DOI: 10.1002/cepa.1878

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FULL PAPER

LCA of building materials within the framework of the Construction Products Regulation (CPR) in Europe

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Abstract

Buildings and constructed assets form the basis for economic and social development. However, their production, construction, maintenance and operation lead, among other things, to the use of natural resources and cause undesirable effects on the global and local environment. Increasingly, therefore, requirements for the environmental performance of buildings are being formulated in funding programs, sustainability assessment systems and legislation. Life cycle assessment (LCA) is used as a method for recording, evaluating and influencing the environmental performance of buildings. The assessment of the environmental performance - and as part of it - the preparation of the LCA requires the provision and availability of environmentally relevant product information on all building materials, components and technical systems. Based on the draft of the Construction Products Regulation (CPR) in Europe as well as the state of standardization, the contribution discusses how requirements for construction product characteristics and construction product information can be derived from the requirements for buildings. Consequences for product development and the communication of technical and environmental product information are discussed.

KEYWORDS
basic works requirements, building material, environmental performance of buildings, environmental product declaration, life cycle assessment (LCA), product information requirements, product requirements, regulation, standardization

1 | INTRODUCTION

Worldwide, great efforts are being made to preserve the natural foundations of life and to enable social and economic development within planetary boundaries. To support sustainable development, the member states of the United Nations have agreed on goals to be achieved by 2030. The achievement of these sustainability goals is directly and indirectly influenced by the construction and real estate industry including its upstream and downstream sectors, the construction product industry and the energy sector. The construction and real estate sector has agreed internationally on a sector-specific understanding of sustainability – see *ISO 15392: 2019 Sustainability in buildings and civil engineering works – General principles*. According to this understanding, in order to contribute to sustainable development, buildings must meet technical and functional requirements and exhibit above-average ecological, economic and social performance. The recording and evaluation of the effects on society, the economy and the environment should be carried out simultaneously and on an equal footing. Criteria and indicators are to be derived from the areas of protection/issues of concern of a sustainable development. Primary object under

consideration are first of all construction works in the sense of buildings and constructed assets in their complete life cycle. In the life cycle analysis, methods such as life cycle assessment (LCA) and life cycle costing (LCC) are used. International and European standards serve as a basis for these methods. The results of LCA of buildings provide an important contribution to the assessment of environmental performance. There, both the use of natural resources in terms of primary raw materials and undesirable effects on the global and local environment are recorded with the aim of influencing them in a targeted manner already in the design stage. The result of a life cycle assessment is strongly influenced by the type and quantity of construction products used in terms of building materials, components and technical systems among other aspects. Environmental related characteristics and product information become more and more important.

Both in the context of sustainable development and in the interest of the competitiveness and future-proofness of the companies involved (e.g. real estate industry, construction product industry) the following questions arise

1. What are the requirements for sustainable buildings?
2. What are the essential assessment criteria and indicators? Which methods are used?
3. What product information must be made available and communicated B2B or B2C?
4. What are the requirements for building materials and their development?

2 | REQUIREMENTS ON FUTURE-PROOF BUILDINGS

2.1 | Overview

Discussions are taking place around the world about the characteristics and attributes that future-proof buildings must have in order to contribute to sustainable development. The direct interests of investors, owners, users and visitors, the neighborhood, the community and society must be taken into account. In addition to the technical, functional, ecological and social aspects, economic aspects such as life cycle costs (in some cases external effects in the form of external costs are taken into account), costs for owners and users, rentability and marketability as well as stability and development are also important.

In Europe, general requirements for construction works are the subject of an annex to a next Construction Products Regulation (CPR) [1]. They are named in Table 1 on the basis of the current draft of the future CPR.

There is a clear reference to the topics that can be assigned to the environmental performance of buildings. In the context of the requirements for buildings, the EC has formulated additional macro objectives [2]. These focus on requirements for the environmental quality of buildings and include aspects of climate protection and resource conservation. These aspects became part of the European reporting framework on the sustainability of buildings LEVEL(s). Requirements

TABLE 1 Basic requirements for construction works

Nr.	Requirement
1	Structural integrity of construction works
2	Fire safety of construction works
3	Workers, consumer and occupant protection against adverse hygiene and health impacts related to construction works
4	Workers, consumer and occupant protection against physical injuries of construction works
5	Fesistance to the passage of sound and acoustic properties of construction works
6	Energy efficiency and thermal performance of construction works
7	Hazardous emissions into the outdoor environment of construction works
8	Sustainable use of natural resources of construction works

for the contribution of buildings to sustainable development are the subject of EN 15643, and on an international scale of the future ISO 21931.

Environmental performance is an important element in the assessment of the contribution of individual buildings to sustainable development. By using the results of life cycle assessment, it has been possible to apply largely quantitative methods for assessing the environmental performance. This has contributed to a more objective discussion of environmental compatibility.

2.2 | Selected assessment criteria

Assessment criteria for evaluating the environmental performance of buildings are derived from protection goals. These include climate protection and resource conservation.

A key indicator is the greenhouse gas emissions caused by the complete building over its entire life cycle. They are determined on the basis of a life cycle assessment. This is based on a building model and a life cycle model. The method of life cycle assessment is described in the ISO 14040 and ISO 14044 standards. Specific standards are available for the applied life cycle assessment of buildings and building products. In the case of buildings, these are ISO 21931, EN 15643 and the future EN 15978-1, and in the case of construction products, ISO 21930 and EN 15804 A2.

One essential criterion of LCA is “climate change”. The sum of greenhouse gas emissions is given as global warming potential (GWP 100) in the unit kg CO_2 equivalents. The result is also called carbon footprint and consists in the case of buildings of an embodied and an operational part. The embodied part is influenced, among other things, by the type and quantity of construction products used and their service life. The carbon footprint of all types of products is the subject of ISO 14067. It is an important indicator worldwide – see ISO 21929-1 and the majority of international sustainability assessment systems. In Europe, it is used in LEVEL(s), has to be specified in the

context of real estate financing – see TAXONOMY – is to become a specification in the energy performance certificate according to the draft Energy Performance of Buildings Directive (EPBD) [3], and is part of the requirements in national subsidy programs. In many countries in Northern and Central Europe, the introduction of binding requirements to limit greenhouse gas emissions in the life cycle of buildings is currently being discussed and prepared.

Another criterion is "resource depletion". It measures the use or consumption of primary raw materials as part of natural resources. However, the abiotic resource depletion (ADP) indicator used for this purpose has hardly become established to date. In particular, for the assessment of buildings it is less suitable from the author's point of view. It is recommended to record and evaluate the cumulative use of raw materials, separated into minerals, ore, biomass and fossil fuels. There are similarities with the ADP, but the disaggregated presentation facilitates resource management and the performance of a material flow analysis. A prerequisite is the documentation of the type, quantity and installation location of the products used in a material inventory as part of a building passport or digital logbook.

Even if the public discussion is currently recognizably focused on the topics of climate protection and resource conservation, other indicators do not lose their importance. It is still weighty to consider and take into account the full range of impact categories and indicators. This serves, among other things, to identify conflicting goals and to avoid burden shifting. This also applies to undesirable effects on health and the local environment. These aspects are referred to and considered as non-LCA indicators.

It is clear that the task of assessing the contribution of buildings to sustainable development creates a need for information. For the assessment of environmental performance, this leads, among other things, to a need for environmental and health-related information on construction products of all kinds, including building materials.

3 | REQUIREMENTS ON PRODUCT INFORMATION

One instrument for communicating environmentally relevant information on construction products is the environmental product declaration (EPD). Its content is standardized in ISO 21930 and EN 15804 A2. EN 15804 is also traditionally used outside Europe as a guide for the provision of environmental product information. In Europe, EN 15942 provides a basis for the business-to business communication of data and EN 15941 is a standard for data quality. Internationally, ISO 22057 regulates the use of EPDs in the context of BIM.

The application of corresponding standards and the publication of EPDs is a voluntary measure. However, binding requirements for the environmental quality of buildings – in particular the limitation of greenhouse gas emissions in the life cycle including embodied parts – require data on all building products. One approach to solving this problem is to make data available in databases. By the end of 2022, the IEA EBC Annex 72 recommendations for the design and further development of such databases will be available. In the medium term, however, it can be assumed that legal obligations to provide environmentally relevant product data will be introduced in order to avoid data gaps. The current draft of the future Construction Products Regulation in Europe points in this direction.

TABLE 2 Requirements for product related information

Product information requirements (selected examples)
Intended uses and users
Conditions of uses
Estimated average and minimum service life span
Main materials used and key parts
Rules for transport, installation
Rules for maintenance, deconstruction/demolition
Safety instructions and information
Rules or recommendations for repair, reuse, remanufacturing, recycling or safe deposit

There are close interrelationships between the criteria and indicators for assessing the environmental performance of buildings and the environmentally relevant information that must be made available for construction products. The assessment of the building generates a demand for data and other information, but a building assessment can only be carried out if this is available on a uniform basis for all construction products like building materials.

Ideally, a job sharing between legal requirements and standards is formed. Often, a law provides the framework while a standard provides the methodological basis and regulates details. The draft for a next CPR first formulates general requirements for product information. Table 2 shows a selection.

Among other things, it is important to specify an average and minimum service life under defined conditions. From this and from the information on maintenance, the type and frequency of repair and replacement measures in the life cycle of a structure or in the reference study period of a sustainability assessment can be derived. These are important parameters for LCA and life cycle costing (LCC). The draft of the CPR specifies the information required for a life cycle analysis. On the one hand, they largely correspond to the contents of an EPD and, on the other hand, to the indicators and data that are determined via a life cycle assessment of the construction products and are required for the assessment of the environmental performance of buildings.

Table 3 shows a good match between the content of the draft of the future CPR and the state of standardization on EPDs in EN 15804 A2.

Differences lie in the details: In future, the information on GWP 100 in EPDs will be divided into GWP fossil, GWP biogenic and GWP LuLuc. Parts of the information will be treated as additional indicators in the EPD. It remains to be seen whether there will be an approximation in terms of content in the course of discussion processes that are still pending. In any case, it can and must be assumed that the preparation of life cycle assessments is indispensable for building materials, among other things, and that their importance – particularly in the area of information on greenhouse gas emissions in the life cycle of the products – will continue to increase. This includes information on

TABLE 3 Indicators, named in CPR and EPD: comparison

Essential characteristics related to life cycle assessment	CPR (draft)	EPD EN*15804* A2
Climate change – total	X[1]	X
Climate change – fossil		X
Climate change – biogenic		X
Climate change – LULUC		X
Ozone depletion	X	X
Acidification potential	X	X
Eutrophication aquatic freshwater	X	X
Eutrophication aquatic marine	X	X
Eutrophication terrestrial	X	X
Photochemical ozone	X	X
Abiotic depletion – minerals, metals	X	X
Abiotic depletion – fossil fuels	X	X
Water use	X	X
Particulate matter	X	X[2]
Ionizing radiation, human health	X	X[2]
Eco-toxicity, freshwater	X	X[2]
Human toxicity, cancer	X	X[2]
Human toxicity, non-cancer	X	X[2]
Land use related impacts	X	X[2]
(Capability to temporarily bind C)	(x)	X

[1]Mandatory.
[2]Additional indicator.

the modules A1-C4 and (in addition) D1 of a life cycle assessment, for the details of life cycle modelling and name of modules see EN 15804 A2. The name D1 comes from new EN 15643.

Not covered by a life cycle assessment is information on material composition in the sense of detailed information and the effects on health and the local environment. In connection with the topics of circular economy and resource management, the demand for information on material composition will grow. This will then allow conclusions to be drawn about the use of primary raw materials as part of natural resources.

4 | REQUIREMENTS ON PRODUCT CHARACTERISTICS

The product information described in Section 3 is an indication of the product characteristics that are in demand. In addition to the traditional issues of structural, physical and processing properties, requirements for the characteristics of products increasingly concern their behavior in the life cycle as well as environmental and health-related issues. In order to contribute to sustainable development and to be able to provide products with attractive characteristics, it is not only important to determine and communicate relevant data on characteristics and features, but also necessary to consider corresponding topics, requirements and goals in the further development of products.

TABLE 4 Requirements in the design and developments of products

Inherent product environmental requirements
Maximizing durability (expected average/minimum life span)
Minimizing whole life cycle greenhouse gas emissions
Maximizing recycled content (without negative impacts)
Selection of safe, environmentally benign substances
Energy use and energy efficiency
Resource efficiency
Reusability
Upgradeability
Reparability during expected life span
Possibility of maintenance and refurbishment
Recyclability and capability to be remanufactured
Capability of different materials or substances to be separated and recovered during dismantling or recycling procedures

Table 4 presents requirements for products and product development as they are named in the draft for a next CPR. Not all of them apply equally to all construction products.

From the author's point of view, the aspects mentioned here should be supplemented by further ones, including the sustainable extraction of raw materials (responsible sourcing) and the minimization of undesirable effects on the local environment through outgassing and spillage (based on the measurement methods of CEN TC 351).

5 | RECOMMENDATIONS FOR THE BUILDING MATERIALS INDUSTRY

In the context of the further development of products and the expansion of product information, the following recommendations for action are provided by the author without any claim to completeness.

1. Preparation/updating of standard-compliant life cycle assessments to optimize the procurement of preliminary products and own processes as well as a basis for the preparation of EPDs
2. Preparation/publication of sector-specific EPDs with mean values and ranges for early phases of building design
3. Preparation/publication of product-specific EPDs to support detailed design and concrete product selection
4. Consolidation of EPDs for individual products into EPDs for building components and product systems
5. Introduction of take-back options and guarantees to improve the credibility of claims in module D1

While many questions have been clarified with regard to the methodological principles of life cycle assessment, there are still

uncertainties about the design of the criteria and indicators in environmental product declarations or comparable instruments. In its own interest, the industry should press for clear specifications on the characteristics to be declared.

Finally, it is recommended that decarbonization strategies be developed into reliable forecasts of future life cycle assessment data.

6 | CONCLUSION AND OUTLOOK

The method of life cycle assessment has proven and established itself as a basis for assessing the environmental quality of buildings and providing environmentally relevant information on building products. It has left the niche of academic discussions. Its results are increasingly becoming an orientation and decision-making aid in industry and an important criterion in sustainability assessment systems. It has already begun to be included in legal requirements that necessitate the preparation of a life cycle assessment.

The situation in the area of construction products is different from that of buildings. A life cycle assessment for construction products is more oriented towards typical processes and work steps. The assessment of the environmental performance of buildings corresponds to an applied LCA in which product quantities are linked to product related data and information, for example, emission factors. In both cases, however, industry-specific standards must be observed and applied. The introduction of legal requirements for the assessment of the environmental performance of buildings and the provision of environmentally relevant data on products is imminent or has already begun. Primarily, interest is focused on the carbon footprint of building products and structures, with growing interest in issues of resource use and recyclability (circularity). Nevertheless, the categories of impacts to be considered are currently being expanded to provide a complete picture of the effects on the global environment. For this purpose, the addition of non-LCA indictors (e.g., impacts on the local environment) remains indispensable.

In the competitive business environment, it is becoming increasingly important to provide the market not only with suitable products but also with the necessary product information. This information must be based on uniform specifications in order to contribute to the assessment of buildings. An even stronger coordination between the requirements of legislation and the further development of standards will be necessary. All stakeholder groups involved should contribute to this process.

In the field of research, questions of how to deal with the uncertainty of data and the dynamics of future developments are increasingly being discussed, both of which are closely related.

An intensive examination of the topic of life cycle assessment is necessary and sensible for all actors in the value chain of construction.

ACKNOWLEDGEMENT

Open Access funding enabled and organized by Projekt DEAL.

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How to cite this article: Lützkendorf T. LCA of building materials within the framework of the Construction Products Regulation (CPR) in Europe. ce/papers. 2022;5:43–47. https://doi.org/10.1002/cepa.1878