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Possibilities of Reducing Energy Costs in the Life Cycle of Office Buildings

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1 Introduction

Buildings are the largest energy consumer in Europe, utilizing about 40% of final energy, of which more than 55% is used for room heating and cooling. At the same time, it is estimated that about one third of the world's energy consumption is related to the use of office and residential buildings. An additional problem is that most of this energy is supplied from non-renewable sources, which contributes to environmental degradation and significant heating/cooling costs (Arendt *et al.*, 2015). It should also be remembered that oil and gas resources are limited and no longer so readily available (Firląg, 2018).

The aim of the paper is to analyse the possibility of reducing energy consumption in office buildings in all phases of their life cycle.

2 Energy Consumption of Buildings in the Various Life Cycle Phases

When analysing the energy consumption of buildings in Poland, it is estimated that at the stage of construction of a building the energy consumption amounts to about 10%, at the stage of use (with implementation performed according to the current standards) – to about 72%, for the needs of renovation – to about 15% and for the demolition of the building – from 1 to 3% of the total accumulated energy demand in relation to the life cycle of the building, as illustrated in Figure 1.

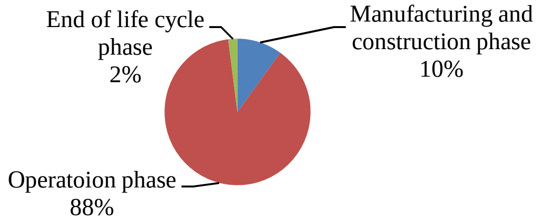

Figure 1. The energy consumption of buildings.

3 Cost-Benefit Analysis of Solutions that Improve the Energy Efficiency Standard of an Office Building

Simulations concerning analyses and benefits resulting from energy-saving construction were performed by the Polish National Energy Conservation Agency on the example of buildings of different purpose (Węglarz, 2017). One of the buildings under analysis was an office building. The model office facility selected for the analysis was a 6-storey building with a usable area of 2 124 m^2. On the basis of simulations and additional own analyses, the authors performed calculations which enabled the assessment of costs and benefits resulting from the application of solutions that increase the energy efficiency of the office building.

For standard buildings, the classic and most frequently used installation solutions were adopted, that is water heating systems with convector heaters and boilers for coal, natural gas, fuel oil, LPG or the application of a heat substation with a connection to a district heating network. In a high standard building, it was assumed that, in comparison to a standard building, the insulation thickness of the envelope was increased by 20 cm and that windows with a penetration coefficient of 0.5 $W/(m^2 \cdot K)$ were used.

In addition, for the model building with energy-saving standards, the following were applied: higher thickness of pipeline thermal insulation, better quality control valves and thermo-valves, water-saving fittings in the hot water installation and mechanical ventilation with heat recovery of 85%. For the building with collectors, the use of flat solar collectors with an area of 32 m^2 was predicted.

The results of simulation analyses for an office building and coal heating are presented in Table 1.

Table 1. Results of simulation analyses for an office building for coal heating.

	construction cost [EUR]	Annual energy cost [EUR/year]	LCC [EUR] (30 year; r=5%)
Standard building	1 373 692	8 428	1 915 361
High-standard building with cooling and heating ceilings	1 432 377	6 730	1 900 120
High standard building with collectors	1 506 222	1 966	1 868 795
High standard building with heat pump	1 536 054	2 096	1 731 453

4 Conclusions

Buildings absorb energy to varying degrees at every stage of their life cycle. By far the greatest demand for energy occurs during the operation phase of a building. Reducing energy consumption during this phase is necessary for both economic and environmental reasons.

The life cycle cost analysis of an office building conducted in the present paper showed the effectiveness of the use of cooling and heating ceilings, solar collectors and heat pumps.

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