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Research paper

Life Cycle Assessment (LCA) and environmental comparison the selected construction methods of residential buildings in traditional and straw cubes technology – a case study

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Abstract: Popular, traditional building materials typically exhibit a high energy intensity and a detrimental effect on the environment. Only a negligible part of them are recovered and recycled, re-used in the building trade or other branches of industry. However, the technology of building detached houses based on ceramic blocks is still most often favored by investors due to its price and high availability (in terms of materials and workmanship). The research indicates that 25–30% of CO_2 emissions generated by buildings originate from materials and their manufacturing process. In contrast, 70–75% can be attributed to the use of buildings over a longer period of time. As a result, the importance of alternative materials with minimal environmental impacts is growing year by year. Eco-friendly housing, using natural products, pollutes the environment less significantly compared to conventional construction. Its key element is the use of materials characterized by the lowest possible degree of processing, and thus by the lowest possible embodied energy. A type of material that perfectly fits into the above assumptions is straw bale. The purpose of the article focus on, four variants of a construction of detached house have been compared by means of the LCA method. Variant I – the reference one, presents the technology utilizing ceramic hollow bricks, variants II, III and IV are eco-friendly technologies employing wood and straw. The study presents the amount of energy required for construction and carbon footprint that remains in the environment following the construction of the buildings.

Keywords: straw bale, CO_2 reduction, Life Cycle Assessment (LCA), sustainable materials, market acceptance

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1. Introduction

Modern wood construction technologies reached Poland relatively late, with the opening of the economy to the Western market in the 1990s. In addition, the structural timber industry is not well supported by state legislative and financial measures, which results in the fact that building based on wood technology is still insufficiently popular in Poland [1]. By comparison, Western European countries such as Norway or Germany launched schemes to support timber construction already in the 80s of the 20th century. Currently, not only single-family housing, but also technical infrastructure and public buildings are being erected using the timber construction in these countries. Summarizes of share of wood technology in selected EU countrys on the housing market was presented in Table 1. The investments undertaken in the aforesaid countries in the area of biochemical engineering, the aim of which is to improve the productivity of trees in plantations, enable an increased use of timber in the construction sector [2]. Nowadays, according to Eurostat, an estimated 70% of timber in the EU is being used in the building industry, but only 20% of it meets structural requirements due to its properties [3].

Table 1. Share of wood technology in the housing market in selected EU countries

	Number of new residential buildings in 2019	Percentage of the wood construction in 2019	Percentage of the wood construction in 2018
Germany (4)	157 791	18.7%	17.8%
Poland (5)	82 799	0.85%	0.83%
Norway (6)	11 301	35.7%	39.3%

Environmental benefits of houses built in wood technology are invaluable and modern technologies allow to build high-quality and durable structures. Wooden technologies in combination with properly selected insulation materials, ideally fit into the vision of low-emission housing. As recent sources indicate, nowadays it is necessary to search for new insulating materials, to study their properties and not to focus only on increasing the thickness of already known materials [7]. Research indicates that not only the material chosen at the design stage, but also a thickness of the binder and plastering of the walls are of great importance in mitigating climatic changes. The use of 15 mm of cement plaster on a 1 m^2 wall, on both sides, reduces EC (Embodied Carbon) by 44% [8]. In response to this demand, it is worth examining the properties of straw as an insulation material, since currently 90% of thermo-acoustic insulation uses synthetic materials that generate greenhouse gas emissions [9]. If properly constructed and stored, straw can compete with popular wall insulation materials such as mineral wool or polystyrene [10].

1.1. Characteristics of straw as a building material

Rye, spelt or wheat straw, or mixtures thereof, are usually used in construction. For reasons of durability, the type of straw chosen is of little importance, as long as the structure itself is not damaged. The structure of the single stalk is cylindrical, and its outer coating is waxy and hydrophobic, so it does not absorb much moisture. Considering the organic composition of straw, it is practically identical to the composition of wood – it contains cellulose, hemicellulose and lignin (in addition, straw has a higher content of silica). For the production of straw bales, used as a wall insulation material, balers that allow to achieve cube densities from 50 kg/m^3 up to 220 kg/m^3, are used. In the case of methods where straw does not have a load-bearing function, the degree of its density is less important, but for cubes that are to be used in construction it must be at least 90 kg/m^3 and if the cubes are to carry loads it is a minimum of 110 kg/m^3. Another very important factor is the humidity of straw, as too much of it leads to the growth of mold, fungi, bacteria or to the formation of rot. That is why, according to the latest studies, the mass humidity of a bale should not exceed 14–15% [11].

Either exterior cladding or plaster is used for the building elevations, while inside either gypsum board or plaster is used. Plaster plays a major structural role. It increases the strength and improves the rigidity of the wall. In addition, it protects against decay and boosts fire resistance, protects against insects or other animals. For humidity reasons, it is necessary to choose plasters according to the principle of greater diffusion resistance on the inside. The external plaster should feature a high vapor-permeability, so that if water vapor enters the structure, it can migrate outside the dividing wall. The interior plaster should be made as a high diffusion resistance layer sd ≥ 0.1 m to limit moisture penetration into the partition [12]. These requirements can be achieved with a 3 cm thick internal clay plaster (sd = 0.3 m) and a 3 cm thick external lime plaster (sd = 0.45 m). The most commonly used plasters are the ones based on clay and lime. Cement plaster protects the straw very tightly against water, but it is quite brittle and not very flexible, it tends to form cracks through which water can penetrate. On the other hand, lime and clay plasters are moisture-binding plasters which is why they are best suited for plastering straw which needs good ventilation to prevent rotting processes.

1.1.1. Fire resistance

Straw, due to its high silica content (from 3 to 14% in its stalks), has good fire resistance parameters – during combustion the stalk is charred, protecting the core. In addition, the strong compression of the straw bales makes it difficult for air to enter them. Numerous tests have been carried out to record the fire resistance of straw bales. In 2006, the Ecological Building Network EBNet from the United States funded and supervised two fire resistance tests of ASTM E 119-05a [13] non-bearing straw bale walls. Walls measuring 425 cm wide ×365 cm filled with 46 × 35.5 × 91.5 cm straw bales were constructed. In the first study, a 1-hour fire resistance test of the wall covered with earth plaster, the wall showed a fire resistance of 60 minutes. In the second test: a 2-hour fire resistance test of a wall covered with cement plaster, the wall proved a fire resistance of 120 minutes. In Vienna, a fire resistance test was carried out according to ÖNORM B 3800, and a wall covered with 3–5 cm thick clay plaster achieved a fire resistance of 90 minutes. Similar tests were conducted in Germany according to DIN 4102. A load-bearing, straw bale wall covered with 3–5 cm thick clay plaster achieved F30 (approximately REI30) [14]]. In the UK, tests on ModCell panels exhibited a fire resistance of over 2 hours for walls plastered with 3 cm thick limestone plaster on both sides. This value is 4 times higher than the value required by the current UK regulations (which specify that the minimum fire resistance time for an exterior wall in residential buildings up to 5 m is 30 minutes). In the Czech Republic, a test was carried out in 2011 on the basis of ČSN EN 1363-1: 2000 and ČSN EN 1365-1: 2000. The wall 300 × 300 × 58 cm was plastered on one side with 5 cm thick clay plaster, while the other side was plastered with 3 cm thick lime plaster. The test showed the fire resistance of the wall was REI 120 [15].

1.1.2. Thermal insulation

Recent studies indicate that paying special attention to the quality of straw bale construction and proper fiber placement can improve the thermal resistance of straw bales by up to 28% [16]. According to Jean-Philippe Costes et al, it is particularly the effect of bale density and thickness that affects thermal performance. Their study showed that for a given wall width, the thermal conductivity λ and the heat transfer coefficient U can be improved by about 25%, depending on the bale density, and straw displays much better insulating properties for fibers oriented parallel to the direction of heat flow [17]. Table 2 summarizes the results of selected straw insulation studies.

Table 2. Summary of straw thermal conductivity values based on selected studies

Density [kg/m^3]	Fiber orientation	λ [W/(m · K)]	Reference
80	perpendicular	0.051	Douzane, 2016 [18]
80	parallel	0.072	Douzane, 2016 [18]
75	parallel	0.066	Conti, 2016 [19]
63	no data available	0.0594 ± 2.5%	Shea, 2013 [20]
75	perpendicular	0.052	Munch-Andersen and Andersen [20]
75	parallel	0.057	Munch-Andersen and Andersen [20]
76.3	no data available	0.0621 ± 2.5%	Shea, 2013 [20]
85	no data available	0.0619 ± 2.5%	Shea, 2013 [20]
90	perpendicular	0.056	Munch-Andersen and Andersen [20]
90	parallel	0.060	Munch-Andersen and Andersen [20]
107	no data available	0.0642 ± 2.5%	Shea, 2013 [20]
114	no data available	0.0642 ± 2.5%	Shea, 2013 [20]
123	no data available	0.0636 ± 2.5%	Shea, 2013 [20]
104.84	no data available	0.046 ± 0.001	Rojas [21]
112.50	no data available	0.047 ± 0.001	Rojas [21]
100	no data available	0.065	Buratti [22]

1.1.3. Sound insulation

Straw is perceived as a material with good acoustic performance. However, the acoustic comfort of houses made of straw bales is not confirmed by research. Some studies and tests have been carried out on the acoustic performance of straw, but these are limited in number. At the Technical University of Eindhoven in the Netherlands, a study was conducted on a plastered straw wall, which showed that the sound insulation index Rw was 53 dB. The wall was constructed of 120–130 kg/m^3 bales and was 46 cm wide, and was plastered on both sides with 2–3 cm thick straw and clay plaster [23]. Deverell et al. conducted a study to evaluate the sound insulation performance of a wall constructed of straw bales in the Genesis Center pavilion at Somerset College of Arts and Technology. The overriding goal was to see if straw bales were suitable for use as sound insulation in educational buildings with stringent acoustic standards [24]. The straw bales were shown to meet contemporary standards. Although plaster impacted the results (higher density, and thus better sound attenuation), it should be noted that it is also used for modern buildings. Dance and Herwin [25] compiled the results of some laboratory and field studies and additionally conducted two complementary studies. Their publication indicates that the sound insulation of straw is particularly poor at low frequencies, which is related to their low deadweight.

1.1.4. Legal conditions

The most extensive building regulations have been developed in the USA, where specific building regulations can vary from state to state and even from city to city. So called StrawBale-Code, contains detailed guidelines, which are the basis for the process of designing and construction of buildings in strawbale technology. Currently, it is possible to build relying on strawbale technology in the following states: Arizona, California, Colorado, Nebraska, New Mexico, Nevada, Oregon and Texas. In Germany, thanks to the activity of the FASBA Society, fire resistance, load bearing capacity of the structural wall, thermal and acoustic properties, humidity parameters and the risk of mould and mildew were among other things examined. As a result of these tests, a technical approval recognizing and allowing the straw bale as a construction product, was developed. In France, the industry standard Règles professionnelles de la construction en paille issued by the RFCP has been available since 2012, based on which straw buildings are constructed. Also in the UK, many strawbale buildings have been constructed in recent years. A major contribution to the research in straw has been made by a research center at the University of Bath, which has looked into issues such as emissivity and carbon footprint, and the energy requirements of straw buildings. Thanks to these activities, among others, ModCell panels have received appropriate technical approvals, allowing for erection of buildings using them [26]. Thus far in Poland, several dozen buildings have been raised basing on this technology, including residential buildings. Along with growing interest in this kind of construction, there are more and more of them every year. The application of straw bales in a building may be fulfilled only on the basis of the Act on Construction Products, which allows for authorization of a construction product to individual use in the building. Such a product must be made according to individual technical documentation drawn up by the building's designer. So far, straw has not had any assessment or technical approval allowing it to be marketed as a construction product. No standards or codes for designing the buildings made of straw have been developed either, which is why all studies and publications supporting this technology are so important for the promotion of this trend.

2. Method

LCA method – in order to determine the environmental impact of a given material or building, an LCA analysis which allows to determine the intensity of impact during the entire life cycle of the building or material, is applied. Moreover, it includes consideration of environmental problems such as global warming, ozone layer depletion, soil acidification, water acidification, etc. Detailed calculations are presented in spreadsheets [27].

Building typology – the analysis conducted concerns detached houses. The selected case study represents a typical house in terms of use of conventional construction method and materials used. For the comparative analysis, three additional variants of this building with different material and construction solutions were adopted, worth evaluating in terms of minimizing CO_2 emissions.

Units of analysis – in this study, the publicly available database ICE (Inventory of Carbon & Energy) in version V.2.0 and version V.3.0 was used. The database includes data on the environmental impact of a given material in the product design phase from extraction to manufacturing process (A1–A3) [28]. Version V.2.0 of the database includes information on parameters such as embodied carbon content and the carbon footprint of individual materials. The database contains an indicator for the cumulative energy of a given material, i.e. information on how much energy was used during production, transport and use of a given product. The embodied energy is given in MJ/kg. The database also provides information on the carbon footprint of individual materials. The carbon footprint indicator is expressed in $kgCO_2/kg$, when only carbon dioxide is considered, and in kg CO_2e/kg when all greenhouse gas emissions are considered. In version V.3.0 of the database, we find only the carbon footprint indicator without considering the cumulative energy of a material, because cumulative carbon is considered a more useful indicator in modern analyses.

Building materials production analysis – the amount of cumulative energy, i.e. primary energy consumed during the entire process of building material production from obtaining raw materials to leaving the factory gates expressed in MJ, was assessed. The carbon footprint was also assessed, i.e. the sum of emissions generated in the process of material production, including CO_2 emissions expressed in $kgCO_2$ and greenhouse gas emissions expressed in $kgCO_2e$.

Case study – the basis of the study for the comparative analysis conducted in the calculation part, is a conceptual design of a single-family house prepared by the author of this paper. The reference building is a single-storey house without a basement. It was designed on an L-shaped plan which we can see in Figure 1. The dimensions of the longer sides are 12.06×11.33 m.

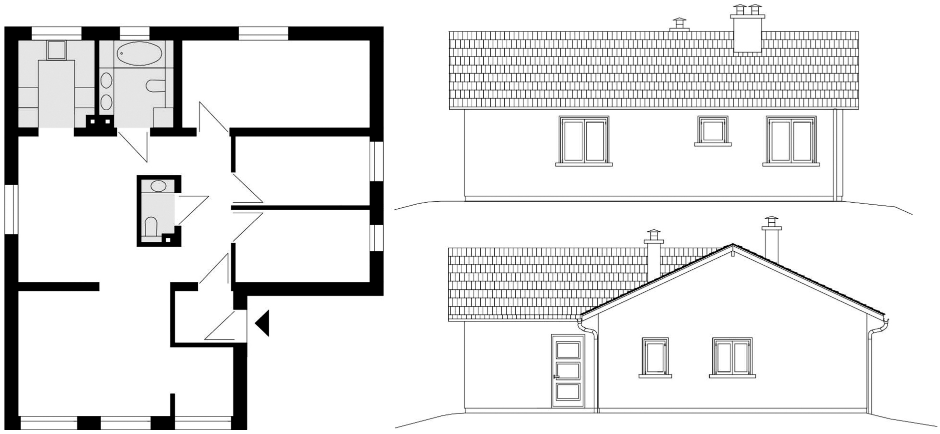


Fig. 1. Layout and elevation view of the reference building

Four different variants of the reference building were assumed in the study (the numerological nomenclature was adopted: variant I – the reference building, variant II, variant III, variant IV). Such constructional and material solutions of the external walls have been assumed for each variant of the building to obtain the similar thermal transmittance $U \approx 0.17$ [W/(m$^2 \cdot$ K)]. Detailed material and technological solutions for particular variants are described in Tables 3–7.

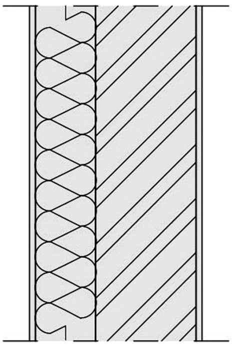
Table 3. Characteristic parameters of the house elements in particular variants

Characteristic parameters	Variant I	Variant II	Variant III	Variant IV
Wall thickness [m]	0.43	0.42	0.52	0.45
Usable floor area [m^2]	94.78	93.52	85.35	96.74
Gross covered area [m^2]	120.28	120.28	120.28	120.28

In all variants the foundation of the building has been assumed directly, on the cross-reinforced concrete B20 foundation slab. The floor (ceiling) of reference building (variant I) is a monolithic reinforced concrete ceiling as thick as 15 cm. It has been assumed that ceilings of variants II, III and IV are wooden beam ceilings. In all variants the unused attic is assumed as non-insulated and is insulated from the surface heated by a layer of thermal insulation laid on the ceiling. The roof of the reference building (variant I) is a multi-pitch roof, with pitches 25° and 27°, covered with bituminous shingle. It has been assumed that the roof structure is the same (collar beam truss) for each of the other building variants. The reference building (variant I) has a PCV window joinery. It has been assumed that dimensions of windows and their arrangement in remaining variants will not change. In calculations concerning thermal conductivity coefficient, the following boundary conditions have been assumed: average outside temperature θ_e is –5°C, average outside temperature θ_i is 20°C. Layers with small thickness have been omitted in the calculations

Table 4. Characteristic parameters of the outer wall – variant

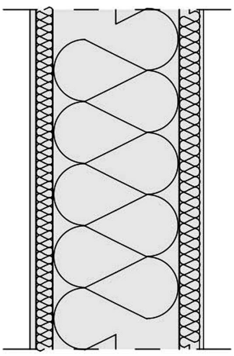
Outer wall – variant I (reference building) – a traditional technology, made of brick: Porotherm ceramic hollow brick with a thermal insulation layer of polystyrene foam



Material	d [m]	λ [W/(m · K)]	R (m^2 · K)/W]
R_{se}	–	–	0.04
Atlas cement-lime plaster	0.015	0.8	0.02
Styrofoam Termonium Plus	0.15	0.031	4.84
Porotherm 25 P+W hollow brick	0.25	0.313	0.80
Atlas silicone-silicate plaster	0.015	0.67	0.02
R_{si}	–	–	0.13
In total	0.43	–	–

Table 5. Characteristic parameters of the outer wall – variant II

Outer wall – variant II (heterogeneous partition) straw bale technology: a lightweight timber framework with padding of straw bales and a double-sided lining of Steico boards



Material	d [m]	λ [W/(m · K)]	R [(m^2 · K)/W]
R_{se}	–	–	0.04
Atlas cement-lime plaster	0.015	0.8	0.02
Steico Protect H insulation board	0.04	0.043	0.93
A) Wooden studs 6 × 30 cm B) Straw bales between studs	0.3 0.3	0.16 0.08	1.88 3.75
SteicoFlex insulation board	0.05	0.038	1.32
SteicoFlex insulation board	0.01	0.84	0.01
R_{si}	–	–	0.13
In total	0.42	–	–

due to the lack of significant impact on the final calculation results. According to different sources (Table 2), the thermal conductivity coefficient λ of straw varies depending on the straw density and the orientation of its stalks. The value of thermal conductivity λ of straw confirmed by DIBt: Deutsches Institut für Bautechnik is 0.052 W/(m · K) when the heat flow is perpendicular to the straw fibres and 0.080 W/(m · K) when it is parallel. For the needs of the calculations, a thermal conductivity value for straw of $\lambda = 0.080$ W/(m · K) has been assumed. For the materials used in respective technological variants of the building, the carbon footprint and the amount of embodied energy needed for their production will be calculated. The results of the consideredes variant comparison are presented in Table 8.

Table 6. Characteristic parameters of the outer wall – variant III

Outer wall – variant III (heterogeneous partition) straw bale technology: a lightweight timber framework with padding of straw bales and boarding from the outside and oriented strand board from the inside

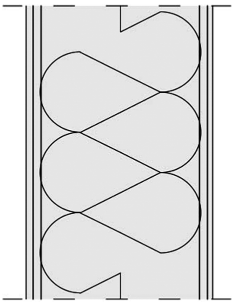
	Material	d [m]	λ [W/(m · K)]	R [(m^2 · K)/W]
	R_{se}	–	–	0.04
	Ventilated boarding	0.02	0.16	0.125
	Wind barrier	omitted in calculations		
	Waterproof plywood	0.02	0.13	0.154
	A) Wooden studs 6 × 44 cm B) Straw bales between studs	0.44 0.44	0.13 0.08	3.385 5.500
	Vapor barrier foil	omitted in calculations		
	Oriented strand board	0.022	0.13	0.169
	Termoline gypsum plasterboard	0.015	0.165	0.091
	R_{si}	–	–	0.13
	In total	0.52	–	–

Table 7. Characteristic parameters of the outer wall – variant IV

Outer wall – variant IV (heterogeneous partition) wood technology: rectangular solid logs, mineral wool padding and imitation of a rectangular log from the outside

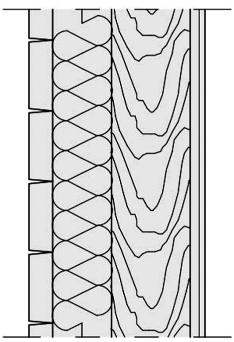
	Material	d [m]	λ [W/(m · K)]	R [(m^2 · K)/W]
	R_{se}	–	–	0.04
	Exterior wooden pine log 6 × 18 cm	0.06	0.160	0.375
	Wind barrier	omitted in calculations		
	A) Pine wood studs 5 × 15 cm B) Rockwool mineral wool between studs	0.15 0.15	0.160 0.032	0.938 4.688
	Rectangular pine wood log 20 × 18 cm	0.20	0.160	1.250
	Vapor barrier foil	omitted in calculations		
	Oriented strand board	0.022	0.130	0.169
	Termoline gypsum plasterboard	0.015	0.165	0.091
	R_{si}	–	–	0.13
	In total	0.45	–	–

Table 8. Comparison of the results of the embodied energy and the carbon footprint for considered variants of the building

Adopted variants	Embodied energy	Carbon footprint	Carbon footprint including carbon capture
	[MJ]	[$kgCO_2$]	[$kgCO_2e$]
Variant I	628 945.61	40 714.97	13 575.51
Variant II	584 742.13	40 401.87	–38 125.16
Variant III	627 437.84	44 398.23	–51 037.07
Variant IV	614 588.14	41 438.77	–43 674.02

In this study, the publicly available ICE (Inventory of Carbon & Energy) database in version V.2.0 and version V.3.0 has been used. The database includes data on the environmental impact of a given material in the product design phase from extraction to manufacture (A1–A3). Version V.2.0 of the database contains information on parameters such as embodied carbon content and carbon footprint of individual materials. The database contains an indicator for the cumulative energy of a given material, i.e. information on how much energy has been used during production, transport and use of a given product. The embodied energy is given in MJ/kg. You can also find information about the carbon footprint of individual materials in the database. The carbon footprint indicator is expressed in $kgCO_2/kg$, when only carbon dioxide is considered, and in $kgCO_2e/kg$ when all greenhouse gas emissions are considered. In version V.3.0 of the database, we find only the carbon footprint indicator without taking into account the cumulative energy of a material, because cumulative carbon is considered a more useful indicator in modern analyses. In addition, the carbon footprint indicator is only given in $kgCO_2e/kg$ notifying of all greenhouse gas emissions of a specific material. It is a comparison between the amount produced or absorbed by a material and the amount of energy consumed in its production. Since timber is an organic material, plants absorb CO_2 as they grow and embody it. The carbon is stored in the wood and the oxygen is released into the atmosphere (as is similarly in the case of straw). In version V.3.0, the carbon footprint indicator of the wood is split into data that includes carbon stored in wood and data that does not include carbon stored in wood.

3. Studies and findings

Variant II has allowed the reduction of the cumulative carbon footprint by 7.03%, while variant III has reduced it by 0.24% and variant IV by 2.28% compared to brick technology (variant I). In the case of carbon footprint including carbon sequestration, the carbon footprint has undergone the reduction by almost 4 times compared to the reference building constructed in a traditional technology. Even better results have been obtained for variants III and IV. This is mainly due to the high proportion of organic materials in the wall construction. This proves the validity of using low-emission materials in construction. The carbon footprint in relation to CO_2 emissions in all cases considered is similar and has not improved significantly (Fig. 2). This may be due to a number of factors, the identification of which requires a more detailed analysis. In case of variant III, the results may not be conclusive as the wall in this variant is much thicker than in the other variants (due to obtaining an appropriate heat transfer coefficient of the wall), which translates into the quantity of materials needed for its construction and may overestimate the carbon footprint. Analyzing the above results the most favorable variant in relation to the reference building (variant I) is variant II. It is a light framework with straw infill and Steico board cladding. Undoubtedly, the use of straw in construction can contribute to environmental protection and significantly reduce emissions of gaseous pollutants. Buildings constructed based on this technology, as you can see, also do not require high energy consumption during the product design phase. Thus, the propagation of this unconventional technology may have a significant and positive effect on the environment as well as economic values which presented in Table 9 and Figure 3.

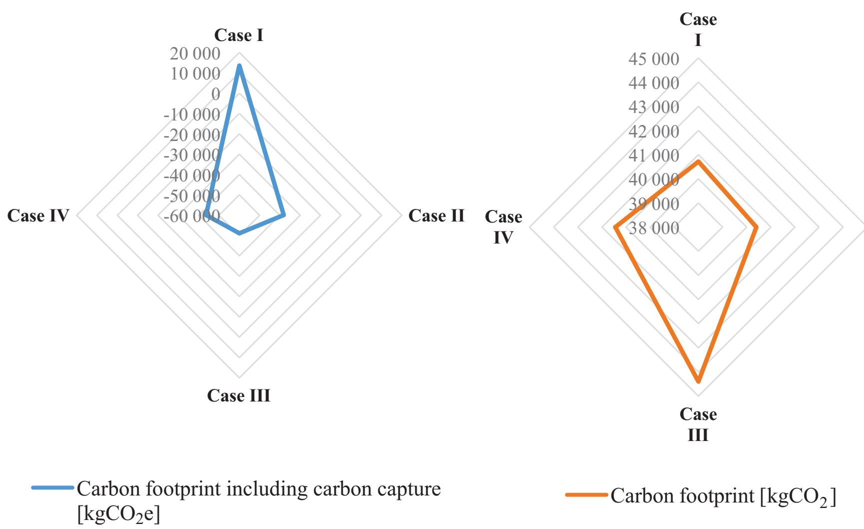


Fig. 2. Comparison of CO_2 footprint and carbon footprint with carbon capture for respective variants

Table 9. Comparison of results of the analysis of material costs and the analysis of workmanship and material costs for individual variants of the building

Compared of results	Variant I	Variant II	Variant III	Variant IV
Cost of materials used per m^2 of elevation (net) [PLN]	145	160	210	460
Cost of materials used per m^2 of elevation including workmanship cost per m^2 of elevation (net) [PLN]	280	315	390	770

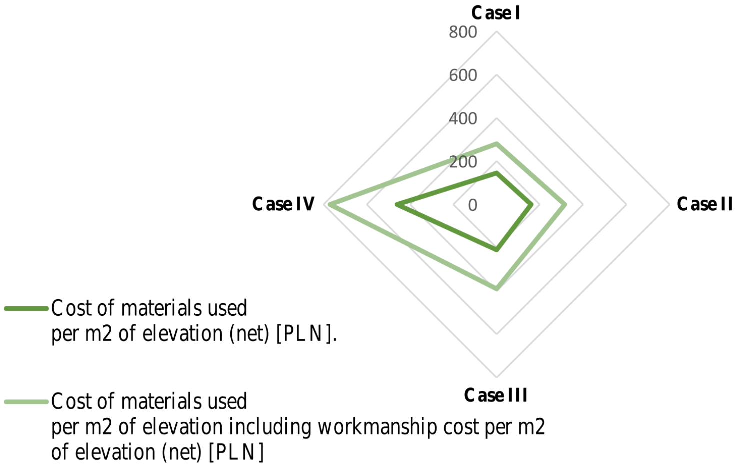


Fig. 3. Comparison of the results of material and workmanship cost analysis for individual variants of the building

4. Conclusions

The research carried out shows how ecological variants of a detached house construction using wood and straw (variants II, III and IV) present themselves in comparison to the most popular conventional method using ceramic blocks (variant I). It has been pointed out that the carbon footprint [$kgCO_2e$] for construction from natural materials is more than 4 times lower than for brick technology. It is quite the opposite when it comes to building and workmanship costs. Traditional technology has turned out to be the cheapest (about 12.5% compared to variant II and as much as 275% compared to variant IV). Variant II is the optimal variant in the overall comparative study, both environment- and cost-wise. The data presented shows that the low popularity of green technologies is associated with higher or comparable construction costs. Therefore, their wider application can only be successful with adequate promotion of environmental benefits, as well as consistent and supportive legislation and public sector. Development of mechanisms designed for acquiring subsidies and subventions, introduction of tax reliefs, invitation of all kinds of local- and state-run activities promoting eco-construction initiatives are evident. The promotion and development of the strawbale technology is also hampered by the lack of coherent and comprehensive characterization of straw bales as a building material. In spite of numerous scientific studies on the subject, research results still vary according to the guidelines adopted. The work authored by ChuenHonKoh and Dimitrios Kraniotis, shows an overview of the properties of straw bales that can serve as a scientific material for future research [28]. Among the possible solutions to make strawbale buildings a major construction technique, the first step is to establish guidelines on the qualities that must be met during the baling process, such as standard dimensions, density, fiber orientation, and so on, since standard characteristics are one of the advantages of traditional materials over innovative ones. Straw bales could then be standardized worldwide and formally certified.

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Ocena cyklu życia (lca) oraz porównanie wpływu na środowisko wybranych metod budowania domów jednorodzinnych w technologii tradycyjnej i kostek słomy – studium przypadku

Słowa kluczowe: straw bale, redukcja CO_2, Life Cycle Assessment (LCA), zrównoważone materiały, badanie akceptacja

Streszczenie:

Popularne, konwencjonalne materiały budowlane zwykle charakteryzują się wysoką energochłonnością i szkodliwym oddziaływaniem na środowisko. Tylko niewielka ich część poddawana jest procesom odzysku i recyklingu, do ponownego użycia w budownictwie czy też innych gałęziach przemysłu. Technologia budowania domów jednorodzinnych z bloczków ceramicznych jest jednak wciąż najczęściej wybierana przez inwestorów z uwagi na cenę i dużą dostępność (materiałową i wykonawczą). Badania wskazują, że 25–30% emisji CO_2 generowanej przez budynki pochodzi z materiałów oraz procesu ich produkcji. Natomiast 70–75% odpowiedzialne jest użytkowanie budynków w dłuższym okresie czasu. W rezultacie znaczenie alternatywnych materiałów o minimalnym wpływie na środowisko naturalne jest z roku na rok coraz większe. Budownictwo ekologiczne, używając produktów naturalnych, znacznie mniej zanieczyszcza otoczenie naturalne niż budownictwo konwencjonalne. Kluczowym jego elementem jest stosowanie materiałów o jak najmniejszym stopniu przetworzenia, a co za tym idzie o jak najmniejszej energii wbudowanej. Materiałem, który doskonale wpisuje się w powyższe założenia są kostki słomy, tzw. straw bale, które na przestrzeni ostatnich lat są coraz chętniej używane w budownictwie ekologicznym. W artykule, za pomocą metody LCA porównano cztery warianty budowy domu jednorodzinnego. Wariant I – referencyjny, przedstawia technologię z wykorzystaniem pustaka ceramicznego, wariant II, III i IV to technologie ekologiczne z wykorzystaniem drewna i słomy. W badaniach przedstawiono ilość energii potrzebnej do wybudowania i ślad węglowy jaki pozostaje w środowisku po wybudowaniu obiektów. Porównano także ich parametry ekonomiczne takie jak rzeczywiste koszty materiałów i wykonawstwa. Wyniki badań są źródłem wiedzy w temacie projektowania ekologicznego z wykorzystaniem słomy. Pokazują i zachęcają do wykorzystania zrównoważonego projektowania w architekturze domów jednorodzinnych.

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