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FRANK U. VOGDT, MANUELA WALSDORF-MAUL, KATHLEEN SCHWABE, FALK SCHAUDIENST, ANNE BAUMBACH*

COMPARISON BETWEEN CALCULATING METHODS OF ENERGY SAVING REGULATIONS AND THEIR ECONOMIC EFFICIENCY

PORÓWNANIE METOD OBLICZENIOWYCH WYKORZYSTYWANYCH W PRZEPISACH DOTYCZĄCYCH ENERGOOSZCZĘDNOŚCI ORAZ ICH WYDAJNOŚCI EKONOMICZNEJ

A b s t r a c t

Following directive (2002/91/EG) adopted by the European Parliament and Council in December 2002 the European member states have to develop simplified calculation procedures of energy performance of buildings. The choice of building components, heating, cooling and ventilation systems as well as lighting plays an important role in the energy performance of buildings. This paper deals with the comparison of possibilities calculating energy savings for residential buildings: using the DIN V 4108-6 [4], the German standard DIN V 18599 [5], the European standard DIN EN 13790 [3] and the American standard ASHRAE 90.1 [6]. Therefore an exemplary residential building is calculated of the methods mentioned above different varying building components and house technology. The variants range from standard buildings to low energy buildings.

Keywords: energy demand, analysis of economic efficiency

S t r e s z c z e n i e

Zgodnie z zarządzeniem 2002/91/EG przyjętym przez Parlament Europejski i Radę Europy w grudniu 2002 roku kraje członkowskie UE muszą opracować uproszczone procedury obliczeniowe w odniesieniu do energetycznej wydajności budynków. Znaczącą rolę odgrywa tu wybór elementów budowlanych oraz systemów grzewczych, chłodzących, wentylacyjnych i oświetleniowych. W niniejszym artykule porównano możliwości obliczania energooszczędności w budynkach mieszkalnych przy zastosowaniu: DIN V 4108-6 [4], zarządzenia niemieckiego DIN V 18599 [5], zarządzenia europejskiego DIN EN 13790 [3] oraz zarządzenia amerykańskiego ASHRAE 90.1 [6]. Dlatego właśnie parametry przykładowego budynku mieszkalnego, w którym zastosowano różnego rodzaju materiały i technologie budowlane, obliczono za pomocą wyżej wymienionych metod. Zakres badań obejmuje rozmaite kategorie: od budynków standardowych po niskoenergetyczne.

Słowa kluczowe: zapotrzebowanie na energię, analiza wydajności ekonomicznej

* Prof. PhD. Eng. Frank U. Vogdt, Eng. Manuela Walsdorf-Maul, BSc. Kathleen Schwabe, MA Falk Schaudienst, Eng. Candidate Anne Baumbach, Technische Universität, Berlin.

1. Introduction

This paper "Comparison between calculating methods of Energy Saving Regulations and their economic efficiency" deals with the energy balances of an exemplary residential building followed by analysis of the economy. As a basis of calculating different standards are used. This involves the European standard DIN EN 13790 [3], the German standard DIN V 4108-6 [4] and DIN V 18599 [5] and the American standard ASHRAE 90.1 [6]. In addition to the above standards different technical building equipments are compared. It is assumed that the standard building has exemplary an oil condensing boiler. This standard version is used for energy balance and compared to different varieties of low energy buildings. For low energy varieties the same building is equipped with district heating, pellets heating or heating pump. To compare the calculations with different standards it is necessary to explain the difference of calculating between the standards above but also the building geometry. For energy balance the building physics software DÄMMWERK [1] and ENERGY PLUS [8] are used. The analysis of the economy is calculated by LEGEP [2].

2. Standards

2.1. DIN EN ISO 13790

The European Standard DIN EN 13790 [3] includes calculation methods to determine the energy demand of heating, cooling, ventilation and hot water supply. In addition to heating, cooling, ventilation and hot water supply the solar and internal heat gains are used to calculate the energy demand of the residential building. The thermal building envelope and the technical building equipment represent the basis. For respective countries use the European standard has to be specifically adapted. For Germany the German standard DIN V 4108-6 [4] and DIN V 18599 [5] are used for adaption.

2.2. DIN V 4108-6

The German standard DIN V 4108-6 [4] calculates the energy demand by using tabular method of the German standard DIN 4701-10. This method is only applicable for residential buildings. Characteristic values for the technical equipment are listed and are related to effective area.

2.3. DIN V 18599

The German standard DIN V 18599 [5] is used to calculate the energy demand of residential and non-residential buildings. In contrast to DIN V 4108-6 [4] the characteristic values for the technical equipment are directly calculated and relate exactly to real situation. Compared to DIN V 4108-6 [4] this standard is much more differentiated.

2.4. ASHRAE 90.1

The American standard ASHRAE 90.1 [6] is used for calculating the energy demand. Therefore the building geometry, the thermal building envelope and the technical equipment as well contain the basis. But also it is the basis for LEED-certifications.

3. Exemplary residential building

Fig. 1 shows the choosen examplary residential building. It is a single-family house with a length of about 10,47 m and a width about 8,00 m. The three fully developed floors – basement, ground floor and first floor – are completely heated. Therefore the external components are also the thermal building envelope.

Table 1 shows the structural components and their heat transfer coefficients (U) but al-so the acceptable heat transfer coefficients according to the German Energy Saving Directive (EnEV 2009).These structural components with their heat transfer coefficients and also the oil condensing boiler as technical equipment form the standard version. Therefore the energy demand is calculated and compared to different varieties of low energy buildings. Only the technical equipment is varied. In total there are four variants: oil condensing boiler, district heating, pellets heating or heating pump.

Fig. 1. Exemplary residential building

Rys. 1. Przykładowy budynek mieszkalny

Table 1

Heat transfer coefficients *U*[W/m²K] of the exemplary residential building compared to the acceptable according to ENEV 2009

Structural component	Heat transfer coefficient [W/(m²*K)]	Acceptable heat transfer coefficient according EnEV 2009 [W/(m²*K)]
Base plate	0.240	0.350
Basement walls against soil	0.218	0.350
Basement walls against outside air	0.218	0.280
Exterior wall	0.159	0.280
Steep roof	0.167	0.200
Ceiling (collar beam)	0.182	0.200
Windows	0.700	1.300
Door	1.010	1.800

4. Energy balances

The energy balances are calculated with the building physics software DÄMMWERK [1] for the German standards DIN V 4108-4 [4] and DIN V 18599 [5] and with the software ENERGY PLUS [8] for the American standard ASHRAE 90.1 [6]. Table 2 shows the different results depending on their calculating methods. Also Fig. 2 shows the final energy demand of all variants. With exception of pellet heating it becomes obvious that for the calculating method DIN V 4108-6 [4] the lowest final energy demand is calculated. Using pellet heating and oil condensing boiler it arises the highest final energy demands according to DIN V 18599 [5].

This occurs because of a greater net floor space according to DIN V 18599 [5] compared to the other calculating methods. In accordance with the American standard ASHRAE 90.1 [6] it is obvious that the efficiency factor only is figured into the calculations. Technical equipment characteristics have no influence on the results. Compared to German standards heating pumps receive worse results according to ASHRAE 90.1 [6]. But all calculating methods show significantly lower final energy demand using heat pumps in contrast to the other technical equipment.

The German Energy Saving Directive (EnEV 2009) considers buildings on the basis of the primary energy demand. Therefore the final energy demand is converted with the help of primary energy factors. This primary energy factor is low for pellet heating and high for electricity.

Table 2

Final and primary energy demand of different variants

Variants	Calculating method	Final energy demand [kWh/(m² a)]			Primary energy demand [kWh/(m² a)]
		Oil-/ Pellet-/ District heating	Electricity	In total	In total
Oil condensing boiler	4108-6	15.479	703	16.182	18.863
	18599	22.443	750	23.193	25.240
	ASHRAE 90.1	20.978	403	21.381	23.303
Pellets heating	4108-6	25.311	1.036	26.347	7.756
	18599	33.746	540	34.286	8.153
	ASHRAE 90.1	22.338	403	22.741	5.744
District heating	4108-6	16.022	619	16.641	12.826
	18599	21.541	508	22.049	16.399
	ASHRAE 90.1	22.259	403	22.662	16.858
Heating pump	4108-6	0	4.270	4.270	11.101
	18599	0	5.044	5.044	13.114
	ASHRAE 90.1	0	5.698	5.698	18.046

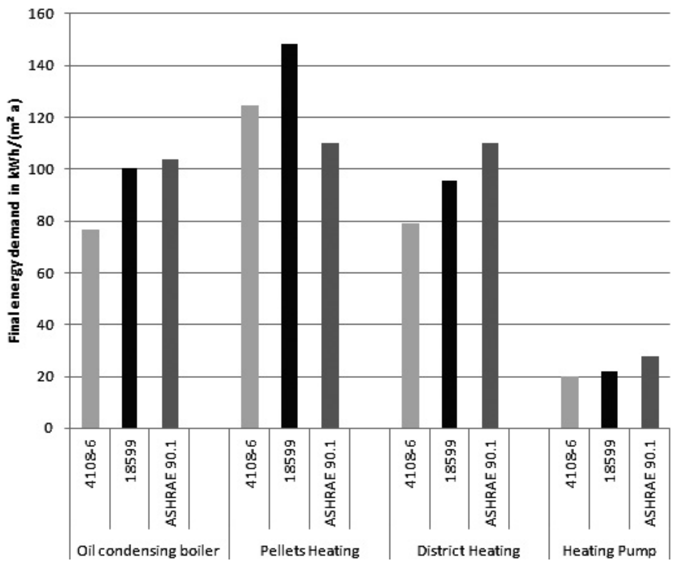

Fig. 2. Overview of final energy demand

Rys. 2. Wykres ostatecznego zapotrzebowania na energię

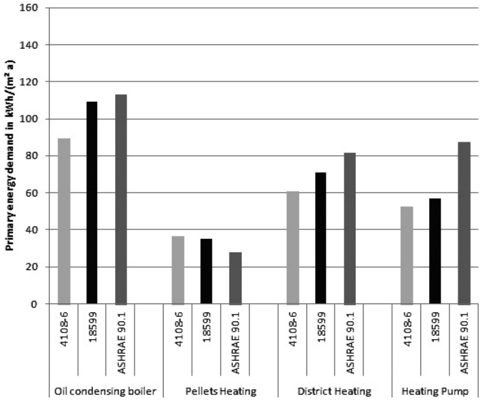

Fig. 3. Overview of primary energy demand

Rys. 3. Wykres pierwotnego zapotrzebowania na energię

Fig. 3 shows the primary energy demand of all variants. Considering the primary energy demand it becomes obvious that pellet heating has the lowest and oil condensing boiler has the highest result. Except of ASHRAE 90.1 [6] district heating has the second highest primary energy demand. The higher primary energy result for heat pumps according to the ASHRAE [6] is based on the higher primary energy factor for electricity. This factor is about 20 % higher than in German standards.

5. Analysis of the economy

The energy balances of all variants are used to analyze the economic efficiency. Therefore capital values are calculated using the software LEGEP [2]. Finally results of all varities are compared and discussed.

As basis for life cycle calculation the characteristics of rating system for sustainable building profile number 2.1.1 [7] is used. It is assumed that the annual rate of price increase is about 2 % in general and about 4 % for heating and electric energy. The applicable discount rate is 5.5 %. The period under review of life cycle is 50 years.

Fig. 4 shows the capital value of the building variants with their different technical equipment. The capital value is a time-adjusted cash amount of any costs within life cycle – discounted to the start time. As a consequence the economic efficiency might be seen as a measure of using financial resources.

Apart from pellet heating it is obvious that using the calculating method DIN V 4108-6 [4] the lowest capital values arises for the period under review about 50 years.

The exactly development of costs are shown in fig. 5. Therefore represented costs are invited to production costs, operating costs and other expenses. The other expenses include costs of maintenance and rehabilitation measures for the exemplary residential building. It is noticeable that production costs are the largest matter of expense for all variants. The reason for this is that all other expenses come up until a later point in time. Therefore all other expenses incorporate at a lower value in the balancing by discounting.

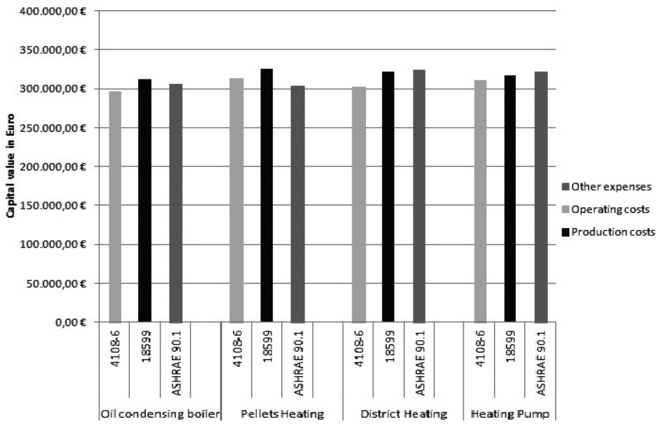

Fig. 4. Capital value of different variants in Euro

Rys. 4. Rachunek kapitału różnych wariantów w euro

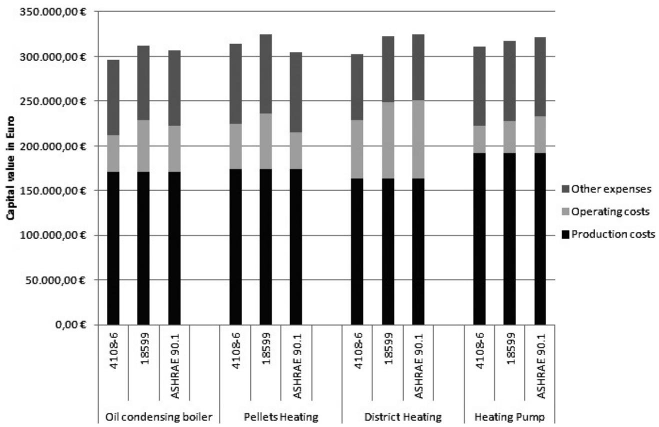

Fig. 5. Capital value of different variants in Euro
(invited to production costs, operating costs and other expenses)

Rys. 5. Rachunek kapitału różnych wariantów w euro
(koszty produkcji, koszty operacyjne i inne wydatki)

According to the German calculating methods it is obvious that the oil condensing boiler has the lowest capital value. Despite low production costs district heating is more expensive than using an oil condensing boiler but also a little bit cheaper than using pellet heating. For the use of heat pumps the capital value is between district heating and pellet heating according to DIN V 4108-6 [4] and between district heating and oil condensing boiler according to DIN V18599.

Compared to German standards the American standard ASHRAE 90.1 [6] shows the best results for the pellet heating. The most expensive variant is using district heating followed closely by heating pump. The variant of oil condensing boiler is only a bit more expensive than pellet heating.

6. Conclusions

From the point of view of energy balances and life cycle assessment it is obvious that not the variant with the lowest final energy demand has to be the cheapest variant.

The use of heating pumps has the lowest final energy demand but has no better result in the economic point of view. Therefore the used energy source and in consequence the operating costs have to receive attention. The standard version – the variant with an oil condensing boiler – shows the highest primary energy demand. According to EnEV 2009 the required verification is only acceptable by a narrow margin. But according to EnEV 2012 the prospective required verification will be not acceptable anymore. From the economic point of view this exemplary residential building is the best variant. The pellet heating has the best primary energy demand but is also the most expensive variant for economic efficiency.

According to ASHRAE 90.1 [6] pellet heating has the lowest primary energy demand and also the lowest capital value.

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