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Sustainable Innovation Approach for Wood Quality Evaluation in Green Business

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Abstract: The purpose of this paper is to propose a method for the optimization of raw wood for the timber construction industry that would meet the green business and sustainable development requirements within the concept of corporate social responsibility. The methodology conceptually applied the ImageJ software in the process of spruce-timber valuation using 100 log specimens according to the standard STN 480055. The impact of timber structure on the environment compared to silicate buildings was assessed via selected environmental criteria of life-cycle assessment. The methodology was applied according to the standards within the monitored phase of the life-cycle cradle to a gate based on the available environmental products declaration. The overall difference in the assortment value when using the ImageJ software as the evaluation method reached €426.68 (+6.7%). The individual construction elements creating the composition of perimeter walls of the evaluated alternatives showed a positive impact of the following indicators: global warning potential, primary energy input for production, ozone depletion potential, and photochemical ozone creation potential of the reference timber structure. The findings presented in this study clearly confirm the ecological approach toward building a wood-based structure while meeting the requirements of sustainable development.

Keywords: green business; life-cycle assessment; timber frame construction; raw-wood assortments; ImageJ

1. Introduction

The business environment is currently characterized by many changes and uncertainties that can be traced back to globalization processes, new technologies, dynamic innovation processes, as well as to the issues associated with the changes in social, economic, and environmental conditions worldwide. The essential part of the market economy is a business, which provides the potential for increasing the standard of living, and thus, it is an initiator and creator of corporate social responsibility in its own environment, as well as in relation to its partners [1].

Although the concept of corporate social responsibility was known for several decades and is already used in practice, there are still certain ambiguities regarding the term. Bowen [2], as one of the first, defined corporate social responsibility as a commitment of businesses to fulfill such strategies, to make such decisions, and to carry out such activities that will be desired from the viewpoint of the entire society and its values. A few years later, Drucker [3] associated corporate social responsibility with key areas, and he claimed that, while making decisions, it is important to consider whether the business's operations will contribute to the social stability, harmony, and cohesion. Current authors [4] have similar views on this issue. They see corporate social responsibility as a voluntary activity of businesses, which is carried out in order to fulfill their own business mission, and their stakeholders' expectations and commitments to the environment and society as a whole. Werther and Chandler [5] provided a more strategic perspective. They defined corporate social responsibility as the businesses' task in the society while reaching their goals and maximizing the profit. The Green Report of the European Commission provides probably the most well-known definition of corporate social responsibility, which can be seen as a voluntary integration of social and environmental concerns in the business operations and in the interaction with business stakeholders [6]. The complex of a socially responsible business can be better understood through the triple bottom line (TBL) concept. This concept suggests that the business operations, in respect to the social responsibility, are assessed at three levels—economic, social, and environmental. This enables us to see business operations in a wider context of social and ecological interactions [7]. The economic level of social responsibility mainly represents monitoring and improving the processes, which the business uses for the development of the economic environment while minimizing the negative impacts of its operations. According to Kuntz [8], it is the overall behavior and business management based on transparency and ethics. At the social level, corporate social responsibility is closely associated with the monitoring and effort to minimize the negative impacts of the business operations on the social system. The environmental level is primarily focused on monitoring and minimizing the business's impacts on the environment. These activities cover conservation of limited sources, investments into ecological technologies, energy savings, as well as producing environmentally friendly products [9].

The present paper focuses on a practical demonstration of using the economic and environmental elements of corporate social responsibility in the context of building timber constructions.

The possibility of using wood, as one of few ecologically renewable resources, and mainly its increasing consumption place higher demands on the optimization of its valuation. The production potential of forests in Europe and worldwide is limited [10,11]. New ecologically friendly approaches toward forest management, associated with the global climate change and negative impacts on forests will cause a change in the volume and quality of forest stands [12–14]. Moreover, green economics highlights more and more the non-production forest functions and the advantages of wood products from the point of view of carbon footprint [15–19]. Timber, as one of few building materials, has a positive CO_2 score, meaning that during the growth phase, wood absorbs more CO_2 than is released during its preparation and use in actual building processes. Due to this fact, wood as a renewable resource will play an extremely important role in the business sector. Since the production potential of forests will not increase in the future, it will be inevitable to optimize the use and valuation of timber. The optimization of the valuation of timber has a key impact on its placement and use in green business [20,21].

The sector of timber construction belongs to dynamically developing sectors due to the simplicity and pace of construction, as well as the energetic characteristics and carbon footprint [22,23]. This sector belongs to green business products by meeting the sustainable development requirement. The essential materials for the structural elements of timber structures are sawlogs. Regarding the wood species, spruce and fir are used most often. They are popular mainly due to the relative ease of processing technology and the quality of wood. As the demand for timber structures increases and the market frequently experiences a lack of the available material, other wood species (e.g., beech) are also being used more often for producing the structural elements of timber constructions [24,25]. The substitution of several wood species in the construction sector will be inevitable in the future because, even now, the market lacks the traditional raw materials.

Spruce and fir sawlogs have to meet qualitative requirements regarding specific technical conditions, which can slightly vary regionally or internationally. Technical requirements are enforced following a range of quantitative and qualitative wood characteristics. Generally, with these assortments, conformity in the main qualitative requirements (degree of crookedness, occurrence of knots, and rot), which are the decisive limiting features, can be found. Assessing and measuring these features in the forestry practice is often not optimal or objective. It results in quality timber being undervalued and designated for not the best possible use [26–28]. The valuation of raw wood can be optimized using software aids and modern approaches toward assessing qualitative features.

An important economic, as well as ecological, aspect of timber utilization in the construction industry is the quantification of the environmental impacts. According to Wu et al. [29], Vilches et al. [30], Weiler [31], and Su et al. [32], the life-cycle assessment (LCA) quantifies the potential impact of a product or service on the environment in a complex way, and is defined in the standards ISO 14040: 2006 [33] and ISO 14044: 2006 [34]. For an effective processing of LCA studies, commercially available databases of processes, and material and energy flows are used. It is one of the most important information tools of environmentally oriented product policy. Life-cycle assessment is a method for comparing the environmental impact of products with regard to their life cycle. It considers emissions into all components of the environment during the product production, use, and disposal. LCA studies often show the relationship between the boundary energy and operational energy (energy required for sustaining a building and its comfort). Recent advancements in LCA indicate that the global tendency is to build constructions with lower energy demands in the operational condition due to the international goals in the field of energy efficiency. Building low-energy wood-based houses is often a solution for this issue.

The aim of the study was to demonstrate the potential of valuation and availability of coniferous sawlogs for the building industry using specific software for a transparent valuation that is in accordance with the principles of economic responsibility and green business. The specific aim was to quantify the comparison of environmental impacts through life-cycle assessment of a silicate-Ytong building and a timber-frame construction with the view of meeting the sustainable development requirement.

2. Materials and Methods

2.1. Reference Building with Disposition Characteristics

The basic features of the reference building are presented in Table 1. The basic features were elicited from a survey on the preferences of potential customers carried out by Debnár and Potkány [35].

Table 1. General information on reference building.

	1st Alternative Timber Structure	2nd Alternative Brick House
Base plate area (m^2)	92 (11.5 × 8)	92 (11.5 × 8)
Usable floor area (m^2)	157	147
Perimeter wall area	148.27	148.27
Household size (no. of people)	4–5	4–5
Number of bedrooms	4	4
Number of floors	2	2
Construction type	Timber frame construction	Ytong
Type of roof	saddle roof	saddle roof
Type of windows	plastic windows	plastic windows
Heat transfer coefficientfor perimeter wall (U; W/m^2K)	0.15	0.18

Source: Authors' compilation.

Plastic windows were selected for both assessed alternatives and determining the environmental indicators due to the same conditions for parameters not being assessed. This type of window is preferred mainly in masonry structures due to lower acquisition costs.

The basic structural material for the timber-frame construction is spruce timber. The required volume of timber, without the roof construction (same for both alternatives—timber and silicate structure), is presented in Table 2.

Table 2. Amount of structural timber for the selected timber structure.

Construction Parts of House		**Unit (m^3)**	**∑ (m^3)**
1st floor	Perimeter wall	2.97	11.44
	Internal battens	0.85	
	Bearing wall	1.48	
	Other walls	0.48	
	Ceiling 1st floor	5.66	
2nd floor	Perimeter wall	2.01	4.12
	Internal battens	0.77	
	Bearing wall	1.18	
	Other walls	0.41	
Construction of roof	-	-	-
Total			15.56

Source: Authors' compilation.

2.2. Quality Evaluation of Spruce Sawlogs

In the forestry practice, the quality marks of sawlogs are assessed visually or on the basis of manual measurement. Methods for measuring and assessing the quality marks of sawlogs are specified in the standards EN 1310 and EN 1311 [36,37]. Some quality marks, e.g., rot, stains caused by fungi, reaction wood, or false heartwood, are, according to these standards and technical conditions, assessed following their areal extent on the log-end area. Assessing the sawlogs visually can lead to overrating or underrating the extent of these marks, especially if their shape is irregular. The standards require creating a circumscribed circle around such marks and measuring the diameter. Accurate assessment of the areal extent of a mark can significantly affect the grading of the assortment into the corresponding quality class. For grading the sawlogs according to the technical conditions regarding the quality marks, the Slovak standard STN 48 0055 [38] was used. This standard classifies the coniferous sawlogs into three classes: III.A, III.B, and III.C. Marks assessed according to the areal extent in these classes are reaction wood, rot, and stains. The allowed extent of these quality marks in individual quality classes of sawlogs is illustrated in Table 3.

Table 3. Allowed extent of marks of spruce and fir sawlogs assessed according to the area, according to the STN 48 0055.

Quality Mark	**III.A**	**III.B**	**III.C**
Tension/compression wood	Not allowed	Up to 30%	Allowed without restrictions
Rot	Not allowed	Not allowed	Dote up to 2/3 area of the end diameter
Stain	Not allowed	Up to 1/3 area of the end diameter	Allowed without restrictions

Source: Authors' compilation.

One hundred pieces of raw-wood spruce assortments were assessed altogether. These assortments were produced according to the technical requirements of the standards [36–38].

The ImageJ software was selected as an alternative tool for the optimization of the quality assessment of these assortments. Its use and methodology for assessing the areal extent of marks (false heartwood and other marks) in beech wood are described in previous studies [26,39,40]. The methodology for assessing the marks using this software was adopted from Reference [26]. The process of assessing the quality marks in this software include the following steps:

- Creating and processing a digital image perpendicularly to the log-end area axis with the quality mark and measuring the log-end area diameter manually;
- Image processing in the software and determining the scale (scale is the log-end area diameter in centimeters);
- Bordering the log-end area in the software;

- Bordering the area of the quality mark in the software;
- Calculating the log-end area of the quality mark.

Following this procedure, it is easy to accurately determine the area occupied by the specific quality mark on the log-end area. The results are, beyond all doubt, more accurate. The processing algorithm in the ImageJ software is illustrated in Figure 1. All logs were assessed in the software using this algorithm.

Figure 1. Evaluation of compression wood in spruce with the ImageJ software: (**a**) scale determination in cm; (**b**) log-end area determination; (**c**) area of compression wood determination.

For evaluating the economic impact of the software use, a standard price list of raw-wood assortments of the state forest enterprise for the second quarter of 2018 was used. The price list is available in the Forestry Market Information System [41]. The prices are in €·m^{-3} without value-added tax (VAT) at the trade parity franko—supplier warehouse.

2.3. Structure of Perimeter Wall for LCA

For the needs of the LCA and the subsequent quantification of comparing the impact on the environment of both alternatives, timber construction and silicate construction, according to the requirements of ISO 14040: 2006 [33] and ISO 140044: 2006 [34], it is inevitable to define the composition of the individual perimeter walls (Figures 2 and 3). For the timber construction, a wall structure meeting the requirement for a heat transfer coefficient of 0.15 W/m^2 K was selected. For the silicate construction, a wall structure meeting the requirement for a heat transfer coefficient of 0.18 W/m^2 K based on Ytong construction was selected. Both structures met the thermal performance requirements of the standard STN EN 73054-2/Z1 [42].

Assessing the building over its life cycle provides insight into the real quality of the building because buildings are usually used over a very long period of time. The main phases of the life cycle of a building are planning/design, construction, use including maintenance, and rehabilitation, as well as demolishing, recycling, and disposal (Figure 1). The phases of a building's life cycle must be analyzed with a view to the different sustainability aspects, and optimized with regard to their interaction. The aim was to achieve an objective and quantitative assessment method for comparing variants of different building designs in order to achieve the best possible building and utilization quality with the lowest possible expenditure and environmental impacts, and to maintain this on a long-term basis. Based on the available environmental products declaration (EPD) that mostly declares the impact only on a certain life-cycle stage, we chose the LCA cradle-to-gate system boundary for simplicity (ISO 14025) [43].

When evaluating the environmental impact of the chosen materials, the following criteria were selected:

- Primary energy input for production (PEI): This is a quantity in MJ including the amount of primary energy consumed in the given material. It is the energy spent in obtaining the raw material, production, and material transport;

- Emission CO_2 ekv. (global warming potential; GWP): This figure covers emissions contributing to the greenhouse effect. Carbon dioxide was used as an equivalent due to its largest amount. The number of kilograms of CO_2 released during the material production was monitored;
- Emission SO_2 ekv. (acidification potential; AP): Sulfur dioxide was used as an equivalent; however, this figure also covers other gases contributing to acidification, mainly nitrogen oxides and ammonia. This figure provides information on the extent of damage to water, forest, and soil ecosystems, as well as to buildings caused by acid rain;
- Ozone depletion potential (ODP): Ozone layer depletion;
- Photochemical ozone creation potential (POCP): Creation of ground-level ozone as summer smog;
- Eutrophication potential (EP): Water, ground water, and soils.

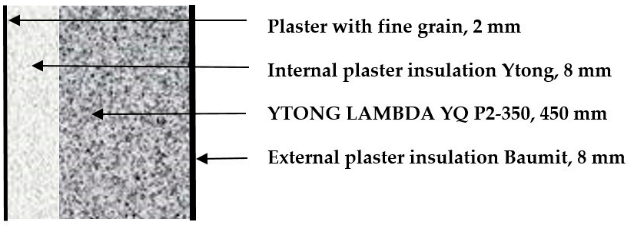

Figure 2. Composition of the perimeter wall of the silicate construction.

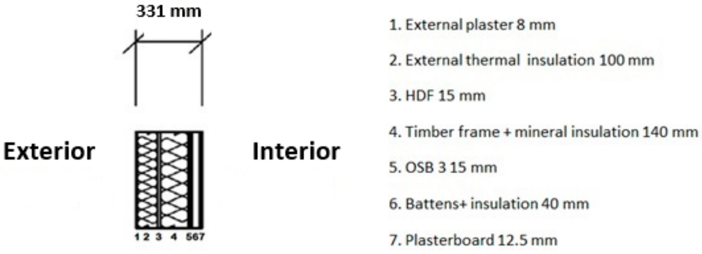

Figure 3. Composition of the perimeter wall of the timber construction.

PEI is the key for environmental assessment. Determining the PEI indicator in the analysis of wall composition is based on currently available EPD certificates of individual materials used for both types of perimeter wall. These certificates are guaranteed by the producers of the product in question. System boundary A1–A3 LCA of the production phase is in accordance with the standard EN 15804:2012, so-called cradle-to-gate. Other modules A4–C4 and D were not incorporated into the LCA due to the difficult availability of the input data, and therefore, are not declared by the EPD certificate. The production phase is, from our point of view, the key, due to the amount of primary energy consumed, and it further affects phases too. The system boundary was determined in order to cover all processes providing the material and energy inputs into and from the system. The source of the input data for a complex analysis of environmental parameters was the software SimaPro 7.3 using the database Ecoinvent, version 2.2. by the Europe Life Cycle Database (ELCD). Based on the data available, the need for PEI and other environmental indicators, GWP, AP, ODP, POCP, and EP, for individual wall compositions was quantified. The quality of the EPD input data respected the time, technological, and geographical criteria. The database, Ecoinvent, considered the energy mix of electricity production in the producing country. In the case of data not being available in the producing country, data valid for the EU were used. The comparability of materials used for the selected wall compositions was guaranteed by the same methodology for issuing the EPD certificate, as well as by following the standard EN 15804:2012.

3. Empirical Results

Results of the Qualitative Assessment of Spruce Sawlogs

From the three selected quality marks that were assessed on the basis of the areal extent, compression wood was recorded in the case of 16% of logs, rot in 26% of logs, and stain in 13% of logs. The grading into the corresponding quality classes in accordance with the requirements of STN 48 0055 is illustrated in Table 4. The assessment was carried out following the standards and using the software. Overall, in the case of assessment using the ImageJ software, a better valuation in a higher quality class was achieved with 21% of logs. The economic evaluation of using both methods for qualitative grading of spruce logs is also illustrated in Table 4. The overall difference in the value of assortments when using the ImageJ software as the assessment method reached €426.68 (+6.7%). When changing the method of assessing the quality marks, which were assessed according to the areal extent, a better valuation of produced raw-wood assortments could be achieved.

Table 4. Economic evaluation of the analyzed spruce using two evaluation approaches.

Quality Class/No. of Logs	Price [1] in €·m^{-3}	Number of Logs According to EN 1310, 1311	Total Price in €·m^{-3} According to EN 1310, 1311	Number of Logs According to ImageJ	Total Price in €·m^{-3} According to ImageJ
II.	115.51	19	2194.69	25	2887.75
III.A	80.57	11	886.27	11	886.27
III.B	85.06	10	850.6	8	680.48
III.C	56.44	20	1128.8	18	1015.92
IV.	48.62	7	340.34	9	437.58
V.	29.28	23	673.44	24	702.72
VI.	21.98	10	219.8	5	109.9
Total		100	6293.94	100	6720.62

Source: Authors' compilation. [1] Prices according to Reference [41].

The results prove that the method for assessing the sawlogs via software enables getting a higher amount of more quality timber assortments. The quality classes II.–III.C are most often used as the input raw material for building timber structures. The economic analysis shows that this innovative approach can contribute to higher profits for primary timber producers due to better timber valuation.

The analysis confirmed that, in the case of irregular quality marks, the methodology established by the standards EN 1310 and 1311 systematically overrates the areal extent of the mark. It subsequently affects the valuation potential of the specific log. A disadvantage of using the ImageJ software is that there is no legislation support in the standards so far, and the approach to creating the images in the real conditions of the forestry practice (different equipment, camera angle, light conditions, etc.) cannot be unified. Nevertheless, it provides a simple tool that can be used in difficult conditions of forestry practice. The utilization of computed tomography (CT) scanners and tomography for detecting the extent of quality marks is impossible due to operational and economic reasons. Very often, the incorrect and inaccurate quality assessment is the reason for grading many logs into lower quality classes, and therefore, the logs lose the potential for more valuable processing [44,45]. In the future, when a lack of coniferous sawlogs is expected, this approach to quality assessment can bring at least some mitigation of this negative trend. Providing that the evaluated spruce raw wood will be further used for construction purposes, the overall evaluation of the impact of individual structural elements used in the selected composition of perimeter walls on the environment can be compared. The results of the LCA within the life-cycle phase cradle-to-gate, which is declared by the manufacturers of the used materials based on EPD, are presented in Tables 5 and 6.

The individual structural elements creating the perimeter wall composition in assessed alternatives in Tables 5 and 6 quantify the impact of assessed environmental aspects expressed in m^3. Table 7 presents the overall impact of perimeter walls within the assessed environmental aspects in m^2.

Table 5. Results of environmental impact of brick wall components.

	Material	t (mm)	Density (kg·m^{-3})	GWP (kg CO_2 eq. m^{-3})	PEI (MJ/m^{-3})	AP (g SO_2 eq./m^{-3})	EP (g $(PO_4)^{3-}$ eq. m^{-3})	ODP (g R-11 eq. m^{-3})	POCP (g C_2H_4 eq. m^{-3})
1.	Interior stopper with gypsum	2	1000	0.0738	1.39	0.20	0.033	1.1286×10^{-5}	0.009
2.	Interior plaster with gypsum	8	1800	0.081	1.537	0.227	0.051	1.1×10^{-5}	0.011
3.	Ytong LAMBDA YQ P2-350	450	600	0.225	2.257	0.308	0.135	5.18×10^{-6}	0.014
4.	Baumit GranoporTop acrylate plast	8	0.0018	0.7699	8.249	1.561	0.324	2.6362×10^{-5}	0.361

Source: Authors' compilation. GWP—global warming potential; PEI—primary energy input for production; AP—acidification potential; EP—eutrophication potential; ODP—ozone depletion potential; POCP—photochemical ozone creation potential.

Table 6. Results of environmental impact of perimeter wall components of timber structure.

	Material	t (mm)	Density (kg·m^{-3})	GWP (kg CO_2 eq./kg)	PEI (MJ/kg)	AP (g SO_2 eq./kg)	EP (g $(PO_4)^{3-}$ eq./kg)	ODP (g R-11 eq./kg)	POCP (g C_2H_4 eq./kg)
1.	Plasterboard—gypsum	12.5	1000	0.35429	5.74453	1.0976	0.498	2.56×10^{-5}	0.046724
2.	Rockwool insulation	40	32	1.1331	20.1923	8.3583	1.83	5.536×10^{-5}	0.44541
3.	OSB3	15	650	0.481323	12.5057	2.0370	0.917	2.46×10^{-5}	0.295185
4.	Timber frame construction	140	420	−779.00	97.2	0.118	0.0273	3.05×10^{-10}	-
5.	Rockwool insulation	140	32	1.1331	20.1923	8.3583	1.83	5.53×10^{-5}	0.44541
6.	HDF, 15 mm	15	900	0.650422	12.723	1.7652	1.366	6.35×10^{-5}	0.1187
7.	Thermal insulation	100	32	1.1331	20.1923	8.3583	1.83	5.53×10^{-5}	0.44541
8.	Baumit	8	0.0018	0.76995	8.24952	1.5612	0.324	2.63×10^{-5}	0.36145

Source: Authors' compilation. GWP—global warming potential; PEI—primary energy input for production; AP—acidification potential; EP—eutrophication potential; ODP—ozone depletion potential; POCP—photochemical ozone creation potential.

Table 7. Results of environmental impact per m^2 of perimeter wall.

Criteria/Envimat	Perimeter Wall of Timber Frame House	Perimeter Wall of Brick House—Ytong	Unit
Primary energy input for production (PEI)	556.6268	838.632	MJ·m^{-2}
Global warming potential (GWP)	–53.7401917	122.8075	kg CO_2 eq. m^{-2}
Acidification potential (AP)	132.3148	109.3134	g SO_2 eq. m^{-2}
Eutrophication potential (EP)	50.00642	41.916	g $(PO_4)^{3-}$ eq. m^{-2}
Ozone depletion potential (ODP)	0.001914603	0.001959185	g R-11 eq. m^{-2}
Photochemical ozone creation potential (POCP)	9.055433	9.200427	g C_2 H_4 eq. m^{-2}
Density (ρ)	199.892	664.762	kg·m^{-3}
Basic weight	64.06	279.20	kg·m^{-2}

Source: Authors' compilation.

An interesting fact in favor of the timber structure wall is that the GWP indicator has a positive impact (-53.7401917 kg CO_2 eq. m^{-2}), i.e., a positive CO_2 balance within the monitored life-cycle phase cradle-to-gate. The structural element affecting the positive balance the most was the structural timber, as illustrated in Table 6. On the contrary, the silicate composition of the perimeter wall represented by the material Ytong affected the given indicator negatively (122.8075 kg CO_2 eq. m^{-2}). This results from the heat energy consumption and from emissions created during the production process of bonding agents such as cement and lime.

Figure 4 shows that the majority of the monitored environmental criteria (GWP, PEI, ODP, and POCP) for assessing the impact of perimeter walls of both alternatives of the reference building on the environment were generally more positive in the case of the timber construction. The more positive score of the PEI indicator in favor of the timber construction is caused by the lower energy demands of producing the individual structural elements. The consumption of primary energy renewable resources is more positive in the case of the timber construction. Overall, the consumed sources of primary energy are higher in the case of silicate composition of the perimeter walls. Other monitored aspects did not show significant differences regarding the impact on environment. The deviation between the aspects could be caused by the utilization of an alternative energy source during production and transport. These findings, however, clearly confirm the ecological approach toward building a wood-based structure when meeting the conditions of sustainable development and corporate social responsibility.

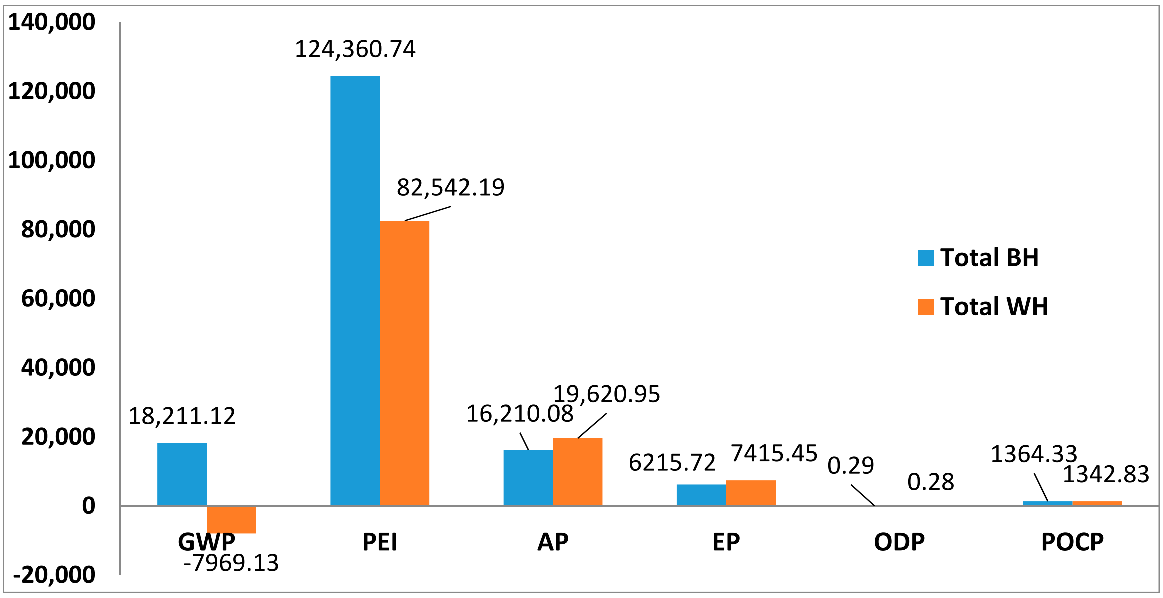

Figure 4. Environmental impact of the perimeter wall in specific units from Table 7.

4. Discussion

Over the course of the last decade, the importance of the concept of corporate social responsibility grew enormously. Many authors dealt with the benefits of corporate social responsibility [9,46–54]. The most often mentioned benefits of social responsible businesses, based on the pressure on more effective source utilization, include profit increase due to reducing the energy and material costs, and productivity increase. Another effect is the improved image of a business and creating a brand of trust through a positive relationship with and loyalty to customers. An inseparable part is also an increase in the business's attractiveness for investors, since the criteria of corporate social responsibility incorporated into the business guarantee the safety and long-term sustainability in the market. This area is also connected with promoting innovative solutions aimed at looking for new, effective solutions for products or production processes.

A specific insight into benefits of the corporate social responsibility was provided by previous studies [55,56], according to which, corporate social responsibility is a tool for making supplier chains in a business better and more effective. In this regard, the present study into the use of the ImageJ software also contributes to improving business operations in terms of creating good supplier relationships based on absolute trust in pricing and valuation of the input raw material in the sector of timber constructions. The overall difference in the assortment value using the evaluation method of the ImageJ software was +6.7% when expressed in numbers. The software is commercially freely available, with the acquisition costs being zero. The risk can lie in the absent support in legislation. A very controversial benefit seems to be increasing the profitability or financial performance of businesses affected by using the tools of responsible business. Many authors deal with this issue. According to some of them, corporate social responsibility affects the profit increase positively [57,58]; however, others claimed that the impact is negative [59,60]. The mentioned authors in their studies find an ideal level of corporate social responsibility when the still-growing profits (resulting from the demand for socially responsible products) level off the higher costs. A neutral relationship was presented in another study [61]. When we synthetize all the individual benefits, we can say that one of the most significant and most complex positives of introducing corporate social responsibility into business operations is increasing competitiveness, thereby improving the reputation and making the business operations more effective. According to Porter and Kramer, businesses will win a unique competitive advantage mainly thanks to implementing the environmental, social, and economic practices in strategic business operation [62].

The use of LCA for assessing the impact of selected aspects on the environment can be considered the environmental aspect of management. We paid attention to comparing the indicators, which confirmed the ecological nature of building low-energy timber construction. This issue was discussed also in multiple studies [63–65], which also confirmed a positive impact of timber construction on the environment using LCA, whether partially or overall. They mention the positive impact regarding energy consumption quantified by the PEI indicator, as well as lower production of CO_2 within the GWP indicator, which were also monitored in the present study as key factors.

The future tendencies in the research are in the field of application of the presented software for assessing alternative wood species (beech, larch) due to the limited availability of timber from coniferous wood species. A further possibility is in implementing the LCA in assessing other life-cycle phases with the potential of connection with life-cycle costing (LCC). The goal would be the quantification of an economic/environmental cost optimum from the viewpoint of the timber construction life-cycle costs.

5. Conclusions

Innovative solutions are essential for sustaining the market position in the competitive business environment. The changes in the business environment caused by globalization and increased energy and material consumption create a pressure on their economical use [66]. Since several years, there are initiatives and calls aiming to fulfil the goals of green economy and sustainable development. The basic characteristics are decreasing the consumption, using renewable resources, socially responsible behavior, and effort to save energy.

This study presents the savings and better valuation of the input material that can be reached using the assessment software ImageJ. It can help increase the available volume of raw material that can be used in building timber constructions from spruce, as well as from other wood species. Overall, the evaluation method using the ImageJ software meant a better valuation in a higher quality class with 21% of trunks.

Our results show the potential of building low-energy houses based on wood, which valuate the renewable material and provide the possibility of using the ecological aspect of production while decreasing the energy consumption needed for their production and operation. In the case of the masonry structure, the overall consumption of primary energy (PEI) of the materials used for the perimeter walls was at the level of 124.360 MJ. For the timber-frame construction alternative, the overall consumption of primary energy PEI of the materials used for the perimeter walls was at the level of 82.542 MJ, accounting for 33.6% lower energy consumption. The secondary effect is the subsequent decrease in CO_2 emissions. These arguments are supported by assessing the environmental impact of the selected materials regarding the selected criteria of wood-based and silicate perimeter walls. During the production of masonry perimeter walls, the GWP indicator was at the level of 18.211 kg CO_2 eq. This is caused by the bonding agents used in the silicate materials (in our case, Ytong). Another significant source of CO_2 emission is the natural gas used in Ytong production. With the perimeter wall of the timber-frame construction, the GWP indicator was negative, at the level of -7.969 kg CO_2 eq. This is largely caused by the selection of input materials based on wood, which can absorb more CO_2 emissions during their life cycle. This way, they also compensate for the impact of other building materials. Further advantages of wood-based structures include larger utility area up to 10 m^2, shorter building time, ecological nature of housing, and utilization of renewable sources. This clearly supports the position of timber constructions among the sectors completely fulfilling the requirements of green business products and principles of sustainable development.

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