicators such as capital investment costs, operating costs, duration of installation works and the operation of heating systems should be used. After the feasibility study, the economic effect is established, the value of which allows the choice of heating system that is the most economic in regards to the specific building.

1. Purpose of work

This study aims to compare the economic performance of a two-pipe heating system of a single-family residential building built in Ukraine and also in Poland.

2. Analysis of existing research

Capital investment and operating costs are the main economic indicators of any heating system (Kravchenko & Kravchenko, 2016). Capital investments include initial investments in the purchase of heating equipment, pipelines, fittings, etc. Operating costs consist of direct costs of the heating system maintenance and depreciation costs:

$$C = C_{dir} + D \tag{1}$$

where:
C_{dir} – direct costs of the heating system maintenance,
D – depreciation costs.

Direct operating costs include annual costs for heat generation, electricity, staff salaries, system management and maintenance (Zhelykh & Dzeryn, 2012). Depreciation costs take into account the annual cost of overhauling the system and deductions for the full return on capital investment.

The given costs for the installation and operation of the heating system are determined by the formula:

$$G = C + E_n \cdot K \tag{2}$$

where:
C – operating costs of the heating system,
K – capital investments in the heating system,

E_n – normative coefficient of economic efficiency of capital investments, it is equal to E_n = 0.12 l/year.

Capital investments are determined by the equipment used in the designed heating system and the calculated heat capacity.

When determining the efficiency of a heating system, the climatic parameters of the outside air and the parameters of the indoor microclimate, as well as the requirements for thermal insulation of the surrounding structures, are taken into account. The parameters of outdoor air for different cities in Ukraine are determined in accordance with DSTU-N V V.1.1-27, in particular, there are calculated outdoor air temperatures for the design of heating systems. The territory of Poland is divided into 5 climatic zones (Fig. 1b), each of which is characterized by a definite value of outdoor air temperature according to the standard PN-EN 12831.

The indoor air temperature, which should be maintained by the heating system, is regulated in Ukraine by DBN V.2.5-67. In Poland, air temperature in buildings is included in the Regulation of the Minister of Infrastructure on technical conditions and how they should respond to buildings and their location. The indoor air temperature that should be maintained by the heating system in residential buildings in Ukraine and Poland are given in Table 1.

Table 1. The indoor air temperature that should be maintained by heating systems (DBN V.2.5.-67, OJ 2019, pos. 1065)

No	Premises	The indoor air temperature [°C]	
		Ukraine	Poland
1	Kitchen	19.5	20
2	Living room, bedroom	22	20
3	Corridor, utility room	19.5	20
4	Study	22	20
5	Bathroom, combined bathroom	25	24
6	Toilet	22	20

As seen in Table 1, the values of indoor air temperature in Poland are lower than the normative Ukrainian values for indoor air temperature.

Requirements for the thermal insulation properties of external building envelopes depend, in Ukraine, on the climatic zone in which the building is located (Fig. 1) and are adopted in accordance with the requirements of the Ukrainian DBN V.2.6-31. In Poland, the requirements for thermal insulation of a building's envelope are uniform throughout the country and are included in the Regulation of the Minister of Infrastructure on technical conditions and how they should respond to buildings and their location.

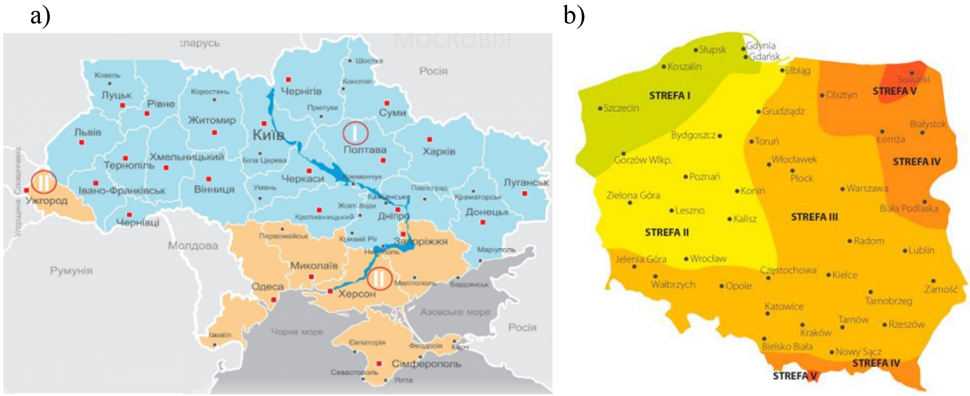

Fig. 1. Climatic zones of Ukraine (a) and Poland (b) (DBN V.2.5-67; PN-EN 12831)

The maximum heat transfer coefficients of a building's envelope in Lviv (Ukraine) and in Poland are given in Table 2.

Table 2. The maximum values of heat transfer coefficients for a building's envelope (DBN B.2.6-31, OJ 2019, pos. 1065)

No	Enclosing structure	The maximum values of heat transfer coefficient	
		Lviv (Ukraine)	Poland
1	Exterior walls	0.30	0.20
2	Covering over the heated attic	0.20	0.15
3	Overlapping over unheated attic	0.20	0.15
4	Overlapping over unheated basement	0.27	0.25
5	Exterior windows	1.33	0.90
6	Exterior doors	1.67	1.30

As seen in Table 2, in Poland, there are more stringent requirements for the thermal insulation of enclosing structures than in Ukraine. This reduces heat loss through the building's envelope during the heating season, and thus reduces the investment expenditure for the heating system.

3. Main material

To compare economic indicators, a heating system was selected in a building, whose external climate parameters matched the corresponding meteorological station climate parameters both in Lviv (Ukraine) and Rzeszow (Poland). The building has two floors. On the first floor there are seven rooms, and on the second floor five rooms. The total heating area of the building is 113.9 m^2, and the heating volume is 296.14 m^3. The heat source is a self-serving internal boiler room.

The heat capacity of the heating system is determined by the value of the total heat loss of the building.
The total heat loss of the building [kW] is determined by the formula:

$$Q = Q_{tr} + Q_{v} \tag{3}$$

where:
Q_{tr} – transmission heat loss [kW],
Q_{v} – heat lost to heating the ventilation air [kW].

Heat losses of the building for Lviv are determined according to the methodology of the Ukrainian regulations and, accordingly, are Q_{tr} = 5.678 kW, Q_{v} = 4.667 kW. The total heat loss of the house is 10.345 kW.

The calculation for transmission heat losses of the building for Rzeszow parameters, heat for heating the ventilation air, as well as the total heat capacity of the heating system was performed using the program Audytor OZC 6.9 in accordance with the algorithms contained in Polish standards. Transmission heat loss was 4.882 kW, and ventilation heat loss was 2.084 kW. The total heat loss of the building, and, accordingly, the total heat capacity of the heating system was equal to 6.932 kW.

The two-pipe system water heating with panel steel radiators from the central heating system was designed to maintain the thermal regime on the premises of the building. The steel panel radiators, Therm X2 Profil-V FTV 22 from the Kermi company were chosen as heating devices. The movement of the heat carrier was by a multilayer pipe provided by the KAN-therm company (PE-RT/AL/PE-RT Multi Universal). The pipes of the heating system were installed under the floor, the connection to the heating devices was from below.

Local estimates for a heating system have been developed to determine capital investment of the building in Lviv and Rzeszów. Accordingly, the capital investment for the heating system of a residential building built in Lviv is K_{Lviv} = 1939.3 euro, and for a house in Rzeszow – $K_{Rzeszow}$ = 1946.5 euro.
Operating costs for the heating system of the house in Lviv are equal to C_{Lviv} = 732 euro, in Rzeszow – $C_{Rzeszow}$ = 884 euro.

The given costs for the heating system of a residential building for the two cities are:
– Lviv: $G_{Lviv} = 732 + 0.12 \cdot 1939.3 = 964.7$ euro
– Rzeszow: $G_{Rzeszow} = 884 + 0.12 \cdot 1946.5 = 1117.6$ euro

As seen from the calculations, the economic indicators of the heating system of a building built in Lviv and Rzeszow differ slightly. Despite the lower installed capacity of the heating system for the building in Rzeszow, the capital investment is almost equal to that of the building in Lviv. This is due to high prices for heating equipment in Poland. The higher value of operating costs for the heating system in Rzeszow is due to higher salaries.

Conclusions

In this article it was established that the requirements for the thermal performance of external enclosures of buildings in Poland are more stringent than in Ukraine. The maximum heat transfer coefficient of a building's envelope is less than a similar building in Ukraine. In addition, the indoor air temperature in residential buildings in Poland, maintained by the heating system, are lower than that of Ukraine. Therefore, Polish regulations reduce the thermal capacity of the heating system in buildings. However, the high cost of heating equipment and the high salaries of employees increase the economic performance of water heating systems in Poland. In the future, to reduce the thermal capacity of the heating system in Ukraine, it is advisable to strengthen the requirements for the thermal performance of external enclosures of the house, in particular, to reduce the regulatory value of the heat transfer coefficient of external enclosures.

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