FoCa – Free of Carbon Architecture – an educational and informational online platform supporting the decarbonization of the construction sector in Poland and Turkey

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FoCa (Free of Carbon Architecture) – an online platform supporting the decarbonization of the construction sector in Poland and Turkey, provides generic environmental declarations for over 100 building materials available on the Polish or Turkish market, enables their comparison and analysis of building project.

Climate neutrality requires the decarbonization of the construction sector as quickly as possible. For this goal to be achieved, all participants in the construction process should be aware of the problem, have appropriate knowledge and tools to manage this process.

However, in the IEA EBC Annex 72 study "Assessing life cycle related environmental impacts caused by buildings", conducted on a sample of 956 architects and engineers in Europe, it was shown that one of the main reasons why respondents do not use LCA indicators to assess embodied impacts is the lack of knowledge about their use (30–37% of respondents) and the answer was also obtained that the "lack of information/data" as one of the main barriers to the use of LCA [1]. Another survey conducted on a sample of 500 architects and engineers found that one of the three main reasons for the gap between the availability of LCA analysis methods and the lack of common practice in their use is, apart from the lack of legal regulations and communication problems between architects and engineers, the high cost of using LCPA (Life Cycle Performance Assessment) methods, which disqualifies their use at an early stage of design [2]. Also, regular reviews of available LCA analysis tools indicate that most of them are paid and only some offer the possibility of trying a trial version for free [3]. To sum up, the problem of limited access to knowledge and data has a negative impact on the decision-making process, because currently obtaining this information requires paid access to tools and the ability to use them, and in the absence of common knowledge, the employment of highly paid specialists.

Construction sector is largely responsible for the greenhouse effect, generating 38% of global CO_2 emissions [4, 5]. Already in 2002, the EPBD directive indicated that operational greenhouse gas emissions should be included in the energy performance of a building, and its latest amendment from April 2024 assumes that in the future new buildings will be zero-emission, meaning that they will have a zero carbon footprint from fossil fuels generated on site [6].

The issue of the built-in carbon footprint is also becoming more important. The above-mentioned recast of the EPBD assumes the obligation to calculate and include the life cycle global warming potential (GWP) on the energy performance certificate. It is to be disclosed for all new buildings from January 1, 2030 and calculated in accordance with the EN 15978 standard and based on the LEVEL(s) framework and national methodologies. Although no regulations regulating these future obligations are currently being prepared in Poland, the construction industry is preparing for these changes [7–11].

It should also be mentioned that other documents of the European Commission's legislative initiative called the European Green Deal [12] will also oblige investors to provide GWP for buildings. For example, the Taxonomy in force from 2022 requires the calculation of GWP for investments applying for financing [13]. In the Regulation of the European Parliament and of the Council establishing

technical qualification criteria (...) for the qualification criterion of climate change mitigation, the condition for co-financing new buildings with an area of above 5000 m2 is to calculate life cycle GWP in relation to individual stages of the life cycle [14].

There is also an obligation to report the carbon footprint under the CSRD Directive [15], which has been in force in Poland since January 2024. It extended the obligation to report non-financial information by large companies to a wider group of companies and to a larger number of indicators. From 2024, listed companies and from 2025, large companies will have to report, among others: greenhouse gas emission index referring in selected cases to scope 3, which includes, for example, the production of materials or the construction of buildings [16, 17].

The regulations in selected European Union countries are already being implemented taking into account the upcoming changes, examples of which are: Denmark from 2023 (Bæredygtighedsklassen [18]), France from 2020 (Réglementation environnementale 2020 [19]), the Netherlands from 2018. (Milieuprestatie Gebouwen [20]), Sweden from 2022 (Klimatdeklarationen [21]).

There are currently no changes planned in Poland in building regulations that would take into account these future requirements, but the construction market is aware of the upcoming changes. This is proven by a survey conducted in 2022 by PLGBC as part of the Bulding Life project, with the participation of the author of the paper, in which 156 representatives of small and medium-sized enterprises took part [8]. According to it, 73% of respondents answered that decarbonization of construction is necessary to achieve climate neutrality in 2050. When asked whether the analysis of the carbon footprint of the designed building should be required by national regulations, 54% answered yes, 8% – no, 29% – yes, but in some cases, 9% – had no opinion. The main difficulties are considered to be the lack of national regulations (46%), low availability of input data (46%), lack of computational tools (18%), lack of specialists (14%), lack of uniform methodology (30%), high costs (16%), difficulties in interpreting the results (24%), 32% had no opinion and only 1% said there were no barriers. It was also assessed that the choice of tool for performing calculations should not be imposed, but arbitrary (67%), as opposed to a national one (20%). 40% of respondents believed that the use of mainly specific environmental declarations for products should be allowed, 16% – generic ones, 28% – any and 16% had no opinion.

In the above context, it is not surprising that the growing number of tools developed by foreign and domestic commercial companies, dedicated mainly to LCA analyses, but also to comparative analyzes of building materials. This second aspect is particularly important in the educational context of future engineers responsible for making decisions in the spirit of sustainable design. The above-mentioned survey shows that a total of 48% of respondents either know nothing about the environmental analysis of buildings using the LCA method or have only heard about it but do not know the details, 28% know it but do not perform it, and 25% perform it occasionally or often. [8]. Hence, the first stage of building awareness of the impact of buildings on the environment, i.e. education, is very important in the above context. Therefore, it is necessary to mention at least two platforms that fill this gap.

The first of them is the „Pyramid of Building Materials" (Byggeriets Materialepyramide) developed by CINARK – Center for Industrialized Architecture, The Royal Danish Academy [22]. By referring to the food pyramid, it compares building materials in a clear and memorable way depending on the selected environmental impact indicator (based on the EPD for Northern Europe), functional unit or product source. Its main advantage is its educational value, especially since the data comes from generic declarations for the most popular materials in Denmark.

The second one is the „2050 Materials" platform, supported by the European Union and implemented by a private company from Cyprus [23]. Due to the fact that it is based on 10,000 specific EPD declarations, it offers much more filtering and sorting possibilities for all products divided into many categories. It is also possible to filter by a selected functional unit or sort by the value of a selected indicator. Unfortunately, the method of presenting the results is not very transparent, and comparing specific declarations without knowing their market share may result in false generalization of the results.

The main disadvantage of both tools is the access to data limited only to the EPD declarations that the tool takes into account. In the case of "Pyramid of Building Materials", these are declarations from northern Europe, which makes them useless for Polish users. In the case of "2050 Materials", the declarations come from many sources, but only 62 from Poland, which also prevents the use of this tool by Polish engineers, which confirms the problem of data accessibility. This gap is filled by the FoCA platform, the primary goal of which is to provide EPD declarations for the most popular building materials in Poland and Turkey.

Project FoCa

The FoCa – Free of Carbon Architecture platform project fills the educational gap and the lack of access to data on building materials. The platform is implemented by a consortium: Polish Green Building Association PLGBC as coordinator, Building Research Institute (ITB), Wrocław University of Science and Technology (WUST), Environmentally Friendly Green Buildings Association (PLGBC) / Turkish Green Building Council (CEDBIK) and Yildiz Technical University (YTU) in Turkey. The project was launched in June 2023 as part of the 33rd competition of the CORNET Initiative (COllective Research NETworking), and is financed by the National Center for Research and Development and PLGBC's own funds. The FoCA project lasts 24 months.

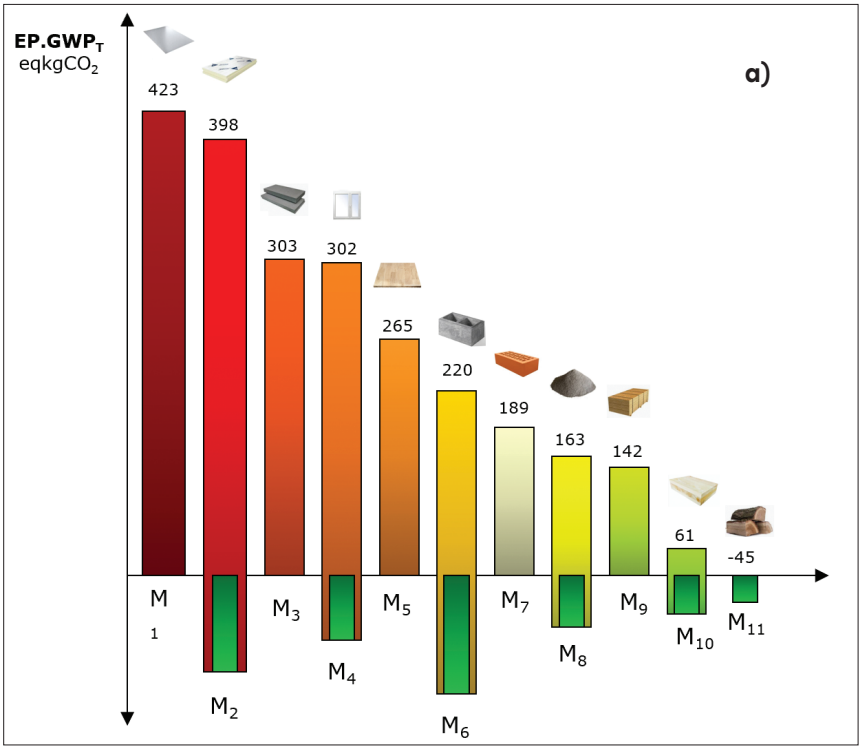
The platform will allow users to assess the environmental impact of selected building materials and products and compare them with each other. As part of the FoCa project, generic EPD declarations are made in modules A1–A3 (product phase, built-in carbon footprint), which will be presented for over 100 materials or products most popular in Poland or Turkey. In addition to access to the above data, the platform also allows you to compare them. There are four functional modules on the platform.

The educational module contains descriptive sections explaining basic concepts about the causes of climate change, information on the policies of the United Nations, the European Union, Poland and Turkey, information on the basics of LCA, presentations of the most popular tools for LCA analysis, the most popular multi-criteria certification systems using GWP values for investment assessment, applicable requirements for calculating GWP in selected EU countries.

The materials and products database includes generic environmental declarations of materials and products popular in Poland, covering six environmental impact indicators.

The following principles were adopted to determine generic values:

- if the association of product producers in the country has a verified declared environmental footprint (e.g. EPD), it is recognized as representative;
- declarations with extreme values for production methods are not taken into account when calculating the average.
- in the case of a small number of EPDs on the market (1–3), if the EPD covers at least 3 plants producing the same product, it will be accepted as representative;
- in case of zero amount of EPD on the market for a group of products, a manufacturer is found and an analysis is performed;
- in the case of a small number of EPDs on the market (1 to 2), a representative declaration is "subjectively" selected;
- in the case of a significant amount of EPD for a group of products (over 5), average values are determined from a minimum of three declarations;



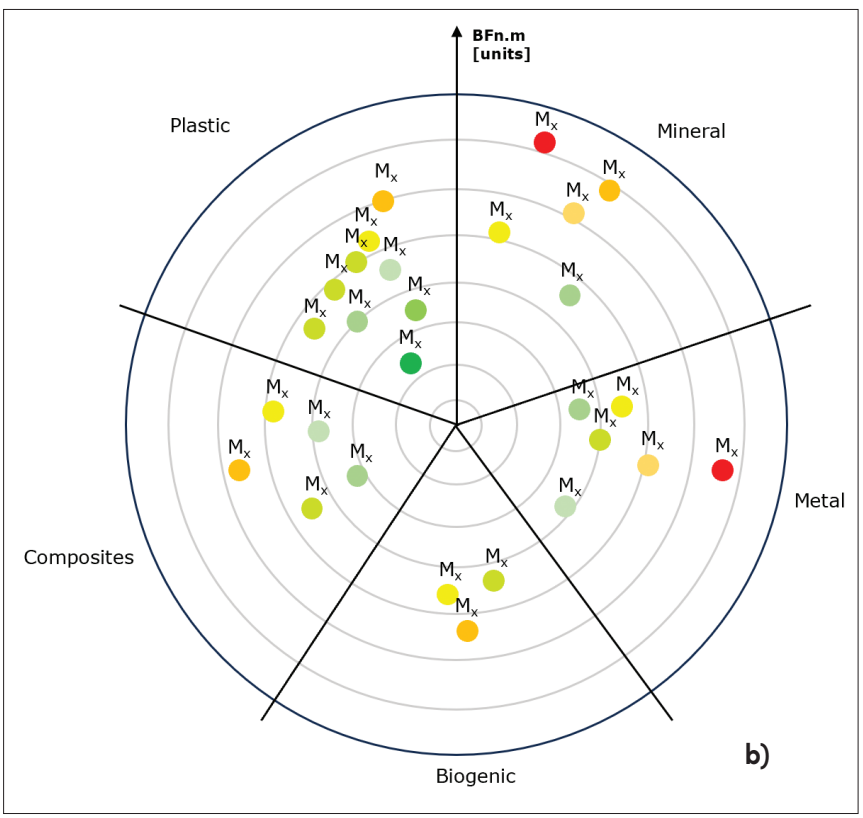


Fig. 1 a) bar chart, b) radial chart; source: own study

- for all cases, the values of indicators for products manufactured abroad are not taken into account.

Data describing the impact on the environment are described by the following indicators: greenhouse gas emissions from the combustion of fossil fuels (GWPfossil), negative greenhouse gas emissions related to the storage of CO_2 from the atmosphere (GWPbiogenic), total greenhouse gas emissions (GWPtotal), primary energy consumption with distinction on renewable sources (TRPE) and non-renewable sources (TNRPE) and water depletion (WD).

Additionally, it is planned to introduce data enabling subsequent filtering of materials, such as: category of material source, categories of material functions or functional units (kg, m^3, m^2, m^2·K/W).

The first three assessment criteria (GWPfossil, GWPbiogenic, GWPtotal) were selected due to the need to take them into account when meeting the requirements of the aforementioned EPBD directive. The next two criteria (TRPE, TNRPE) are a non-obligatory supplement but were selected due to their universality in calculating the impact of the building on the environment in the form of an embodied energy indicator. The last criterion (WD) was selected authoritatively by the project partner.

To familiarize users with the differences in the values of environmental impact indicators between individual materials, they are compared on charts. The basic form of the chart is a bar chart (Fig. 1a), but optionally there are also radial charts available, grouping materials with the same source of origin (Fig. 1b) and row charts grouping charts with the same function (Fig. 2a). An additional, characteristic form of the chart is a bubble chart (Fig. 2b) showing two pieces of information on one plane: the value of the indicator for the functional unit in relation to the weight of the material and the value of the indicator for the functional unit in relation to the volume of the material.

The last module is the analytical part for calculating the total value of any environmental impact indicator for the entire building. This will allow the user to estimate, among others: GWP value for the building. Examples of results presentation are presented below:

- a table of results containing all information about the materials included in the analysis.
- a multi-bar chart that is intended to indicate the values of the impact of materials or products on the environment for selected indicators (Fig. 3a)
- pie chart divided into categories for detailed classification of functions with the option of selecting the type of environmental impact (Fig. 3b)

To verify the correctness of the assumptions regarding the functionality of the Foca platform and the degree of their acceptance, a survey was conducted during the project in which 64 representatives of small and medium-sized enterprises participated. 96% of respondents assessed that the platform would be a useful tool supporting the decarbonization of construction and the educational module would be a useful and valuable element of the platform. Opinions on the number of materials in the database varied: 46% of respondents said that the number of 100 materials was sufficient, 39% said it was not sufficient and 14% said they had no opinion. The majority of respondents assessed

the proposal to filter results in relation to specific functional units in different ways. 70% rated the functional unit kg·CO_2eq/m^3 as very useful, 69% – the functional unit $kgCO_2eq/m^2$, 31% – the functional unit kg·CO_2eq/(m^2K/W), 14% – the functional unit kg·CO_2eq/(kg/ m·s·Pa) and 16% – functional unit kg·CO2eq/MPa. The method of presenting the results was assessed positively by most of them – the bar chart was positively assessed by 82% of respondents, the radial chart by 60%, the line chart by 68% and the scatter chart by 56%.

Limitations and advantages of the project

Although the FoCa platform will be a unique and valuable tool in Poland and Turkey supporting the construction sector in the decarbonization process, the project's limitations resulting from its assumptions should be noted. They are:

- limiting the preparation of generic EPD declarations to 100 materials, which results from the limited project budget;
- limiting the calculations for the product phase (A1–A3) without taking into account the remaining product phases (A4, A5), use phase (B), demolition (C) and reuse (D). This is due to the financial limitations of the project and the main goal of providing information on the environmental impact of the materials production phase;
- inability to use specific EPD declarations, which results from the project's assumption of the need to provide average values for the entire market, although some users may treat the lack of this functionality as a limitation of the project;
- limited only to the area of Poland and Turkey as project partners, excluding other countries of Central and Eastern Europe.

After launching the FoCa platform, it is planned to obtain financing for its development and supplement its functionality with the above-mentioned elements.

The advantages of the project include:

- providing a reliable source of generic environmental information on greenhouse gas emissions, primary energy demand and water depletion resulting from the extraction and processing of raw materials used in the production of construction products;
- enabling architects and other stakeholders to gain knowledge on the impact of individual classes of materials and products on the environment;
- enabling architects and other stakeholders to choose environmentally friendly solutions that reduce the environmental footprint of the construction sector;
- supporting adaptation to the goals indicated in national and EU policies;

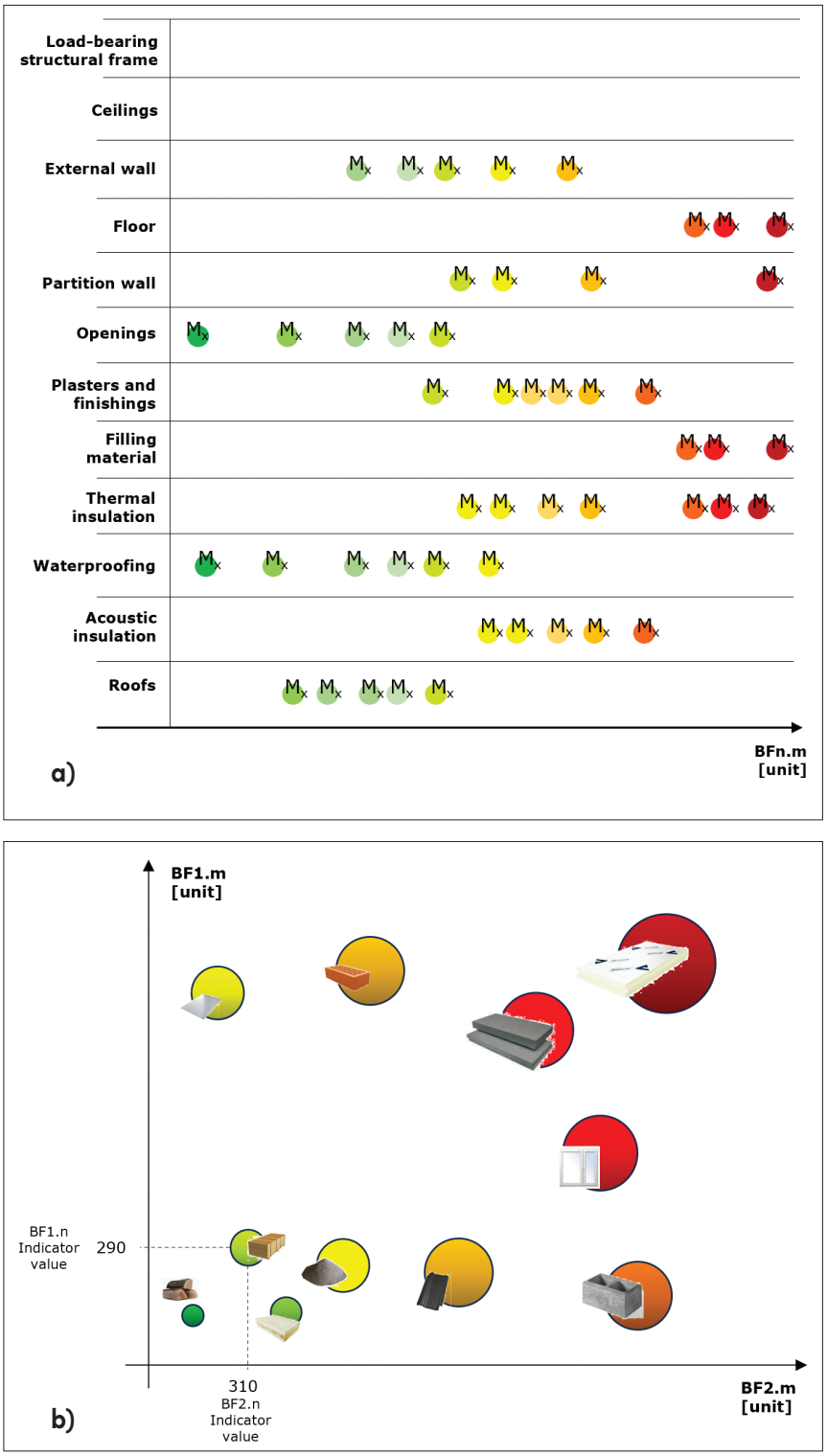
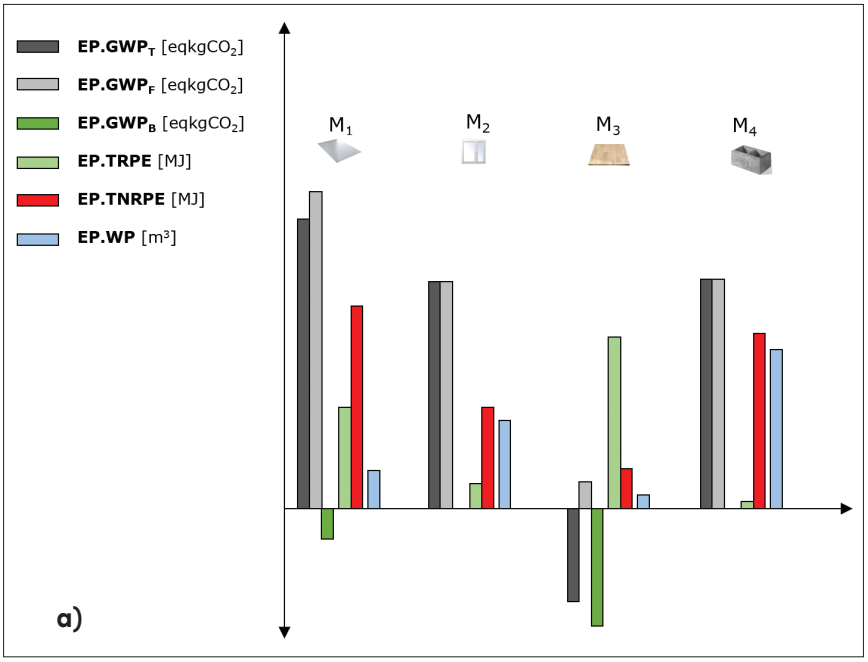


Fig. 2 a) line chart, b) bubble chart; source: own study

- it is estimated that the platform will reach all interested users in Poland and Turkey, which is approximately 15,000 and 30,000 people among architects and engineers, respectively. In addition, approximately 150–200 manufacturers of building materials in Poland and Turkey may be interested in the results. Another group of beneficiaries will be engineering universities, in particular students of architecture. It is estimated that around 6,000 architecture students in Poland and around 7,880 architecture students in Turkey will be interested in learning about the carbon footprint of building materials as part of their courses or interests.

Summary

The FoCa project presented above is intended to support the process of



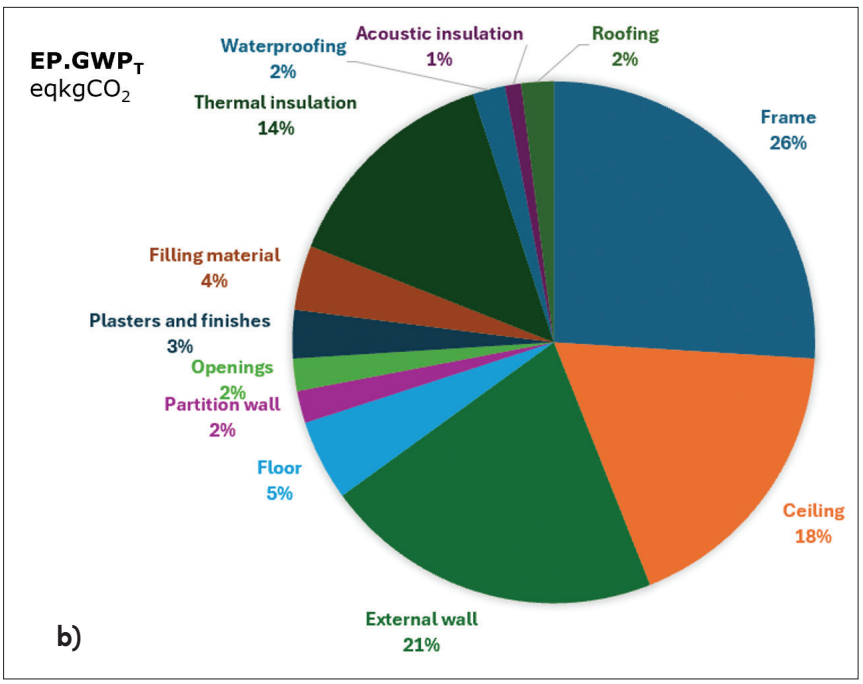


Fig. 3 a) pie chart, b) multi-bar chart; source: own study

decarbonization of construction by providing knowledge about the environmental impact of selected building materials available in Poland and Turkey. To prepare a tool that meets the above assumptions, cooperation is carried out with representatives of small and medium-sized enterprises. Surveys conducted before and during the project implementation provided important information about the expectations of the construction sector and its level of acceptance of the proposed solutions. After the launch of the platform, there will be a period of verification of the level of acceptance of its functionality and the collection of data from users on the value of the environmental impact for the buildings they design - which will be the subject of future research.

Abbreviations

GWP – Global Warming Potential

GWPfossil – Global Warming Potential, fossil fuels

GWPbiogenic – Global Warming Potential, biogenic

GWPtotal – Total Global Warming Potential

TRPE – Total Renewable Primary Energy

TNRPE – Total Non-Renewable Primary Energy

WD – Water Depletion

LCA – Life Cycle Assessment

LCPA – Life Cycle Performance Assesment

EPBD – Energy Performance Building Directive

A1–A3 – modules of Life Cycle Assessment

EPD – Environmental Product Declaration

kg – unit of weight

m^3 – unit of volume

m^2 – unit of area

$m^2 \cdot K/W^1$ – unit of thermal resistance

$kg \cdot CO_2eq/m^3$ – unit of global warming potential equivalent per unit of volume

$kg \cdot CO_2eq/m^2$ – unit of global warming potential equivalent per unit of area

$kg \cdot CO_2eq/kg$ – unit of global warming potential equivalent per unit of weight

$kg \cdot CO_2eq/(m^2K/W)$ – unit of global warming potential equivalent per unit of thermal resistance

$kg \cdot CO_2eq/(kg/m \cdot s \cdot Pa)$ – unit of global warming potential equivalent per unit of vapor permeability

kg·CO2eq/MPa – unit of global warming potential equivalent per unit of strenght

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PRAWIDŁOWY SPOSÓB CYTOWANIA
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ABSTRACT:

Wrocław University of Science and Technology, in consortium with the Polish Association of Ecological Buildings (PLGBC), the Institute of Building Technology (ITB) and research and scientific units from Turkey, started the international project FoCA – Free of Carbon Architecture. Its aim is to create a publicly available tool – an interactive internet platform providing information on the environmental properties of construction materials and products available in Poland and Turkey. The platform allows users to compare and evaluate the environmental impact of selected building materials. As part of the platform's development, information is collected about building materials or products available on local markets, in the form of data describing their selected environmental impacts (GWP-fossil, GWPbiogenic, GWPtotal, TRPE, TNRPE, WD). The platform allows to compare building materials and perform analyzes for conceptual building designs. In addition, producers of building materials can also benefit from the project because they will receive information about the environmental properties of some of their products. The platform will be available in the second half of 2024.

KEYWORDS:

decarbonization, carbon footprint of building materials, generic EPD, carbon footprint of buildings

STRESZCZENIE:

FOCA – FREE OF CARBON ARCHITECTURE – EDUKACYJNA I INFORMACYJNA PLATFORMA INTERNETOWA WSPIERAJĄCA DEKARBONIZACJĘ SEKTORA BUDOWLANEGO W POLSCE I W TURCJI. Politechnika Wrocławska w konsorcjum z Polskim Stowarzyszeniem Budownictwa Ekologicznego (PLGBC), Instytutem Techniki Budowlanej (ITB) oraz jednostkami naukowo-badawczymi z Turcji rozpoczęła międzynarodowy projekt FoCA – Free of Carbon Architecture. Jego celem jest stworzenie ogólnodostępnego narzędzia – interaktywnej platformy internetowej dostarczającej informacji na temat właściwości środowiskowych materiałów oraz wyrobów budowlanych dostępnych w Polsce i Turcji. Platforma umożliwia użytkownikom porównywanie i ocenę wpływu wybranych materiałów budowlanych na środowisko. W ramach rozwoju platformy zbierane są informacje o materiałach budowlanych lub produktach dostępnych na rynkach lokalnych, w postaci danych opisujących ich wybrane oddziaływania na środowisko (GWP-fossil, GWPbiogenic, GWPtotal, TRPE, TNRPE, WD). Platforma umożliwia porównywanie materiałów budowlanych oraz wykonywanie analiz do projektów koncepcyjnych budynków. Ponadto na projekcie mogą skorzystać producenci materiałów budowlanych, którzy otrzymają informacje o właściwościach środowiskowych niektórych swoich produktów. Platforma będzie dostępna w drugiej połowie 2024 roku.

SŁOWA KLUCZOWE:

dekarbonizacja, ślad węglowy materiałów budowlanych, generyczne EPD, ślad węglowy budynków