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Carbon footprint problems in construction

Problemy śladu węglowego w budownictwie

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Abstract. The article discusses the challenges associated with calculating the carbon footprint in the construction industry. It analyzes the difficulties in estimating the amount of emitted greenhouse gases and recognizing their impact on the natural environment. Attention is drawn to the risk of making incorrect assumptions when seeking ecological solutions and the comparative difficulties between different building materials in terms of carbon footprint. Despite these challenges, the importance of carbon footprint analysis as a tool to support sustainable construction efforts is emphasized. The need to continue improving methodologies and measurement precision to enable a more accurate assessment of the construction sector's impact on the natural environment is highlighted.
Keywords: carbon footprint; construction; ecology; global warming

Streszczenie. W artykule omówiono trudności związane z obliczaniem śladu węglowego w budownictwie. Przeanalizowano trudności związane z oszacowaniem ilości emitowanych gazów do atmosfery i rozpoznaniem ich wpływu na środowisko naturalne. Zwrócono uwagę na ryzyko przyjmowania nieprawidłowych założeń przy poszukiwaniu ekologicznych rozwiązań oraz na trudności porównawcze między różnymi materiałami budowlanymi pod względem śladu węglowego. Pomimo wskazania na trudności, podkreślono znaczenie analizy śladu węglowego jako narzędzia wspierającego dążenia do zrównoważonego budownictwa. Wskazano na potrzebę kontynuowania prac nad doskonaleniem metodologii i precyzją pomiarów, aby umożliwić bardziej dokładną ocenę wpływu sektora budownictwa na środowisko naturalne.
Słowa kluczowe: ślad węglowy; budownictwo; ekologia; ocieplenie klimatu.

The Paris Agreement obliges countries to reduce greenhouse gas emissions in order to keep the rise in global temperature below 1.5°C, in order to minimize the effects of progressing climate change. The International Energy Agency (IEA) reports that *in 2021, building operations accounted for 30% of global final energy consumption and 27% of total emissions from the energy sector* [1].

The United Nations Environment Programme (UNEP) report indicates 37% for the entire construction sector [2], which has the greatest impact on climate change. The sources of greenhouse gas emissions in architecture can be divided into operational and embedded in the structure. The first step to reducing CO_2 values is to define the most important emitters of emissions. The next is the ability to compare the impact of adopted design solutions on the climate. This process is often complex, and the most important factors complicating the correlation are the scope of assessment and the time variable. Ultimately, the most important action is to change technology or completely eliminate harmful factors. Carbon footprint analysis is intended to help in this task.

The method for calculating carbon footprint generally divides into CCF *(Corporate Carbon Footprint)*, which is the carbon footprint of a company, and PCF *(Product Carbon Footprint)*. The most commonly used standards and protocols for calculating PCF include ISO 14067, EN 15804, PAS 2050, the GHG Protocol, and the Product Environmental Footprint (PEF). These standards differ in scope and assessment method. ISO 14067 is general in nature and focuses on the carbon footprint of products, offering flexibility in the assessment approach. PAS 2050 and the GHG Protocol are more detailed and focus on specific methods and requirements for measuring the carbon footprint. PEF and EN 15804 go a step further, providing very detailed guidelines for environmental assessment, including a wide range of environmental impact categories and not limiting to CO_2 emissions only. ISO 14067 and PAS 2050 may differ, for example, in their approach to emission allocation in the supply chain. The GHG Protocol covers a wide range of greenhouse gas emissions and is more often used for managing CCF emissions than PCF. PEF involves a more comprehensive environmental assessment, not just carbon, and is strongly focused on comparability between products. The differences also concern application: ISO 14067 is recognized internationally and used in various industries, while PAS 2050 is popular in the UK and often used in an international context. PEF, an initiative of the European Union, aims to create a consistent system for assessing the environmental impact of products across Europe.

In construction, calculating the carbon footprint is intended to aid in making an informed choice of the most ecological solution. Knowledge of the carbon footprint is meant to be helpful both in selecting sources of heating and cooling (direct/operational emissions), as well as construction and finishing materials (indirect emissions).

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The Importance of Precise Carbon Footprint Calculations

Neglecting precision in carbon footprint calculations can reduce our analyses to superficial conclusions. One of them is the commonly known principle that it is better to limit the use of non-renewable resources than to allow their excessive exploitation. Although this statement is true, it does not contribute to a deeper understanding of complex environmental issues, nor does it help in developing effective strategies for reducing greenhouse gas emissions. Precise calculations, on the other hand, allow for a deep dive into the mechanisms that influence the carbon footprint, which is key in the case of effective environmental protection.

Calculating carbon footprint values begins with identifying the sources, amounts, and types of greenhouse gas emissions. Already at this stage, there are many problems. It's difficult to obtain precise information about the products emitted into the atmosphere by a specific technology. For example, the products of burning coal alone can vary even within a single emitter. Reasons include differences in the type of fuel burned (its calorific value/purity), as well as the technological processes that require delivering more or less oxygen to the combustion chamber. Burning 1 kg of bituminous coal can generate 2.2 – 2.7 kg of CO_2. In this situation, there are only two possible solutions:

- averaging the values;
- detailed analysis of gases leaving the emitter.

At the current level of technological advancement, for the vast majority of emitters, only the first option is feasible. This means that we can expect an error margin of about 20% right at the initial phase of carbon footprint analysis. Once we manage to define the averaged size of gas emissions and their volume, it is necessary to use Global Warming Potential (GWP) values to calculate the carbon footprint. For example: The National Centre for Balancing and Emission Management states that in the case of coal burned in kitchen stoves, free-standing stoves, and others (…) with a nominal thermal power ≤ 0.05 MW, to achieve 1 GJ of thermal energy, the emission obtained is:

- Total dust = 749 g;
- PM10 dust = 667 g;
- PM2.5 dust = 517 g;
- Carbon dioxide = 94 180 g (GWP = 1);
- Carbon monoxide = 3,182 g;
- Nitrogen oxides = 192 g (GWP = ?);
- Sulfur oxides = 338 g;
- Benzo(a)pyrene = 0.37 g.

In this example, the only greenhouse gas is carbon dioxide. It can be easily estimated that the production of 1 GJ of energy is associated with a CO_2 equivalent emission of about 94 kg. However, do the other gases indeed have no greater or lesser impact on the greenhouse effect?

Nitrogen oxides are not greenhouse gases, but they have a significant impact on the production of tropospheric ozone, whose role can be likened to that of a catalyst. It is estimated that the Global Warming Potential (GWP) of NOx is 30 – 33 over a period of twenty years and 7 – 10 over a hundred years [3]. The emission of NOx should be assessed over a somewhat longer perspective than just its residence time in the atmosphere, as it is relatively quickly removed from the atmosphere (acid rain). Microorganisms, such as denitrifying bacteria, convert NOx into nitrates (NO_3^-) and nitrites (NO_2^-). The next step is the transformation of nitrates and nitrites into nitrous oxide (N_2O) through a process called denitrification. Denitrification is a chemical reaction in which oxygen is removed from nitrates or nitrites, resulting in the stable greenhouse gas N_2O with a GWP of 265. Currently, this fact is not accounted for in carbon footprint reports (nitrogen oxides do not have an assigned GWP value, unlike nitrous oxide).

The number of greenhouse gases with described Global Warming Potential (GWP) is increasing. In 2013, the IPCC published GWP values for 207 greenhouse gases, starting with CO_2 and ending with $HCF_2O(CF_2CF_2O)_4CF_2H$. By 2021, the number of greenhouse gases with a described GWP value had risen to 252, beginning with CO_2 and ending with butane n-C4H10. A fundamental problem is the lack of even a simplified method for calculating GWP. It's not possible to reliably determine whether, for example, NOx will actually undergo denitrification to a significant extent, or if the chain of chemical dependencies will stop at nitrates.

Another challenging aspect in the interpretation is the values of GWP. When calculating the carbon footprint using formula 1, the impact values of GWP over 100 years are typically used. This stems from the Paris Agreement, in which 197 countries agreed on this method for reporting aggregated emissions and the removal of greenhouse gases at the national level. This is a significant simplification. Greenhouse gases behave very differently in the atmosphere. Sulfur hexafluoride (SF6) tends to increase its greenhouse effect over time, methane decreases its greenhouse potential, and nitrous oxide (N_2O) reaches its peak environmental impact approximately after a hundred years in the atmosphere.

$$GWP = \int 0\ t\ RF(t')dt' \ [4] \qquad (1)$$

where:
GWP – Global Warming Potential; RF(t′) – Radiative Forcing at a specific time (t′); t = the period over which the GWP is calculated.

Due to the very specific behavior of gases in the atmosphere, the value of RF (t') is calculated differently for almost every gas (halogen compounds and other less significant greenhouse gases, for example, have the same formula). Examples of these formulas are presented in Table 1. It appears that GWP can never be a constant value.

In practice, it is assumed that the Radiative Forcing (RF) of carbon dioxide (CO_2) does not change as a result of changes in CO_2 concentration in the atmosphere. RF for CO_2 is calculated based on changes in CO_2 concentration between specific periods, rather than depending on the current CO_2 concentration. This represents the difference in the absorption of solar radiation and the emission of thermal radiation between two scenarios: one referring to baseline conditions (e. g., the year 1750), and the other to current conditions. RF (Radiative Forcing) for CO_2 is constant in a specific reference period, such as the

Table 1. Simplified expressions to compute radiative forcing (RF) [5]
Tabela 1. Wzory oddziaływania promieniowania [5]

GAS	Simplified Radiation Interaction Formula	Coefficients
CO_2	$C_{\alpha max} = C_0 - \frac{b_1}{2a_1}$ $\alpha' = \begin{cases} d_1 - \frac{b_1^2}{4a_1};\ C > C_{\alpha max} \\ d_1 + a_1(C - C_0)^2 + b_1(C - C_0);\ C_0 < C < C_{\alpha max} \\ d_1;\ C < C_0 \end{cases}$	$a_1 = -2.4785 \cdot 10^{-7}$ W m^{-2} ppm^{-2} $b_1 = 7.5906 \cdot 10^{-4}$ W m^{-2} ppm^{-1} $c_1 = -2.1492 \cdot 10^{-3}$ W m^{-2} ppb$^{-1/2}$ $d_1 = 5.2488$ W m^{-2} $C_0 = 277.15$ ppm
N_2O	$SARF_{N_2O} = (a_2\sqrt{C} + b_2\sqrt{N} + c_2\sqrt{M} + d_2)(\sqrt{N} - \sqrt{N_0})$	$\alpha_2 = -3.4197 \cdot 10^{-4}$ W m^{-2} ppm$^{-1/2}$ ppb$^{-1/2}$ $b_2 = 2.5455 \cdot 10^{-4}$ W m^{-2} ppb^{-1} $c_2 = -2.4357 \cdot 10^{-4}$ W m^{-2} ppb^{-1} $d_2 = 0.12173$ W m^{-2} ppb$^{-1/2}$ $N_0 = 273.87$ ppb
CH_4	$SARF_{CH4} = (a_3\sqrt{M} + b_3\sqrt{N} + d_3)(\sqrt{M} - \sqrt{M_0})$	$\alpha_3 = -8.9603 \cdot 10^{-5}$ W m^{-2} ppb^{-1} $b_3 = -1.2462 \cdot 10^{-10}$ W m^{-2} ppb^{-1} $d_3 = 0.045194$ W m^{-2} ppb$^{-1/2}$ $M_0 = 731.41$ ppb

year 1750. The increase in CO_2 concentration in the atmosphere affects the long-term effect of climate warming, but it does not change the RF value of carbon dioxide. As the concentration of CO_2 increases, so does its impact on the greenhouse effect and climate, but RF remains unchanged. GWP *(Global Warming Potential)* takes into account the long-term impact of CO_2 on climate warming, which is why it is always 1.

The situation is different for other greenhouse gases. As science advances, their GWP changes.

Knowledge about GWP *(Global Warming Potential)* continues to evolve, which is significant from the perspective of assessing the impact of greenhouse gases on climate change. For example, in 1995, it was reported that the GWP for methane (CH4) was 21 over a hundred-year perspective, whereas in 2021, this value increased to 27.9, indicating a significant upward trend (Table 2). There is controversy among the scientific community regarding the choice of time perspective to consider when calculating GWP. Some researchers prefer a 20-year period to emphasize the impact of short-lived greenhouse gases on climate change more. Others believe that 100-year GWP values are more appropriate as they consider the long-term impact of greenhouse gas emissions [11].

Should climate pollutants (SLCP – *Short-lived Climate Pollutants*) with a short lifespan, such as methane, tropospheric ozone, and hydrofluorocarbons (HFC – *hydrofluorocarbon gases*), be treated differently than CO_2? They have a stronger warming effect than carbon dioxide, so their reduction can beneficially impact limiting the greenhouse effect in the near term and can be very cost-effective from an environmental standpoint. Actions currently taken to address this issue can slow the warming of the planet by about 0.6°C by 2050. Additionally, some SLCPs are also air pollutants and can be harmful to human health. Thus, their reduction can not only decrease climate warming but also save lives and improve public health.

At the 2016 Meeting of the Parties to the Montreal Protocol in Kigali, Rwanda, countries worldwide agreed to a legally binding commitment to reduce emissions of hydrofluorocarbons (HFCs). This groundbreaking agreement, known as the Kigali Amendment, includes targets and timelines for phasing out HFCs in favor of cleaner alternatives. Countries that ratified the protocol were subjected to restrictions, such as on trade from 2033 with countries that have not done so. Additionally, wealthier countries were obligated to finance the transition of poorer countries to new standards [12].

Table 2. Historical changes in GWP values of basic greenhouse gases
Tabela 2. Wartości GWP podstawowych gazów cieplarnianych

Liczba lat	SAR 1995 [6]			TAR 2001 [7]			AR4 2007 [8]			AR5 2013 [9]			AR6 2021 [10]		
	20	100	500	20	100	500	20	100	500	20	100	500	20	100	500
CH_4	56	21	6.5	62	23	7	72	25	7.6	84	28	b.d	81.2	27.9	7,95
N_2O	280	310	170	275	296	156	289	298	153	264	265	b.d	273	273	130

Many alternative metrics related to GWP *(Global Warming Potential)* have been developed, and one of the more interesting ones is GWP* (with an asterisk added). Proponents of GWP* argue that for Short-lived Climate Pollutants (SLCPs), the rate of change in atmospheric concentration is crucial. If methane is released into the atmosphere at the same rate it is degraded into water and CO_2, then it does not have a global warming effect. Introducing the concept of accounting for SLCPs in this way has complicated the task for architects in finding the right environmental solutions, as it adds another layer of complexity to the considerations in sustainable design and construction.

The American Society of Heating, Refrigerating and Air-Conditioning Engineers, in its standard ASHRAE 189.1, publishes emission indices for fossil fuels delivered to buildings, electricity used in buildings, and thermal energy supplied to buildings from plants producing steam, hot water, or chilled water. The project committee for standard 189.1 decided to use GWP20 *(Global Warming Potential over 20 years)* to assess GHG *(Greenhouse Gas)* emissions in buildings. This decision to apply GWP20 in standard 189.1 was not unanimous but was supported by the majority of the committee. This decision is also in line with the guidelines of the IPCC *(Intergovernmental Panel on Climate Change)*. The IPCC recommends using GWP100 *(Global Warming Potential over 100 years)* for consistent reporting of aggregated emissions and absorption at the national level and recognizes that GWP20 is suitable for other applications. In practice, this leads to the conclusion that beyond the basic assumption – the less energy a building uses, the lower its emissions – there is currently a lack of deeper, more detailed knowledge about the environmental impact of chosen solutions. This means that beyond the obvious conclusions that the less energy a building consumes, the lower its emissions, we do not know much more precisely today.

For example, it is unclear whether a gas boiler or a heat pump is a better environmental solution. GWP20 places much greater emphasis on methane emissions, making electric devices appear somewhat better than gas ones, which is quite the opposite of what would be the case with GWP100 [13].

As evident, calculating the carbon footprint is a complex process that begins with identifying the sources and amounts of greenhouse gas emissions. However, difficulties in obtaining accurate data on this matter exist. Moreover, controversies regarding the choice of GWP values and the period they cover introduce challenges in assessing climate impact. Issues with Short-lived Climate Pollutants (SLCP) further complicate this assessment. Choosing appropriate metrics, such as GWP*, is crucial in evaluating environmental impact. The entire process requires continuous knowledge development and advanced tools to more precisely assess the impact of emissions on the climate.

Incorrect Assumptions

There is a range of issues stemming from a lack of understanding of how to calculate the carbon footprint in construction. The basis for incorrect assumptions is always the consideration of data in isolation from the environmental context. Here are a few examples of misconceptions related to operational emissions in buildings:

■ an overly short analysis chain that does not take into account the complete set of data.

Unfortunately, the problem of an overly short carbon footprint analysis chain can currently be seen even in Polish building regulations. While the term "carbon footprint" is not directly mentioned, primary energy has colossal importance. Primary energy is obtained from renewable and non-renewable resources. Non-renewable resources include fossil fuels such as coal, oil, and gas, while renewable resources are geothermal energy, wind, and sun. The regulations aim to achieve low coefficients of non-renewable primary energy, thereby limiting greenhouse gas emissions from the burning of fossil fuels. This simultaneously means a low carbon footprint.

Photovoltaic (PV) panels are currently treated as emission-free sources of electricity. This is emphasized by the value of the coefficient of non-renewable primary energy input required to produce and deliver the final energy carrier wi. According to the Regulation of the Minister of Energy from October 5, 2017, on the detailed scope and method of preparing an energy efficiency audit and methods of calculating energy savings, the value of this coefficient for solar energy is set at 0.0 (zero). For comparison, biomass has a value of 0.2, and the systemic electrical grid 2.5. The short analysis chain of the emissivity of this solution begins and ends at the site of the photovoltaic system installation, which is a fundamental error. In the case of PV panels, greenhouse gas emitters are not located at the photovoltaic farm, but can be easily found on the side of the grid operator to which the installation is connected.

A problem generating significant emissions is the necessity of energy storage. Ideally, prosumers should produce and consume energy on-site. Unfortunately, the production profile does not align with the consumption profile. During winter in our geographical latitude, PV panels significantly lose efficiency (Photo), while energy demand increases.

We lack developed alternative storage methods like power-to-gas in our country. Energy storage essentially means "transferring energy" to other consumers (in the summer period), and in the longer term, "producing energy" from a stable source (in the winter period). In Poland, during winter, prosumers rely on energy produced

PV panels in December, location: Krakow. 2023
Panele PV w grudniu, lokalizacja: Kraków. 2023 r.

from coal. Formally, this is their energy, reduced by the costs of "storage". Illustration shows the efficiency distribution of PV panels in Poland from January to December.

In Polish climatic conditions, the carbon footprint of a building equipped with photovoltaic cells is not zero. If the w_i parameter for the systemic grid is 2.5 and at least 20% of the energy in buildings using PV must be covered from this grid, then the w_i for PV should be around 0.5. This value could be "mitigated" because the energy from sunny days is not wasted but transferred to other consumers (changing the carbon footprint of buildings without PV). However, the computational value of the carbon footprint for operational energy in a building with PV panels cannot be zero.

In Poland, during winter, there will always be a need to produce energy from a stable source, even if PV panels are installed on every roof in the country. Therefore, there is a necessity to verify the w_i parameters adopted for solar energy.

Analysis chain that does not take into account physicochemical processes

The earlier mentioned Regulation of the Minister of Energy indicates a w_i

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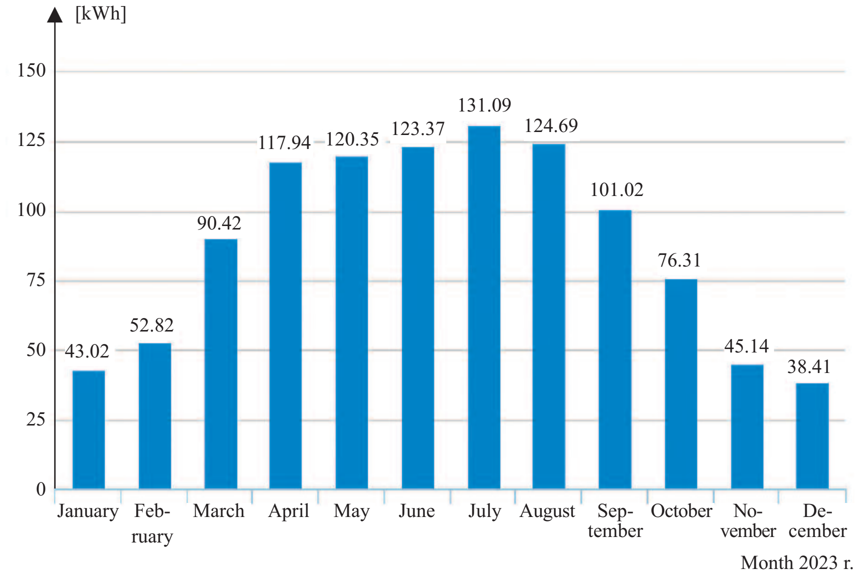

Estimated annual level of photovoltaic energy production in Poland [14]
Szacunkowy poziom produkcji energii fotowoltaicznej w Polsce [14]

parameter for biomass at the level of 0.2. Its combustion raises some controversies and it might seem that it causes the emission of dangerous greenhouse gases. In the report by the Chatham House center, it was presented that the burning of biomass is characterized by a higher carbon footprint than the burning of coal [15] (Brack, 2017 s. 15). The authors of the report failed to notice that carbon dioxide is a greenhouse gas, but at the same time, it is very necessary in the natural environment. From an environmental protection perspective, the removal of relatively new plantations of plants intended for biomass, even without ensuring the continuity of plantations (without new plantings), does not have significant environmental consequences. In a simplified manner, it can be said that such action reverts the CO_2 balance in the atmosphere to the time before the plantation was established, i.e., to the time before the plants began to bind CO_2. The process of binding and releasing CO_2 is just a few, more often several, years. The situation looks completely different when, for example, equatorial forests are cut down, thus destroying ecosystems that have been forming for even 180 million years [16]. By removing such an ecosystem, we release into the atmosphere carbon dioxide that our planet had bound even before the appearance of humans. The situation is even worse when we burn fossil fuels. We emit greenhouse gases that the Earth had bound up to 500 million years ago (oil deposits are found in formations from the Cambrian to the Tertiary, mainly in Mesozoic formations). In doing so, we are effectively „rewinding" our planet back to the Cambrian era. Even if the carbon footprint of biomass burning is greater than that of coal burning, biomass burning is not a threat to humanity because we are reintroducing into the atmosphere carbon dioxide that was in our friendly atmosphere just a few decades earlier. However, this reasoning should not be applied to tree plantings intended to offset CO_2 emissions from the burning of fossil fuels. Such plantings should be considered as permanent ecosystems, as only their permanence ensures effective sequestration of CO_2 eq.

From the perspective of greenhouse gas emissions, biomass burning is the most ecological solution. It releases combustion products that the biomass had bound in a short period, without significantly changing the planet's atmosphere. The w_i coefficient for this solution should be zero. At the same time, it should be emphasized that safe biomass burning in boilers is only possible in areas that have the capability for rapid air circulation.

The identification and assessment of the carbon footprint in construction encounter many challenges and problems. Incorrect assumptions often arise from a lack of consideration of the environmental context and from not fully analyzing data. Misunderstanding or incorrect assumptions can lead to false conclusions about a building's impact on climate change and the natural environment.

Results – Comparative Difficulties

Currently, the declared product carbon footprints for construction purposes can most easily be found on EPD *(Environmental Product Declaration)* sheets, known in Poland as „Type III Environmental Declarations". These are documents that should transparently inform about the environmental efficiency or impact of any product or material throughout its entire usage period. Knowing the contents of EPDs, engineers should be able to choose the most sustainable option for their project.

The carbon footprint of building products presented in EPDs was typically calculated in accordance with the EN 15804 standard in modules A1 – A3, i.e., considering the extraction and processing of raw materials, processing of secondary material inputs, transport to the manufacturer, and production. On June 21, 2019, after a formal vote by the European Committee for Standardization (CEN), a fundamental change to the EN 15804 standard was accepted.

Under the revised standard (EN 15804 + A2), the EPD declaration should cover all life cycle stages. Now, all building products and materials must have declared modules A1-A3, C1-C4, and D (A4-B7 are additional modules). This expanded scope ensures a more comprehensive assessment of the environmental impact of products over their entire lifecycle, from raw material extraction and processing to end-of-life disposal or recycling [17]. Therefore, it is necessary to declare the emissions from a construction product at stages including: demolition; transport to waste processing; processing waste for reuse; recovery and/or recycling, or eventual disposal. It is required to present the potential for reuse, expressed as net impacts and benefits. Only under very specific conditions is it still possible to conduct an EPD assessment (A1-A3) exclusively. In all other cases, the end of life (EOL) must be considered. All these procedures are necessary for the comparability of results. However, it should be emphasized that EPDs were never intended for product comparison. The declared carbon footprint was meant for identifying the most significant threats and attempts at their elimination. Attempting to compare the carbon footprint results of a construction product and including it as a key element in decision-making for choosing one solution over another is very problematic today. For instance, building material „A" has a lifespan of 15 years, a low carbon footprint, and is 100% recyclable, while building material „B" has a lifespan of 60 years, a high carbon footprint, and is also 100% recyclable.

Theoretically, a thorough comparison of products „A" and „B" should consider, in the case of product „A", adding at least three times the carbon footprint from the C1 – C4 range (as the product will originate from recycling three times more often). In practice, there will also be three times greater emissions in the ranges A4, A5, B4, which are not required (according to EN 15804 + A2) – these emissions are associated with installation and dismantling. It's even more challenging to compare materials that are only partially recyclable. In the case of building products, practically none are 100% recyclable.

Including the durability of building materials is absolutely necessary in analyses of a product's impact on the natural environment. At the same time, this parameter can be a way to distort the results indicated in the declaration and can, in fact, be used to manipulate data. The primary problem concerns the reliability of the declared value describing durability. Currently, there are two warranty strategies from manufacturers of building materials and not just building materials:

a) overstating the quality of the building product – a higher price for the product does not match quality but balances out the potential need for warranty repairs.

b) understating the quality of the building product – a good quality building product has its declared durability reduced so as not to be liable for warranty repairs.

Each of these cases is unsuitable for an accurate analysis of durability in the context of carbon footprint and impact assessments on the climate. Currently, comparing building materials in terms of parameters described in declarations is very difficult. An additional mundane problem is the lack of consistent units used in declarations made by different entities. For instance, a cement manufacturer might refer CO_2 eq to kg or m^3 of material, or even m^3 of concrete.

Summary

Considering the broad range of issues related to calculating the carbon footprint in construction, it's impossible to avoid numerous difficulties and challenges. From analyzing the life cycle of building products to obtaining accurate data and establishing uniform standards and assessment methods, the process is complex and time-consuming. Additionally, attempting to compare different building materials, taking into account aspects such as durability and recyclability, becomes an exceptionally intricate task.

Despite these challenges, calculating the carbon footprint in construction is meaningful. It serves as a tool to identify key environmental threats and to take actions to mitigate them. It helps designers and engineers make more informed decisions, guided by the principles of sustainable development and aiming for climate-friendly solutions. The key challenge, however, remains the need to standardize carbon footprint assessment methods and for manufacturers to present data reliably. Despite the difficulties, calculating the carbon footprint is a step towards a more sustainable future where buildings serve people while minimizing their negative impact on our planet.

Photo: M. Ciuła

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