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IMPACT OF RESIDENTIAL HEATING COSTS ON THEIR VALUE

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ABSTRACT: This article deals with the essence of the influence of factors related to various heat sources on property valuation. The study's main aim is to show that the applied heating system impacts the costs of maintaining and operating a building. A thesis was made that the type of heat source used to heat the property is a factor that significantly influences the value because its efficiency and general characteristics can significantly affect the amount of the building's operating costs. For this reason, the method of heating building objects should be an attribute taken into account during the valuation carried out by a property appraiser.

KEYWORDS: building real estate, real estate appraisal, real estate value, building heating costs

Introduction

In the era of the development of new technological solutions, contemporary housing construction is designed to provide the basic housing needs of the population and create the required comfort of use. Investors pay more and more attention, for example, to the heating systems used, taking into account not only the environmental protection aspects but, above all, the maintenance costs of the facility during its operation. There is no doubt that factors related to different heat sources in residential buildings impact their value and should be considered in the valuation process. Analyzing the literature on the subject and the legal basis for real estate valuation in the form of the Real Estate Management Act and the Regulation of the Council of Ministers on the valuation and preparation of the appraisal report, it is clear that there is a specific group of attributes taken into account in the valuation process. Unfortunately, none of the estimation methods takes into account the factors related to the heat sources used. However, there is no doubt that when buying real estate, the heating method that affects the cost of maintaining a building is an important element in the decision-making process. This article is to prove the validity of the thesis. The community of real estate appraisers could consider whether it would be worth considering the heating method as one of the attributes influencing the value in the valuation process.

Analysis of the installation costs of selected building heating systems

Buildings consume over 40% of the overall energy consumed globally and play a significant role in sustaining electric grid power balance; therefore, it is very important to choose the right heating system (Alimohammad-isagvand et al., 2016). When choosing a building heating system, the investor decides what fuel to use to ensure optimal thermal comfort at a reasonable price during the heating period. Additionally, the choice of heat supply options in new residential areas depends on various factors, including available local energy resources, their market prices and the scale and density of heat demand in these areas (Truong, Gustavsson, 2019). In addition, it is important to analyze the investment costs associated with the purchase and installation of a heating system. Therefore, the overview of selected heating systems presented below depends on the price of heating power, device efficiency, brand and others.

The heat from combined heat and power plants

The use of energy from combined heat and power plants for the heating of buildings is the most common type of heating in Poland. This method is a convenient solution, especially in large cities, where the district heating network is well developed. Furthermore, the user of this system can enjoy the comfort of not purchasing and storing fuel, maintaining thermal devices, or, for example, removing ash.

Outside the city limits and large housing estates, access to heat network connections is significantly difficult. Construction of district heating mains in suburban areas, where single-family housing is dispersed, may turn out to be unprofitable. Initial expenses are the purchase of radiators and installation inside the building. The prices of radiators vary, but the cheapest of them cost about PLN 200 per piece (panel radiators). Another important issue affecting the profitability of the project is the offered tariff rate for the supplied energy. The table below shows the net prices for 1 running meter of the connection depending on the standard and the capacity of the main pipe – internal nominal diameter – Dn.

Table 1. Price list for the connection to the MPEC thermal network in Białystok

No.	Types of fee rates depending on the diameter of the connection	Unit measures	Net price [in PLN]
1	Dn 25	PLN/m	215,57
2	Dn 32	PLN/m	216,21
3	Dn 40	PLN/m	229,75
4	Dn 50	PLN/m	249,73
5	Dn 65	PLN/m	264,81
6	Dn 80	PLN/m	303,25
7	Dn 100	PLN/m	341,42
8	Dn 125	PLN/m	448,56
9	Dn 150	PLN/m	510,59

Source: <http://www.mpec.bialystok.pl/kategorie,86.html> [27/06/2021].

Coal-fired boilers

Despite the extensive promotion of ecological energy sources and attempts to reduce the so-called low emission still, a very common method of heating real estate in Poland is coal-fired boilers. The significant advantage of

this solution is the relatively low installation cost. Due to the purchase price, hard coal boilers can be divided into three categories:

Low price group. There are charging boilers operated by hand, with the natural draft, with upper or lower flue gas discharge, coal-fired in the sort of cubes or nuts. The best devices in this group are characterized by a theoretical efficiency of up to 70%.

Average price group. There are charging boilers, operated manually, equipped with air blows. In the case of the bottom flue gas discharge, they are fed with lump coal (walnut or cube); in the case of the upper flue gas discharge, they are fired with pea coal or fine coal. The best devices in this group are characterized by a theoretical efficiency of up to 85%.

High price group. It includes automatic boilers equipped with an air blower, fired with pea or fine coal. The most effective devices in this group achieve theoretical efficiency of up to 90% (Zawistowski, Janiszewski, 2010).

Table 2. Costs of exemplary boilers fired with coal, fine coal, wood, eco-pea coal

Make, type	Type of coal	Heating power [in kW]	Boiler efficiency [in %]	Gross price [in PLN]
Tomiterm – PLESZEW BOILER	coal, fines, wood	11 – 27	82 – 88	from 5,000
MALKOT, MALINA PREMIUM	eko-pea coal	9 – 48	80 – 90	from 8,000
DEFRO, OPTIMA COMFORT	coal, fines, wood, chips	8 – 58	80 – 90	from 12,000

Source: own study based on current information from sellers of heating boilers [27/06/2021].

LPG-fired boilers

With modern condensing boilers, natural gas consumption in the central heating installation is relatively low because they can receive more heat from the flue gas than traditional boilers. Thus, they are characterized by greater efficiency (Kosieradzki, 2009). In the absence of access to the gas network, the cost of purchasing a gas-fired boiler and implementing a complete central heating installation. The purchasing costs or leasing costs of a container for storing this fuel should be added.

The purchase of an LPG gas tank is associated with a large expenditure of PLN 6,000 to PLN 10,000. Having your own tank involves the choice of a good supplier, the necessity to take care of the proper functioning and servicing of the device on your own, as well as refilling the gas level on your own. The advantage of this solution is independence from a single gas supplier.

A convenient way to provide gas for household needs without having to deal with technical service and constant ordering and refilling of fuel is the lease of such a tank.

Table 3. Costs of sample LPG-fired boilers

Make, type	Heating power [in kW]	Boiler efficiency [in %]	Gross price [in PLN]
ARISTON, CLAS B, 24BFFI	22	108	from 6,800
TERMET SILVER 1	35	109	from 3,800
ARISTON, GENUS PREMIUM 35FF	31	107.20	from 8,700

Source: own study based on current information from sellers of heating boilers [27/06/2021].

Biomass-fired boilers

Biomass fired boilers are currently the most advanced boilers in terms of design. They are equipped with mechanisms allowing for almost maintenance-free operation for a long period.

Table 4. Costs of exemplary biomass-fired boilers

Make, type	Type of biomass	Heating power [in kW]	Boiler efficiency [in %]	Gross price [in PLN]
STALKOT KWM-SGR	pellet	19	82.70	from 6,400
SAS AGRO-ECO	pellet	17 – 23	82	from 14,520
TROTEX 25	pellet, chips, wood	25	86-88	7,300

Source: own study based on current information from sellers of heating boilers [27/06/2021].

Heat pumps

Heat pumps are considered to be easy to operate and, at the same time, use the possibility of bringing low-temperature heat sources to a higher temperature. Therefore, they can be used to reduce the need for fossil fuels and greenhouse gas emissions. Their great advantage is the power supply for both heating and cooling and the possibility of working in a simultaneous mode. It means that virtually no heat is dissipated, making such systems truly efficient (Osterman, Stritih, 2021). The investment cost of installing a heat pump depends on many factors. The conditions for obtaining heat in a given area are an important issue here. It often happens that the costs of producing

a heat source and the costs of earthworks are comparable to the devices' price.

Table 5. Costs of making a heat source for a pump with a power of 10 kW

Type of heat source	Costs [in PLN]	Comments
Flat collector	5,000 – 10,000	No earthworks costs
Vertical probes	10,000 – 15,000	Total cost
Wells	15,000 – 20,000	Total cost
Air	2,000 – 5,000	Pump inside the building
Air	0	Pump outside the building

Source: (Oszczak, 2011, p. 44).

There is also the choice of the heat pump. The price difference between the most expensive pump and the cheapest one can be up to 100% (with the same heating power). More expensive pumps, as a rule, are more durable and more economical (Adamczewski, 2010).

Table 6. Costs of exemplary heat pumps

Make, type	Source of heat	Power range [kW]	COP	Gross price [in PLN]
NIBE SPLIT	air / water	3 – 16	4.4	29,000
EXOTHERM 30KW	brine / water	30	5.5	35,150
STIEBELELTRON WPL13/18/23E	air / water	7.7 – 17.1	3.3	up to 41,950

Source: own study based on current information from heat pump sellers [27/06/2021].

Solar panels

Installing solar collectors is an ecological and modern way of obtaining heat for heating residential buildings. These devices are now technologically well-developed and allow for savings in operation. Unfortunately, solar systems are still relatively expensive. The cost of the installation depends on the demand for domestic hot water. Standard solar collectors can provide about 60% of the annual demand for domestic hot water. The cost of installing this technology can pay off after 5-8 years (but only if the purchase is subsidized). The investment turns out to be completely unprofitable in economic terms if the user pays for the collectors himself. In addition, you should bear in mind

the expenses related to periodic inspections. The cost of inspections will be around PLN 150-300 / year (Solar collectors).

The minimum cost of installing solar collectors for a house used by a family of four is about PLN 10,000. This price includes installing and installing flat plate collectors from the lowest price range, e.g. Hewalex 2TLP-250C. More technically advanced devices with vacuum collectors and a selective absorber can cost about PLN 14,000. The prices of vacuum collectors with a heat pipe start from about PLN 18,000. Each extension of the functionality of the collectors or their integration with other heating systems will result in higher costs. The upper limit of financial expenditure on this type of equipment is difficult to define and depends on many factors (<http://kb.pl/teksty/2017/01/25/kolektor-sloneczne-do-domu-jednorodzinnego/>).

Table 7. Costs of sample solar collectors

Make, type	The composition of the kit	Efficiency [in%]	Optical efficiency	Gross price [in PLN]
Hewalex 2 TLP-250C	2 flat plate collectors, KS2000 TLP type with a total (active) aperture area of 3.6 m ² and a 2-coil hot water heater with a capacity of 250 liters	64	0.802	7,780
Hewalex 3 KSR10-250	3 vacuum collectors type KSR10 with a total aperture area (active) 3.0 m ² and a 2-coil water heater with a capacity of 250 liters	73	0.780	11,570

Source: own study based on current information of solar collector sellers [27/06/2021].

The solar set price does not include the cost of installing the collectors, which depends on the complexity and size of the installation, the degree of integration with another heating installation, the method of routing the solar pipes, and the type of roofing.

Depending on the above factors, the installation price ranges from PLN 1,500 to PLN 3,000 (<http://www.instalacjebudowlane.pl/6770-23-55-jaki-jest-koszt-kolektorow-sloneczne.html>).

In large installations, where collectors, for example, heat the water in the swimming pool, the economic sense of the investment is justified to a large extent. On the other hand, in small installations (e.g. in small single-family houses), where daily water consumption at 45°C is about 200-240 l, profitability depends on the price of supplied energy (the most expensive are electricity, fuel oil and LPG), growth fuel prices on the market, the amount of the subsidy. It is possible to use the subsidy from the National Fund for Environmental Protection and Water Management (NFOŚiGW), which offers a dona-

tion of 45% of the loan amount taken for the installation of collectors; however, income tax must be paid on this subsidy (<http://www.budujemydom.pl/kolekty-sloneczne/13063-czy-oplaca-sie-instalowac-solary>).

Summing up, it should be said that the prices of heating systems differ from each other depending on the brand, type of device, or the efficiency and heating power. Devices using renewable heat sources are a more expensive investment in comparison to boilers fired with solid fuels. However, with the development of the market sector offering unconventional energy, one should expect more and more competitive prices of modern devices generating the so-called clean energy.

Analysis of the operating costs of selected building heating systems

In order to determine the costs of heating a property with its own independent heat source, the following parameters should be analyzed: the current price of the energy carrier, the calorific value of the fuel, the efficiency of the heating system and the heat demand of the building.

Prices of energy carriers

The cost of fuel used to heat a residential building is a very important factor that is influenced by many factors. The price, in this case, depends on the offers and tariffs of local suppliers. However, a wide selection of energy resources and the emerging competition on the supplier market means that the prices of the offered fuels may sometimes turn out to be attractive. The table below shows the average prices of the fuels used.

Table 8. Costs of fuels offered in Poland

Fuel Type	Unit price
natural gas	2.35 PLN/m ³
LPG gas	2.40 PLN/l
LPG gas (tank lease)	4.50 PLN/l
heating oil	3.35 PLN/l
hard coal of the eco-pea type	1000 PLN/t
hard coal of fine type	650 PLN/t
pellet	950 PLN/t
electricity	0.74 PLN/kWh

Source: own study based on current information from fuel suppliers [27/06/2021].

Fuel calorific values

Fuel calorific value [MJ/unit] is the energy obtained from fuel combustion related to its quantity (mass), assuming that the combustion is complete and the water vapour released with the exhaust gas is not condensed.

Table 9. Calorific values of various fuels

Fuel Type	Calorific value
natural gas	37.6 MJ/m ³
LPG gas	43.5 MJ/l
heating oil	42.6 MJ/l
coal	30 MJ/kg
hard coal of fine type	32.7 MJ/kg
pellet	18 MJ/kg

Source: own study based on current information from fuel suppliers [27/06/2021].

The house's need for heat

On January 1, 2009, the Ministry of Infrastructure adopted a regulation according to which each building and apartment should have its energy certificate, covering the necessary scope of information for its users and possible records. The energy certificate contains an assessment of the estimated amount of energy needed for heating, lighting, ventilation, and air conditioning of the building and domestic hot water preparation. The basic measure in this system is the total energy demand of the property during the year, converted to 1 m² of its area [kWh/m²/year]. A building is considered energy-efficient when the energy consumption is 70-100 kWh/m²/year (Juliszewski, 2009).

According to the PN-EN ISO 13790: 2009 standard, the energy demand of real estate is the heat that should be supplied to maintain the intended thermal conditions.

Determining the heating costs of a residential building per year is a difficult task, requiring knowledge of many data. Information on this is provided in the building's energy performance certificate.

Annual expenses for heating a building real estate depend on the price of the energy carrier, its calorific value, the type and efficiency of the heating system and the building's heat demand. Therefore, choosing the most effective

tive and optimal heating solution requires comparing and comparing the operating costs of various heat sources.

Table 10. Energy standards adopted for buildings in Poland

The period of building a house	Energy demand [kWh/m ² / year]
Houses built until 1967	240 – 350
Houses from 1968 to 1985	240 – 290
Houses from 1986-1992	160 – 200
Houses from 1993-1997	120 – 160
Houses built since 1998.	90 – 120
Energy-efficient houses	max 70
Low-energy houses	max 45
Passive houses	max 15
Zero-energy houses	max 0

Source: Polish National Energy Conservation Agency.

The table 11 shows the annual heating costs of a building property with 150 m² with selected heat sources, taking into account the data provided and the division into different energy standards of the building.

Table 11. Annual heating costs of a building property with an area of 150 m² with the various heat source [PLN]

Type of heating device	Gas condens-ing boiler	Condens-ing boiler for LPG	Condens-ing boiler for LPG	Cauldron for heat-ing oil	Cauldron for pellets	Cauldron for coal – eco-pea coal	Brine / water heat pump
Fuel Type	natural gas	LPG gas	LPG gas (leased installation)	heating oil	pellet	eco-pea coal	electricity
Annual heating cost (well insulated building)	2,911	3,237	5,958	4,940	2,347	2,075	1,460
Annual heating cost (poorly insulated building)	4,528	5,036	9,269	7,684	3,651	3,228	2,271

Source: own study based on current information from fuel suppliers [27/06/2021].

Selection of the most favourable heating method

This analysis presents selected thermal systems used to heat residential buildings along with their installation and operating prices. The most optimal heat source selection is associated with a thorough analysis of information about heating technologies and energy raw materials available on the market. It would be best if you also considered the type and characteristics of your property to match a heating system that is the most efficient, economical and safe to operate. In this case, the volume and structure of the property, its location (free-standing or compact building), the region and its climatic features, the presence of utilities such as municipal heating network or gas network installation in the vicinity are important. The factor determining the purchase of a specific heating system in practice is also the investor's financial capacity and expectations regarding the effectiveness and efficiency of the heat source.

In order to consider the selection of the most advantageous method of heating a residential building property, certain criteria should be adopted. Undoubtedly, operating costs are of great importance here. In the light of the analysis, the cheapest solutions during operation are a brine/water heat pump, a coal-fired boiler and a pellet-fired boiler.

The heat pump requires a high investment in the installation phase. Depending on many factors, the cost of purchasing and installing such a system can reach up to 60,000. PLN (www.tendeo.pl). Suppose the investor is able to cover these costs and decides to use a heat pump as a means of heating the property. In that case, he will be able to experience the many advantages of using this efficient heating system in the future.

The use of a coal-fired boiler is contrary to the idea of supporting ecology and the principles of environmental protection but still common. The operating costs resulting from heating with coal are not prohibitive compared to the operational costs of other thermal systems. It goes without saying, however, that the use of coal-fired boilers is definitely an outdated method.

Another solution that is characterized by low operating costs is a pellet-fired boiler. Pellet users appreciated its numerous advantages, which include: wide availability of the raw material on the market and competitiveness of its prices in relation to coal prices, high efficiency of pellet-fired boilers (usually above 90%) and their high automation and maintenance-free (granulate charging is often only necessary). Pellets are also clean and non-staining fuel, and the emission of harmful substances to the atmosphere during combustion is negligible (www.muratorplus.pl).

The use of modern and unconventional methods of heating real estate, such as heat pumps (based on the use of renewable, free energy from the so-called lower heat sources), requires relatively high financial outlays for

the purchase and installation of devices. Over time, however, low operating costs will translate into savings. In addition, such solutions are also characterized by great convenience and comfort of use. Undoubtedly, the attractiveness of using the so-called „Clean energy” in building heating has increased due to numerous government and EU programs supporting and subsidizing the use of unconventional heating methods that make a significant contribution to protecting the environment.

To sum up, the most advantageous methods of supplying heat for the needs of a building real estate, among those described in this paper and meeting the criterion of low operating costs, are two thermal systems: the use of a heat pump and a pellet-fired boiler. Both of these solutions are distinguished by modernity, ease of use, efficiency, high efficiency and care for the natural environment. Considering the above-mentioned characteristics of heating methods, they can be considered the most advantageous in selecting them as the optimal heating and building real estate method.

Influence of building heating method on real estate value

Many different factors influence the market value of a real estate building. Some of them determine the price of real estate more than others, so the impact is uneven. Such attributes include, among others: the location of the property, its area and cubature, the technical condition of the building, its surroundings and many others. One of the parameters significantly influencing the value of a residential building is the method of its heating. Therefore, when assessing the impact of heating conditions on the value of a building, one should focus on the specific object.

Currently, there are many ways to heat a property on the market. These systems are very different from each other on the following levels: general characteristics, type of fuels used, installation costs and everyday use. The advantages or disadvantages resulting from the specific use of the installed heating devices may encourage or scare a potential client considering purchasing a given property. Modern and effective technologies providing heat for the needs of residential buildings are, in this case, extremely desirable by buyers of single-family houses. The customer pays attention to the fact that the home heating installation generates future profits and savings and ensures comfort and convenience of use. The analysis indicates that, in addition to energy-efficiency measures regarding the building skin, a well-designed heating and ventilation system plays an important role in reducing financial costs and environmental impact over the lifespan of a dwelling (Debacker W. et al., 2013). For this reason, outdated, ineffective and requiring

constant control central heating systems based on, e.g. tiled stoves or coal-fired boilers, are not able to increase the value of a given property and usually lower it. In addition, a drop in the market price of a used building may be affected by the poor technical condition of the thermal installation and the need to replace or repair its individual components.

As already mentioned, the increase in the market price of real estate is positively influenced by the installation of modern and effective heating technologies, characterized by great convenience and ease of use. Furthermore, depending on the degree of availability of utilities (heat network, gas network), these can be heat systems powered by clean fuels, such as natural gas, LPG gas, heating oil, hot water from a combined heat and power plant, pellets and solar energy. Therefore, using any of the above-mentioned ecological heat sources contributes significantly to the increase in the value of the property and, at the same time, has a positive impact on the protection of the natural environment.

Conclusions

The article's main aim was to justify the hypothesis that the method of heating a building real estate has a significant impact on its market value. Considering the assumptions of the property valuation, the essence of the impact of the type of heating on the value of the building in question results from the analysis of energy raw materials and various heating systems available on the market. The sources of information on the current prices of heating devices and fuels were the data posted on the websites of energy suppliers or energy raw materials and internet offers of shops and distributors of heating devices.

This study attempts to indicate the most advantageous heating systems for residential buildings. One of the decisive criteria for the benefits of a specific heating system is low operating costs. Other factors contributing to the benefit of a given method of heating are efficiency and effectiveness of the heat source, ease of use, the comfort of use, environmental protection aspects and the financial profitability of the investment over the years. It was found to be modern and efficient heat sources are desired by potential property buyers and can significantly increase the value of a building. At the same time, obsolete heating methods, such as coal-fired boilers, for example, can lower.

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