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THE PROFITALBILITY OF INVESTING IN PASSIVE HOUSING IN POLAND

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ABSTRACT: The article discusses the problem related to the profitability of investing in passive construction from the point of view of economic calculation and benefits related to environmental protection and energy conservation. The analysis was made to compare the costs of construction and operation of a single-family residential building in two variants: in traditional technology and in passive building standard. The analysis was aimed at providing an answer to the question of whether the construction of a passive house will bring sufficient energy effects to be profitable for the investor. The ROE method was used and is interpreted as a rate of return on the investment financed by the investor. Using the simple payback period method, the number of years after which the investment outlays invested in the project will return on the benefits obtained from the project was calculated. Finally, the economic viability of the investment was assessed by calculating the NPV index. The essence of the article is to indicate optimal solutions that would promote passive construction in Poland by offering, among others, beneficial subsidies for such projects.

KEYWORDS: passive building, residential building, investment in passive construction, the profitability of investing in passive buildings

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Introduction

The changing preferences of future owners are a big challenge in 21st-century residential construction. More and more often, apart from factors such as location, purchase or construction price, they take into account the standard of finishing, applied technologies or costs of building maintenance during its later operation. Residential construction in Poland offers not only many different architectural solutions but also technical ones, which are in line with environmental protection and are oriented towards saving usable energy. It is estimated that the demand for energy, along with the development of the world economy, is constantly growing, and the rate of this growth is extremely fast. Studies show that the highest energy consumption is in the residential sector. It is one of the main energy consumers in the modern economies of developed countries, and it is mainly during the exploitation phase of these facilities (Lis, Sekret, 2016).

An innovative idea in the approach to energy saving in modern construction was included in the concept of the passive house, focusing primarily on improving the parameters, elements and systems of the existing building (Gołąbeska, 2019). The name "passive building" is related to the fact that such buildings use energy from solar radiation in a passive way, i.e. passively without using active installation solutions.

The EU's 2010 directive on the energy performance of buildings assumes that from 1 January 2021 all new buildings are to be nearly zero-energy buildings. The same regulations also oblige to significantly reduce energy consumption in existing buildings. Currently, about 40 percent of all primary energy is consumed by buildings, so it is in them that the greatest reduction potential lies. Achieving high energy efficiency of buildings becomes necessary in the context of achieving overall primary energy savings both in Poland and all European Union countries. The emerging variety of energy-efficient buildings is a response of the market not only to the EU requirements but also to the growing awareness of the society about sustainable construction.

According to the available analyses, the costs of building low-energy residential houses are in Polish conditions about 10 to 15 percent higher than the costs of a house built according to the energy standard specified in the regulation of the Minister of Infrastructure on the conditions to be met by buildings and their location. In the case of passive houses, in turn, these costs are higher even by about 25 to 30 percent. (Węglarz, 2009). It follows that not all investments beneficial from the environmental point of view are economically viable. To determine the profitability of such investments, it is enough to compare the benefits achieved during the operation of the building with the costs incurred for a given investment. The investor should approach the planned project with special care (Gołąbeska, 2018). He faces a dilemma whether it is worthwhile to build energy-efficient and passive houses. Implementation of the passive construction concept is connected with a big challenge, because the investor has to reckon with the necessity of incurring higher costs of building the object, taking into account the long period of return of these costs through savings on energy consumption.

An overview of the literature

The topic of energy-efficient and passive construction is addressed by many authors in various studies. In Poland, the analysis of economic and environmental profitability of such solutions is dealt with by, among others Kaczkowska (2009), Markiewicz (2017), Lis (2018) and others. The essence of the considerations is primarily energy efficiency achieved through modern technological solutions and ways of using renewable energy in various types of buildings, including residential buildings. Analyses contained in the work Kapuściński and Rodzoch (2010) indicate that the unit heat demand of residential buildings in Poland has changed with the period of their construction. This may give hope for the development of energy-efficient and passive construction in the near future.

The subject of numerous studies is the promotion of the idea of a passive house and the cost-effectiveness of the use of construction solutions that guarantee beneficial economic effects (Kaczkowska, 2009). Feist (2012) explains the concepts associated with passive construction perfectly. It addresses all aspects related to reducing energy consumption by increasing the thermal protection of the building, the use of solar energy, methods of heating and ventilation in energy-efficient and passive construction, hot water solutions as well as electricity generation. All elements characteristic for energy-efficient buildings should be taken into account already in the design phase. Integrated energy design of single-family, energy-efficient residential buildings is the starting point for passive construction (Markiewicz, 2017). Therefore, at the stage of investment planning, the investor should take into account factors that may significantly contribute to obtaining the most favourable conditions from the point of view of energy conservation and environmental protection. Numerous studies of companies involved in this type of construction emphasize the importance of the passive building's orientation towards the world, the type of roofing or the number of windows in the building. These issues significantly affect the level of energy consumption during operation.

The number of engineering studies presented at conferences, symposiums or publications shows a great interest in this issue.

Passive construction

The era of passive housing construction began in Western Europe in the 1990s. Wolfgang Feist is considered to be the creator of the concept of such construction, who together with the staff of the Institute of Housing and Environment developed in 1988 an innovative concept for a passive building. The first project of such a building was created in Darmstadt, Germany in the early 1990s. The energy crisis in the 1970s forced the need to save energy, which resulted in a policy to significantly reduce the energy consumption of buildings.

The assumptions for a passive house were mainly related to the energy consumption needed to operate it. The energy consumption for a conventional building is about 120 kWh/m^2/year. The passive house was to have a demand of no more than 15 kWh/m^2/year, which corresponded to the consumption of 1.5 litres of heating oil, 1.7 m^3 of natural gas or burning 2.3 kilograms of hard coal (at least 23 thousand kJ/kg) (https://www.pasywny-budynek.pl/technologie/historia-i-definicje/historia budownictwa-pasywnego, 2020).

An important element in the development of energy-efficient and passive construction was the development of technologies related to the use of renewable energy sources to cover the energy needs of buildings. It should be emphasized that along with the reduction of consumption of energy carriers (electricity, heating oil, gas) the emission of pollutants into the atmosphere decreases, which is crucial in the idea of passive construction.

However, ecological housing, supported by the European Union, has not caused its revolutionary popularity. Admittedly, the number of energy-efficient and passive buildings in the world is constantly but relatively slowly increasing, especially in Western European countries. In Poland, for the time being, one can meet rather with the promotion of technologies conducive to the construction of energy-efficient or passive houses, but one should still wait a little bit for their construction. The first Polish passive building was built only in 2004 in Wólka near Warsaw and it is hard to say that it started a dynamic growth of this kind of building in our country. The National Fund for Environmental Protection and Water Management has even developed a special program, which assumes support for building energy-efficient houses and apartments. Large savings, which are undoubtedly brought by buildings erected in energy-efficient or passive technology, can be an attractive offer for many people undertaking the construction of their own homes. However, it is necessary to stimulate the awareness that although the average cost of construction is higher than traditional constructions, it will pay off with time.

Energy-efficient and even more so passive construction requires a lot of knowledge and skills from construction companies and contractors, i.e. companies producing elements of these houses (e.g. window and door joinery, other building materials and equipment and installations necessary to achieve the passive building standard). Currently, there are already investors in Poland who are very willing to realize new buildings in the passive standard. Awareness in this area is slowly growing. Passive building guarantees, above all, comfort and health for people staying in it every day. The most important thing, however, is the issue of energy savings (the price of which will continue to rise) and environmental protection in its broadest sense.

In 2004 the Passive Building Institute was established in Poland. It is a non-profit institution that deals with a number of important issues related to passive technology. The Institute of Passive Building deals primarily with the dissemination of knowledge about this type of solutions and renewable energy sources. It is accredited by PHI to certify all types of passive buildings in Poland. It also provides consulting services related to passive construction, giving opinions on passive house designs, as well as cooperation with scientific entities and manufacturers of components for passive construction (https://kb.pl/porady/budownictwo-pasywne-w-polsce, 2020).

In order to consider the construction of a passive house, it is necessary to first define the requirements characterizing such a building, and then to assess the financial, material and technological possibilities. The key assumptions for the construction of a passive house are among others: (https://kb.pl/porady/domy-pasywne-liczymy-czy-dodatkowe-wydatki-sie-zwracaja, 2020):

- the compact body of the building,
- the windows are located on the southern side (solar radiation constitutes about 40% of the used heat energy),
- installation of a ventilation system with heat recovery,
- no conventional heating system,
- high insulation parameters of external partitions,
- using any kind of energy coming from the ground, from the air, the sun, the heat of residents, solar collectors, heat from the ventilation air, from electrical devices,
- maximum reduction of heat loss,
- impermeability and total tightness of all materials used to build the house,
- use of a thorough heat exchanger,

- doors that open inwards, not outwards,
- giving up too large glass surfaces, which force the heating demand to increase, and in the summer cooling,
- maintaining the right colour balance of the building: bright surface colours quickly cool the building without taking the sun's rays, while dark ones make the building heat up quickly by absorbing the sun's energy, but give it back more slowly.

The essence of a passive house is the use of excellent quality thermal insulation materials that would guarantee heat retention without allowing it to be lost. The basis is therefore external partitions with low heat transfer coefficient. The technical characteristics of materials used in the construction of a passive house are defined, indicating the following (https://kb.pl/porady/domy-pasywne-liczymy-czy-dodatkowe-wydatki-sie-zwracaja/, 2020):

- external partitions (walls, roof, floor) with heat transfer coefficient U < 0,14W/m^2 K,
- windows with a heat transfer coefficient of 0.8 W/m^2 K,
- maximally reduced thermal bridges of internal partitions,
- recuperator with a capacity of over 75%.

An important issue for a passive house is the heating source. Significant reduction of heat demand for heating purposes caused the main role in the energy balance of the building to be played by the heat demand for hot water preparation. The average value of heat demand for water heating is between 18 and 35 kWh/m^2/year (according to the Passive Building Institute).

As far as water for household and sanitary purposes is concerned, it is usually heated in a passive house by a solar collector installed on the roof, and partially also by a heat pump, with heat shortages from these sources covered by an electric heater of little power.

As already mentioned, the use of renewable energy sources is crucial in passive buildings. This reduces the demand for non-renewable primary energy and reduces greenhouse gas emissions. The use of renewable energy sources should be individually analysed economically.

It should be kept in mind that not all investments that are beneficial from the environmental point of view turn out to be profitable and have a chance to pay off in the short term. It is estimated that the installation of a photovoltaic cell in a single-family building, taking into account the savings on fees, will pay for itself after about 25 years, so in the absence of external funding, it is difficult to consider such an investment as profitable. In passive buildings it is recommended to use the following renewable energy sources (Węglarz, 2009):

- solar radiation energy, e.g. solar collectors for hot water preparation and photovoltaic panels for electricity production,
- biomass energy, e.g. biomass boilers for heating and domestic hot water preparation,
- the energy accumulated in the ground, e.g. for preheating of ventilation air – GWC as the lower heat source for heat pumps,
- wind energy for the production of electricity by small wind power plants.

Experts estimate that, given the constant development of technology, it can be expected that in the near future, passive construction, not only in the world but also in Poland, will become commonplace. Aspects of environmental protection and energy conservation will cause almost all facilities to be adapted to extremely low levels of energy consumption. This will require the use of better materials, advanced tools, innovative solutions, supported by the awareness, knowledge and skills of contractors.

Research methods

The starting point for the implementation of the passive construction concept is primarily the proper calculation of the costs of construction and maintenance of such facilities and the payback time of the invested capital. Simple rates of return, which are a relative measure of absolute profitability of investment projects and express the relation of net benefits from a given investment project to the amount of capital involved in them, may prove to be a useful method, which works well in assessing the profitability of investing in this type of solutions. Among them, a simple ROE (return on equity) expressed by the formula can be indicated:

$$ROE = \frac{net\ income}{total\ capital\ expenditure\ financed\ by\ equity} \cdot 100\ (\%) \qquad (1)$$

which in the course of subsequent calculations will be determined by *r*.

The ROE method, from the owner's point of view, is interpreted as a rate of return on investment outlays financed by the owner. This method is not a decision criterion, however, the principle of achieving a value greater than the limit rate is adopted. The construction of the limit rate is subjective in nature and alternative rates of return can be adopted for it as, for example, the interest rate on a long-term bank deposit with a maturity close to the life cycle of the investment project (Janik, 2020).

In the case of profitability of investing in passive construction, the simple payback period (PP) method may be more appropriate, which determines the length of time it takes for the investment outlays incurred for the implementation of a given investment project to be balanced with the net benefits generated by that project. The algorithm of this method is presented in the formula (2):

$$PP = \frac{capital\ expenditure}{net\ profit + amortization + interests} \quad . \qquad (2)$$

PP is interpreted as the number of years after which the investment outlays invested in the project will return the net benefits obtained from the project. The obtained result from this method can also be compared with the limit period of return, for which in this case the loan repayment period can be assumed, or the average period of return from similar projects carried out in a given industry (Janik, 2020).

The investor starting the construction of the house assumes that the profits achieved in the future due to minimizing energy costs will cover the initial outlay and will additionally bring a profit. Seemingly, the bill may seem simple. However, in reality, it looks a bit different. An economic evaluation of investment profitability can be made by one of the simple ways of calculating *NPV* (Net Present Value), i.e. the value of current future cash flows. Calculated *NPV* determines how much the future cash flow from the venture is really worth (according to their present value), after deducting the present expenses.

The key figure that influences the size of the *NPV*, in addition to the actual performance of the new business, is the value used to calculate the discount rate, which, expressed in %, determines the amount of devaluation of money over time.

$$NPV = \sum_{i=1}^{n} \frac{CF_i}{(1+r)^n} - I_0 \ , \qquad (3)$$

where:
CF_i – cash flow,
I_0 – initial charge value,
n – number of periods,
r – a required rate of return.

The *NPV* indicator should always be higher than zero within the assumed time horizon. Its lower value means that in real terms the expenses incurred will not return to the investor, even if he will nominally recover his money. This means that the higher the *NPV* value, the better.

Proper evaluation of the profitability of investing in a passive building is a starting point for the investor to take up such a challenge.

Results of the research

According to data from the Polish Institute of Passive Construction and Renewable Energy (PIBP), a passive house uses 8 times less energy than a house built in the traditional technology. However, the cost of building an energy-efficient/passive house is 8-15% higher than a traditional house. However, depending on the selected materials, a passive house can be up to 35% more expensive to build than an ordinary building (Gwardecki, Passive House or energy-efficient house – price and profitability, https://enerad.pl/aktualnosci/dom-pasywny-czy-dom-energooszczedny-cena-i-oplacalnosc/).

The calculations concerning the profitability of such investments depend on many factors (e.g. type of photovoltaic or heat pump, type of window joinery, method of building insulation and others).

The analysis of economic efficiency, carried out for the purposes of this article, is based on the estimated unit costs of a single-family, detached, single-storey building with a usable attic built in traditional brick technology, heated by an eco-pea oven and a similar passive building with a heat pump. Construction costs and annual estimated operating costs of the facilities in question were compared, with operating costs taking into account the expenses for fuel used for heating, ventilation and hot water preparation, as well as electricity used by auxiliary equipment.

Table 1. Estimated costs of construction and annual exploitation of the building in traditional technology and passive building

	Traditional building	Passive building
Construction costs [in PLN/m^2]	3038.94	3516.63
Operating costs of central heating and hot water [in PLN/m^2 year]	30.52	15.53

Source: author's work.

Based on an as-built cost estimate for a traditional building, the total unit construction cost was PLN 3038.94 per square meter. In turn, the passive house generated costs of PLN 3516.63 per square meter. In the case of the passive standard, the costs of construction and operation of auxiliary equipment are higher (the air handling unit uses additional electricity), while the operating expenses are lower.

To assess the economic viability of the investment, the cumulative cost method can be used, which is the sum of construction costs for the analyzed energy standard and the discounted cost of operation over a specific period of time. It should be mentioned that in the long run the change of costs should be taken into account, which is connected with inflation and a possible increase in energy costs. The expenses related to the servicing of central heating and hot water preparation systems can be considered equal for both standards. In order to compare the cumulative costs, the lifetime of both facilities should be indicated. In this type of analyses, usually, 25-30 years are assumed.

On the basis of the construction and operation costs included in table 1, the estimated period of return on investment can be calculated. Both analyzed buildings have a usable area of about 130 m^2.

Table 2. Estimated costs of construction and the annual operation of the building in traditional technology and passive building

	Traditional building	Passive building
Construction costs [in PLN/m^2]	3038.94	3516.63
Construction cost [in PLN]	395062.20	457161.90
Operating costs of central heating and hot water [in PLN/m^2 year]	30.52	15.53
Operating costs of central heating and hot water [in PLN/year]	3967.60	2018.90

Source: author's work.

The difference between the total costs of building a passive and a traditional building is:

$$457\,161.90 - 395\,062.20 = 62\,099.70 \text{ PLN}$$

The difference in operating costs between a traditional building and a passive building is:

$$3\,967.60 - 2\,018.90 = 1\,948.70 \text{ PLN}$$

On the basis of the above results you can calculate a simple payback period, i.e. the time needed to return the invested capital:

$$PP = \frac{62099.70}{1948.70} = 31.87 \text{ years}$$

The calculations did not take into account depreciation and interest and the assumptions that, in accordance with the environmental protection policy, which supports the use of renewable energy sources, the prices of fuels used in traditional buildings will increase. Therefore, it should be stressed that in the long run, higher construction costs may pay for themselves slightly faster thanks to lower operating costs.

To make an economic assessment of the profitability of the investment, it is enough to calculate the NPV index. The discussed example shows that building a passive building requires 62 099.70 PLN more than building such a building in the traditional technology. This amount should therefore be treated as an investment contribution. The investor expects that the realization of this project will be the source of 32 cash flows occurring once a year in the amount: 1 948.70 PLN (this is the estimated annual energy savings). On the basis of the analysis of the cost of capital raised, the annual rate of return can be easily calculated using formula (1):

$$r = \frac{1948.70}{62099.70} \cdot 100 = 3.14\%$$

By substituting all values to formula (3) we obtain the value of NPV indicator. The calculations are presented in table 3.

Table 3. Calculations to NPV index for passive building

n	cash flow	r	discount factor	discounted cash flow
0	-62 099.70	3.14	1.0000	-62 099.70
1	1 948.70	3.14	0.9696	1889.37
2	1 948.70	3.14	0.94	1831.83
3	1 948.70	3.14	0.9114	1776.07
4	1 948.70	3.14	0.8837	1722.07
5	1 948.70	3.14	0.8568	1669.55
6	1 948.70	3.14	0.8307	1618.79
7	1 948.70	3.14	0.8054	1569.51
8	1 948.70	3.14	0.7809	1521.71
9	1 948.70	3.14	0.7571	1475.39
10	1 948.70	3.14	0.7341	1430.45
11	1 948.70	3.14	0.7117	1386.88
12	1 948.70	3.14	0.69	1344.67
13	1 948.70	3.14	0.669	1303.74
14	1 948.70	3.14	0.6487	1264.08
15	1 948.70	3.14	0.6289	1225.6
16	1 948.70	3.14	0.61	1188.3
17	1 948.70	3.14	0.5912	1152.05

n	cash flow	r	discount factor	discounted cash flow
18	1 948.70	3.14	0.5732	1116.99
19	1 948.70	3.14	0.5558	1083.03
20	1 948.70	3.14	0.5389	1050.06
21	1 948.70	3.14	0.5224	1018.08
22	1 948.70	3.14	0.5065	987.08
23	1 948.70	3.14	0.4911	957.03
24	1 948.70	3.14	0.4761	927.86
25	1 948.70	3.14	0.4617	899.64
26	1 948.70	3.14	0.4476	872.25
27	1 948.70	3.14	0.434	845.68
28	1 948.70	3.14	0.4208	819.92
29	1 948.70	3.14	0.408	795
30	1 948.70	3.14	0.3955	770.79
31	1 948.70	3.14	0.3834	747.2
32	1 948.70	3.14	0.3718	724.56
NPV				-23 114.47

Source: author's work.

The calculated NPV ratio = PLN 23,114.47 means that there was no surplus of updated net revenue over the initial outlays incurred, nor was it balanced. It is therefore difficult to talk about the profitability of such an investment. If the result was greater or equal to zero (NPV≥0), the investment should be realized because it would meet the investor's expectations. In this case, the project should not be realized from an economic point of view. However, taking into account the environmental benefits, on the basis of the obtained result, it is possible to consider the number of possible subsidies for the implementation of the planned investment.

Conclusions

The analysis confirmed that building a passive house in financial terms is much less profitable than a house in the traditional technology. Therefore, it is important that in such situations the investment is supported by the state – offering e.g. subsidies for photovoltaics, heat pumps and others.

Contrary to appearances, building a passive house does not have to be much more expensive than a traditional one. This investment, however, requires an appropriate plan and calculation, but ecological buildings may prove to be an attractive solution. The passive house gives a better guarantee of increasing the value of the property and brings huge savings in its use.

The right approach at the stage of their design can be a guarantee of lucrative investment because within the same budget it is possible to design and build a building with much lower energy demand while maintaining its utility and aesthetic values. It is true that a passive house requires more expenditure on insulation, special window joinery or ventilation system, but you save on the heating system, which a passive house usually does not require. Insulation of walls, windows and ventilation are needed in every building, but in passive houses, all these elements must be optimized for energy saving, which requires more expensive materials. The growing popularity of passive houses makes them more and more common and thus can be expected to be cheaper over time. Work is constantly underway to reduce the costs of passive construction so that it becomes more accessible. It is to be hoped that the differences between the cost of building a traditional house and a passive house will diminish over time. On the other hand, the profits resulting from exploitation, given the growing costs of energy, will increase over time. The passive construction is not supported by the economic calculation for the time being, but by the high comfort of use and care for the environment. These are the arguments that have the greatest influence on the development of the idea of passive construction. What is needed is its popularization, both among professionals in the construction industry and those who want to live in passive houses for their own benefit (https://www.muratorplus.pl/technika/konstrukcje/budowa-domu-pasywnego-aa-7w2n-N2gZ-fvkR.html, 2007).

It should also be borne in mind that in Polish climatic conditions it may be better to build energy-efficient, not necessarily passive buildings. The passive solution is characterized by an unreasonably high return on investment.

In order to save energy in the national and EU dimension, Poland should strive, as developed Western countries do, to develop construction in an energy-efficient standard, or maybe in the near future – passive, offering favourable subsidies for such projects.

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