Evaluating the Sustainability of External Thermal Insulation Composite Systems (ETICS): A Comprehensive Assessment

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ABSTRACT

The External Thermal Insulation Composite System (ETICS) is widely utilized in European countries to enhance the energy efficiency of buildings. This study employs the life cycle assessment (LCA) method to analyze the environmental impact of producing ETICS with expanded polystyrene (EPS) or mineral wool (MW). Data from the 2017 real production were obtained from five manufacturing plants in Poland, covering modules from A1 to A3 (cradle-to-gate) based on the EN 15804 standard.

The assessment includes indicators for 1 m^2 ETICS with different thicknesses of thermal insulation materials. Results reveal that, across all environmental indicators, MW systems exhibit a more negative environmental impact compared to equivalent systems with EPS. Additionally, a comparative analysis spanning 2012 to 2017 illustrates a significant reduction in the overall negative environmental impact of the entire ETICS, showcasing improvements in key indicators such as GWP, and others over this five-year period. The research underlines the importance of considering not only immediate environmental impacts but also the long-term sustainability and performance of ETICS. By providing essential data for current and future assessments, the study aligns with the principles of sustainable development, encouraging a holistic approach to building energy efficiency.

1. INTRODUCTION

Safeguarding, preserving, and enhancing natural capital, coupled with shielding citizens' health and well-being from the repercussions of environmental degradation, stands as a paramount challenge today. The European Commission's (EC) European Green Deal (EGD) [1] epitomizes the commitment to achieving zero net greenhouse gas emissions in the European Union (EU) by 2050. This reflects a recognition of the urgent need to intensify efforts in addressing the environmental impact of human activities. The EGD emphasizes circular economy, resource efficiency, and sustainable construction, integrated into key initiatives like Next Generation EU, the Multiannual Financial Framework (MFF) for 2021-2027, and the Fit-for-55 package. The construction industry, with significant resource consumption and emissions, is a pivotal focus of European initiatives for sustainable development. Official statistics highlight the sector's leadership in raw material consumption, emissions, and waste production [2,3]. In 2020, EU building activities contributed to 511 million metric tons of CO_2 equivalent, constituting 15% of global emissions. Despite a 24% reduction in EU emissions from 2005 to 2020, achieving an additional 20% reduction by 2030 is imperative to align with EC targets [1,4]. Fulfilling

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EC objectives requires coordinated efforts to reduce building energy consumption, decarbonize energy sources, optimize renewable energy use, minimize emissions, and mitigate the environmental impact of construction products in all stages.

Sustainability of construction products in compliance with CPR requirements

The Construction Products Regulation (CPR), in effect since July 1, 2013, has played a crucial role in regulating the construction products market in EU countries [5]. The CPR introduced the concept of product sustainability, building upon the six basic requirements of the previous Directive 89/106/EEC [6]. This paradigm shift emphasizes the imperative for sustainable practices in designing, building, and demolishing construction works, focusing on the responsible use of natural resources and environmentally compatible materials [7,8]. Despite the importance of sustainable development, the seventh basic requirement introduced by the CPR is not yet mandatory for assessing construction products in the EU market, revealing a gap in addressing environmental considerations in the Assessment and Verification of Constancy of Performance (AVCP) process. Recognizing this gap, the EC proposed a significant regulatory amendment on March 29, 2022, aiming to establish harmonized conditions for marketing construction products, amending Regulation (EU) 2019/1020, and repealing the CPR [9]. The proposed changes, including the introduction of the attestation of Conformity System 3+, underscore the fundamental importance of the CPR and its anticipated evolution in shaping future construction products market in the EU. According to the amendment manufacturers can evaluate the environmental impact of construction products by developing voluntary Environmental Product Declarations (EPDs), independently verified documents providing transparent information on a product's life cycle environmental impact [10,11]. While EPDs are internationally recognized and comply with ISO 14025 standards [12], their usage remains voluntary, primarily limited to business-to-business communication and certification processes. When utilizing these documents, it is essential to pay special attention to data quality and be mindful of shortcomings associated with product category rules (PCRs) and determining environmental impact factors, especially when comparing construction materials with different uses and production methods. However, they serve as an invaluable source of environmental data, allowing analysis of how production impacts on the environment have evolved over the years and providing insights into the path for ongoing improvements.

External Thermal Insulation Composite System (ETICS)

Over 220 million building units, comprising 85% of the EU's building stock, were constructed prior to 2001. Nearly 75% of these buildings fall short of current energy efficiency standards. With around 90% expected to endure until 2050, they contribute to 40% of total energy consumption and 36% of Europe's CO_2 emissions. Recognizing this, renovating the existing building stock is a crucial strategy for addressing climate change [13,14]. The current annual building renovation rate in Member States ranges from 0.4% to 1.2% [1], falling short of the doubling required to meet the 2050 target of the EGD. Hence, there is an imperative need to significantly scale up the renovation of both public and private buildings. A widely employed strategy in EU countries for energy conservation involves the use of External Thermal Insulation Composite Systems (ETICS). This method holds substantial potential for achieving energy efficiency goals and aligning with sustainable construction practices. As defined in the CPR, ETICS comprises specified prefabricated components applied directly to the facade on-site. The Polish ETICS market, boasting an estimated annual volume of around 50 million square meters, is one of the most substantial markets in Europe [15]. Annually, manufacturers in the ETICS sector strive to enhance the functionality of their solutions, aligning them with customer expectations. This pursuit is particularly significant given that just over a decade ago, Polish buildings exhibited the highest average heating energy consumption, surpassing the European average by 63% [16]. During this period, buildings in Poland, alongside those in France, also ranked highest in airborne emissions and solid waste production [20ad]. In Poland, as in other EU countries, EPS and MW panels are commonly employed as insulation materials in ETICS. Approximately 84% of ETICS in Central Europe utilize EPS, while MW accounts for around 12% as a thermal insulation material for walls. ETICS systems, when correctly applied [17], present a straightforward solution to challenges related to the continuity of thermal insulation on foundation surfaces, walls, and underground elements. They confer various properties, including the reduction of heating costs [18], enhancement of a building's ability to accumulate heat [19,20], lowered energy consumption, and greenhouse gas emissions [21], increased building operational durability [22], and protection against the direct impact of atmospheric factors [21]. The commonly used thermal insulation materials in EU countries differ in terms of fire behavior, physical properties, structure, durability, and manufacturing costs.

Consideration of life cycle aspects is crucial in building design and insulation technology selection. The impact of the type of render and cementitious adhesive used in ETICS is well-understood [23,24]. In today's context, understanding material safety aspects is vital for informed choices, considering various factors, including environmental impact. This work aims to demonstrate the environmental impact of thermal insulation materials on the values of ETICS.

2. MATERIALS AND METHODS

External Thermal Insulation Composite System (ETICS)

European requirements for ETICS were initially outlined in ETAG 004 [25] until October 2020 and are now defined by the European Assessment Document (EAD) 040083-00-0404 [26]. ETICS manufacturers in Poland can obtain a European Technical Assessment (previously European Technical

Fig. 1: Layers arrangement in EPS-ETICS and MW-ETICS as described in reference documents: (1) wall structure (substrate), (2) adhesive (basic fixing), (3) thermal insulation (EPS or MW), (4) anchor (if necessary, additional fixing), (5) reinforcement layer (base coat with glass fiber mesh embedded), (6) key coating (if necessary), (7) finishing coat (renders), (8) primers (optional), and (9) decorative coats (optional).

Table 1: ETICS components as described in the National Technical Approval ITB AT-15-9090/2016 (for ETICS with EPS) and ITB AT-15-2930/2016 (for ETICS with MW).

Component	Component description	Quantity EPS/m²	Quantity MW/m²
Adhesive for bonding	Modified cement-based adhesives	4.5 kg	4.5 – 5.5 kg
Insulation[1]	Prefabricated EPS board or MW panel.[2]	ca. 1.35 kg	3.5 – 4.5 kg
Adhesive for base coat	Modified cement-based adhesives.	5.5 kg	5.5 – 6.5 kg
Glass fiber mesh[1]	Glass mesh of 150 or 165 g/cm².	≥ 0.15 kg	≥ 0.15 kg
Key coat	Dispersion-based key coat		
with mineral/quartz fillers.	ca. 0.2 kg	ca. 0.3 kg	
Finishing coat	Modified cement-based render	2.0 – 4.5 kg	2.0 – 4.5 kg
Ancillary materials[1]	Anchors, special fittings.	-	-

[1] products from suppliers, [2] for thermal conductivity coefficient λ = 0.039 W/m K.

Approval) based on EAD 040083-00-0404 for the CE marking or a National Technical Assessment for the building mark B. Criteria for the National Technical Assessment (previously National Technical Approval) for ETICS with EPS and MW are specified in guidelines [27,28]. Under the Polish national system, ETICS undergoes assessment based on the same requirements and methods as in the European framework, with additional assessments for fire spread rate and susceptibility to algae growth. Atlas ETICS and Atlas ETICS Roker are trade names for ETICS, detailed in National Technical Approvals ITB AT-15-9090/2016 (EPS) [29] and ITB AT-15-2930/2016 (MW) [30] from the Building Research Institute (ITB) in Warsaw. These systems, comprising various components, are illustrated in Figure 1 depicting the arrangement of ETICS layers. For this study, mineral render systems were chosen from the options outlined in ITB AT-15-9090/2016 (EPS) and ITB AT-15-2930/2016 (MW) [29,30].

Table 1 outlines detailed specifications for all components of ETICS with EPS, according to the National Technical Approval ITB-AT-15-9090/2016, alongside analogous data for ETICS with MW, as described in ITB-AT-15-2930/2016.

Life cycle assessment

Environmental impact assessments used the Life Cycle Assessment (LCA) method for a thermal insulation system outlined in National Technical Approvals. This analysis focuses on ETICS with EPS or MW panels of various thicknesses (10, 12, 15, 20, and 25 cm), with a mineral render finishing layer. Data from 2017 (EPDs released in March 2019) from five production facilities in Poland - Bydgoszcz, Dąbrowa Górnicza, Piotrków Trybunalski, Suwałki, and Zgierz were utilized. The collective production volume of these facilities reached around 10 million square meters in 2017 (based on manufacturers data).

Type III Environmental Declarations (EPD), developed under EN 15804 [31] and verified by Third Party (ITB), covered life cycle stages from A1 to A3, including raw material extraction, transport, and production [32-34]. This paper specifically examines cumulative values of modules A1, A2, and A3 for the studied ETICS. In summary, for ETICS with EPS, module A1's share ranged from 94.14% (10 cm) to 96.82% (25 cm).

For ETICS with MW, the A1 module ranged from 98.11% (10 cm) to 99.14% (25 cm). The transport share (module A2) for ETICS with EPS ranged from 1.44% to 0.80%, while for ETICS with MW, it varied from 0.38% to 0.17% for 10 and 25 cm, respectively. The share of module A3 (production) ranged from 4.42% to 2.38% for ETICS with EPS and 1.38% to 0.69% for ETICS with MW for thicknesses of 10 and 25 cm. The environmental assessment focuses on the product unit - 1 m^2 of insulation using the comprehensive system described in National Technical Approvals. Impacts and raw material consumption were allocated using mass allocation rules based on weighted average mass, with data sourced from reputable databases, including Ecoinvent, Ullmann's, Plastic-Europe, ITB-Data, SPC, and selected Type III environ-mental declarations (EPDs) for ETICS components used.

Fig. 2.: Production process scheme for ETICS kit components including adhesive for bonding and base coat, key coat and finishing coat.

3. RESULTS AND DISCUSSION

Table 2 and Table 3 provide environmental characteristics for ETICS with different insulation materials and mineral renders finishing layer, calculated for 1 m^2 of insulation [33,34]. The data includes: global warming potential (GWP); depletion potential of the stratospheric ozone layer (ODP); acidification potential of soil and water (AP); eutrophication potential (EP); formation potential of tropospheric ozone (POCP); abiotic depletion potential for non-fossil (ADP-elements) and fossil (ADP-fossil fuels) resources; total use of renewable primary energy resources (PERT); total use of non-renewable primary energy resources (PENRT). For all the indicators examined in this study, the environmental impacts linked to the production of 1 m^2 of MW-ETICS are greater than those for 1 m^2 of EPS-ETICS. Despite the higher value of PERT for EPS vs. MW, it's important to note that this signifies an environmentally advantageous scenario. In terms of GWP, the production of 1 m^2 of MW-ETICS, when compared to 1 m^2 of EPS-ETICS, is associated with nearly three times higher CO_2 equivalent emissions for 10 cm thick insulation material and almost four times higher for 25 cm thickness as showed on Figure 3.

The ozone layer depletion potential (ODP) of ETICS with MW is nearly twice as high as that of ETICS with EPS, irrespective of insulation material thickness. It is noteworthy that EPS, commonly used in ETICS, does not utilize ozone-depleting substances regulated by the EU, such as chlorofluorocarbons (CFCs) or hydrofluorocarbons (HCFCs). Regarding the acidification potential of soil and water (AP), ETICS with MW exhibits a higher AP than ETICS with EPS. The AP ratio of MW to EPS varies between 4 and 5.5 for different thicknesses (10 cm to 25 cm) of thermal insulation material. In terms of eutrophication potential (EP), the change in MW thickness from 10 to 25 cm results in more than a twofold increase, while the change is less significant with EPS.

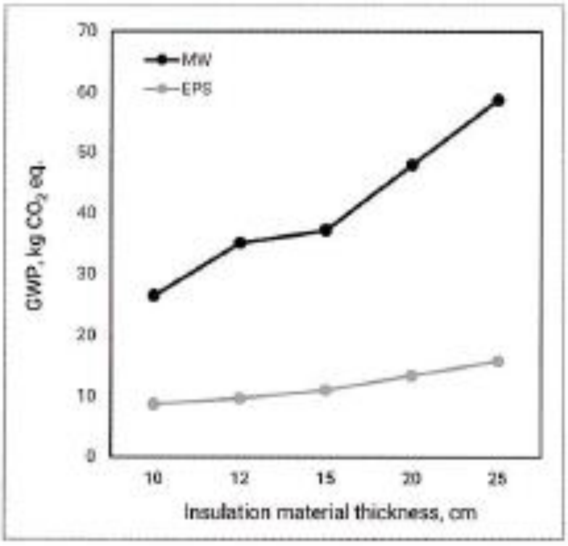

Fig. 3:
GWP for 1 m^2 of EPS-ETICS or MW-ETICS depending on the thermal insulation thickness.

The formation potential of tropospheric ozone (POCP) is 5.3 to 6.0 times higher for ETICS with MW than for ETICS with EPS, depending on MW thickness. The formation potential of tropospheric ozone (POCP) is 5.3 to 6.0 times higher for ETICS with MW than for ETICS with EPS, depending on MW thickness. The abiotic depletion potential (ADP-elements) for non-fossil resources increases almost threefold with the thickness of ETICS with MW, while it remains unaffected by EPS thickness.

Table 2: Environmental characteristics of 1 m^2 ETICS system described in the National Technical Approval AT-15-9090/2016 calculated in the year 2019 (data from 2017) with 10, 12, 15, 20, and 25 cm of EPS and mineral renders finishing layer [29].

Indicator [unit]	A1 – A3				
	10 cm	12 cm	15 cm	20 cm	25 cm
Environmental impacts per 1 m2					
GWP [kg CO_2 eq.]	8.70	9.64	1.10×10^1	1.34×10^1	1.57×10^1
ODP [kg CFC 11 eq.]	5.01×10^{-5}	5.01×10^{-5}	5.01×10^{-5}	5.02×10^{-5}	5.02×10^{-5}
AP [kg SO_2 eq.]	2.57×10^{-2}	2.78×10^{-2}	3.10×10^{-2}	3.63×10^{-2}	4.16×10^{-2}
EP [kg $(PO_4)^{3-}$ eq.]	4.63×10^{-3}	4.82×10^{-3}	5.11×10^{-3}	5.60×10^{-3}	6.09×10^{-3}
POCP [kg Ethene eq.]	2.41×10^{-3}	2.68×10^{-3}	3.07×10^{-3}	3.73×10^{-3}	4.38×10^{-3}
(ADP-elements) [kg Sb eq.]	9.90×10^{-3}	9.90×10^{-3}	9.90×10^{-3}	9.90×10^{-3}	9.90×10^{-3}
(ADP-fossil fuels) [MJ]	1.55×10^2	1.82×10^2	2.23×10^2	2.90×10^2	3.57×10^2
Environmental aspects related to the consumption of raw materials per 1 m^2					
PERT [MJ]	8.70	9.09	9.69	1.07×10^1	1.17×10^1
PENRT [MJ]	1.62×10^2	1.90×10^2	2.32×10^2	3.01×10^2	3.70×10^2

Table 3: Environmental characteristics of 1 m² ETICS system described in the National Technical Approval AT-15-2930/2016 calculated in the year 2019 (data from 2017) with 10, 12, 15, 20, and 25 cm of MW and mineral renders finishing layer [30].

Indicator [unit]	A1 – A3				
	10 cm	12 cm	15 cm	20 cm	25 cm
Environmental impacts per 1 m²					
GWP [kg CO_2 eq.]	2.65×10^{1}	3.51×10^{1}	3.72×10^{1}	4.79×10^{1}	5.87×10^{1}
ODP [kg CFC 11 eq.]	9.21×10^{-5}	9.25×10^{-5}	9.26×10^{-5}	9.31×10^{-5}	9.35×10^{-5}
AP [kg SO_2 eq.]	1.03×10^{-1}	1.36×10^{-1}	1.45×10^{-1}	1.87×10^{-1}	2.29×10^{-1}
EP [kg $(PO_4)^{3-}$ eq.]	4.22×10^{-3}	5.40×10^{-3}	5.69×10^{-3}	7.16×10^{-3}	8.63×10^{-3}
POCP [kg Ethene eq.]	1.28×10^{-2}	1.64×10^{-2}	1.73×10^{-2}	2.19×10^{-2}	2.64×10^{-2}
(ADP-elements) [kg Sb eq.]	1.38×10^{-1}	1.89×10^{-1}	2.01×10^{-1}	2.64×10^{-1}	3.27×10^{-1}
(ADP-fossil fuels) [MJ]	2.45×10^{2}	3.35×10^{2}	3.58×10^{2}	4.70×10^{2}	5.83×10^{2}
Environmental aspects related to the consumption of raw materials per 1 m²					
PERT [MJ]	6.26	6.26	6.26	6.26	6.26
PENRT [MJ]	2.69×10^{2}	3.68×10^{2}	3.93×10^{2}	5.17×10^{2}	6.41×10^{2}

Additionally, the value of ADP-elements is significantly higher for ETICS with MW compared to EPS. For the abiotic depletion potential (ADP-fossil fuels) indicator, ETICS with MW has higher values than similar systems with EPS.

Comparing the PERT and PENRT indicators, both indicate that more non-renewable primary energy resources are used in the production of ETICS components, regardless of the insulation material. However, more renewable primary energy and primary energy resources as raw materials are used for ETICS with EPS compared to systems with MW. In terms of the PENRT indicator related to non-renewable primary energy resources, ETICS with MW is less environmentally friendly.

The Polish market for ETICS is among the largest in the European Union, estimated at approximately 50 million square meters of ETICS annually [15]. Table 4 illustrates the global warming potential resulting from the production of 50 million m² of insulated external walls each year, comparing ETICS with MW (10 and 25 cm) and EPS (10 and 25 cm). The data used for this calculation is derived from the information gathered in this study.

ETICS and their components undergo continuous refinement, just like the methods used in their production, energy sourcing, and raw material acquisition. Ongoing advancements aim to enhance the efficiency and sustainability of these systems, ensuring they align with evolving environmental standards. This dynamic process reflects a commitment to improving insulation technologies, minimizing environmental impact, and optimizing resource utilization in the construction industry. Most indicators show changes associated with a decrease in the negative impact on the environ-

Table 4: Global warming potential of manufacturing ETICS (modules A1-A3) calculated for 50 million m² insulated external walls annually with ETICS with MW (10 and 25 cm) and with EPS (10 and 25 cm).

Insulation material thickness in ETICS [cm]	**GWP [t CO_2 eq.]**	
	EPS	MW
10 cm	435,000	1,325,000
25 cm	785,000	2,935,000

ment over the considered period of five years [35]. Based on data gathered in 2012 and 2017 for EPS-ETICS only, the production of 1 m² of insulation within the scope of modules A1-A3 was associated with a reduction in the greenhouse effect by 22.3%, 23.1%, and 23.1% for EPS thicknesses of 10, 15, and 20 cm, respectively.

Figure 4 illustrates the global warming potential (GWP) values calculated for 50 million m² of ETICS in three tested system variants in 2012 and 2017. By comparing the GWP values resulting from the production of 50 million m² of ETICS with greenhouse gas emissions, one can gain an understanding of the scale of the environmental impact associated with the manufacturing awareness of insulation system components. Based on existing research, the potential greenhouse gas emissions (GWP) associated with a conventional single-family masonry house in Central Europe, featuring a usable area of 151.43 m², amount to 36.2±12.1 tons of CO_2 equivalent in the developer's state. This metric, expressed in tons of CO_2 equivalent, comprehensively considers the overall impact, encompassing both the construction phase and the materials utilized during the developer's state. This highlights that making informed choices regarding building materials, within a broader context, can pave the way for the construction of thousands of additional buildings while respecting the environment. When comparing the choice between 10 cm of EPS and MW for insulation across the entire market, making the right decision can potentially lead to the construction of an additional 20,000 to 40,000 houses in Poland within the same environmental context. It's important to note that this impact is solely related to the insulation material, and while the choice of other materials may have a smaller impact, it still contributes to the overall environmental footprint of External Thermal Insulation Composite Systems (ETICS). A detailed examination of the comparison of global warming potential impacts generated between the years 2012 and 2017 reveals noteworthy insights into the environmental consequences during this specific

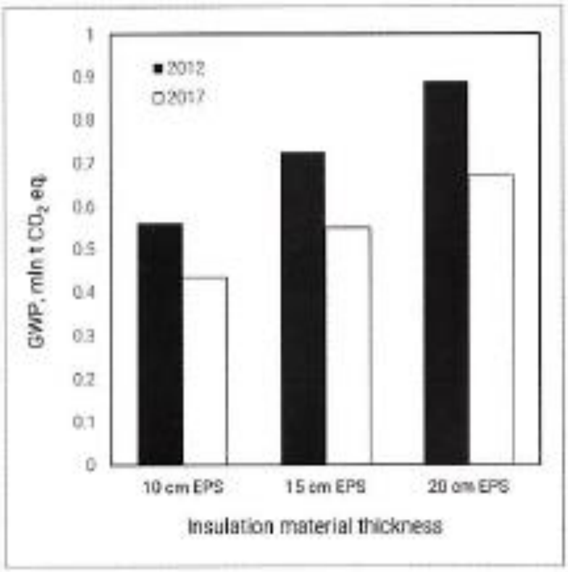

Fig. 4:
The comparison of global warming potential (GWP) impact of EPS ETICS produced in Poland in the years 2012 and 2017.

timeframe. The global warming potential of manufacturing ETICS (modules A1-A3) decreased by approximately 23% from 2012 to 2017, with a simultaneous 3.6% increase in greenhouse gas emissions. In 2012, production of all EPS-ETICS components, described in the AT-15-9090 standard with mineral plasters and 15 cm thick EPS panels (for 50 million m^2), resulted in emissions of 725 thousand tons of CO_2 equivalent, comprising 0.22% of total CO_2 emissions and 0.18% of total greenhouse gas emissions in Poland [36]. Five years later, these figures reduced to 550 thousand tons of CO_2 equivalent, contributing to 0.17% of total CO_2 emissions and 0.14% of total greenhouse gas emissions in the country [37]. For buildings insulated with ETICS, energy payback depends on factors such as insulation thickness, heating method, and energy source, with an average payback period of less than 2 years [21]. A study on the ecological cost-effectiveness of building external walls insulation in Poland indicated an ecological payback period ranging from 0 to 6 years, depending on the studied variants [35]. It is noteworthy that using larger insulation thicknesses than optimal for economic reasons is cost-effective, providing more significant environmental benefits without a significant decrease in economic benefits [39]. In essence, environmental impact issues are intertwined with economic and social aspects, emphasizing the equal consideration of economic, social, and ecological factors in sustainable development. The compa-rison of environmental indicators for modules A1-A3 for EPS-ETICS during this period provides a comprehensive measure of the alterations that have taken place.

These changes encompass the extraction and production of various raw materials, such as expanded polystyrene boards, cement, sand, modified methyl cellulose ethers, redispersible polymer powders, cement setting time regulators, limestone fillers, dolomite, as well as water-based dispersions, hydrophobic agents, film-forming agents, biocides, and more. Furthermore, modifications in the transportation of raw materials, packaging, and other materials essential for the production and manufacturing process of all components of the ETICS system, including thermal insulation material, have occurred. These changes result from a combination of deliberate actions aimed at positive environmental effects and adaptations compelled by non-environmental factors throughout the entire chain of processes related to modules from A1 to A3. Although the consumer choosing construction products might not readily access the results of the calculations presented in the article, considering the growing significance of environmental impact in construction, a paradigm shift in this regard seems inevitable. The incorporation of essential characteristics related to environmental impact in performance assessments demands widespread coordination and active participation from all stakeholders in the construction market. Additional insights into other environmental factors can be found elsewhere [35].

4. CONCLUSIONS

In today's construction landscape, top priority is given to indoor environmental quality, occupant health, and environmental conservation. Addressing challenges posed by human activity necessitates a holistic approach considering all influencing factors, with thermal insulation playing a pivotal role in energy-efficient buildings. The text emphasizes the significance of understanding External Thermal Insulation Composite Systems characteristics. It envisions a future where environmental impact is a mandatory consideration in assessing construction materials. The study analysed nine environmental indicators for ETICS, focusing on thermal insulation materials EPS and MW. Findings reveal that MW systems generally have a more negative environmental impact compared to EPS. The comprehensive assessment considers various thicknesses and emphasizes the importance of indicators like PERT and PENRT, especially in the context of modules from A1 to A3. Utilizing real industry data from significant production in Poland, the study aims to demonstrate the environmental impact of ETICS production (modules A1-A3). Currently, ETICS lacks mandatory assessment for sustainable resource use. Disseminating real industry data is deemed essential for establishing realistic evaluation criteria in standardization efforts and fostering awareness about sustainable development. The primary focus is showcasing the environmental impact of ETICS using LCA method. Real data from production locations in Poland form the basis for estimating environmental impact, with results compared to national greenhouse gas and CO_2 emissions. The comparison demonstrates environmental benefits and highlights a significant reduction in environmental burden over a five-year period, attributed to both planned and unplanned industry changes. The authors assert that these results provide additional arguments for the widespread use of external wall insulation as an effective energy-saving solution. The data, especially showcasing changes in environmental impact over time, can contribute to understanding national trends in CO_2 emissions and motivate consumers to make informed choices about sustainable solutions. In the upcoming year, an environmental impact analysis of the specified systems is planned for another five-year period, utilizing production data from the year 2023.

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