# Level of knowledge and application of LCA in design practice: results and recommendations based on surveys

## A Contribution to IEA EBC Annex 72

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# Preface

This publication is an informal background report. It was developed as part of the international research activities within the context of the project IEA EBC Annex 72. Its contents complement the report “Context-specific assessment methods for life cycle-related environmental impacts caused by buildings” by Lützkendorf, Balouktsi and Frischknecht et al. (2023). The sole responsibility for the content lies with the author(s).

In the context of IEA EBC Annex 72, several surveys were carried out and evaluated. In a survey, the level of knowledge of designers around assessing the environmental performance of buildings and using life cycle assessment (LCA) in the design process to support decisions, as well as the need for further development of principles and tools for a wider use of LCA, were analyzed.

This background report focuses on the topic of applied LCA in the design process. In most cases, the surveys were carried out with the support of the national and regional architects’ associations in the following countries: Australia (AU), Austria (AU), Canada (CA), China (CN), Czech Republic (CZ), Denmark (DK), Finland (FI), France (FR), Germany (DE), Hungary (HU), India (IN), Italy (IT), The Netherlands (NL), New Zealand (NZ), Norway (NO), Portugal (PT), Slovenia (SI), Spain (ES), Sweden (SE), Switzerland (CH), United Kingdom (UK), United States (US). The response rate among the participating countries varies a lot.

Together with this background report, several papers have been published. A list is part of introduction on page 11.

# Summary

The progress in dealing with the basics of an applied life cycle assessment (LCA) as a prerequisite for quantitative assessments of the environmental performance of buildings and its direct application in the design process is very dynamic on the one hand and shows major differences on the other hand. While some designers already have knowledge of the basics and experience with LCA application, others are taking a wait-and-see attitude for thew moment but are planning to deal with the topic more intensively in the mid-term future. It became clear that the following prerequisites must be met for a wider use of LCA as a tool for assessing environmental performance:

– Demand and reward of such services by clients
– Legal requirements including clear methodological bases
– Quality-assured data and public available data basis
– Quality-assured assessment tools
– Offers for training and further education.

In countries where these conditions exist or are just being created, the use of LCA is increasing significantly. Some of the designers in these regions perform LCA themselves during design (preferred way of working) or commission specialized service providers.

# Table of content

# Abbreviations

| Abbreviations | Meaning |
|---|---|
| **BIM** | Building Information Modelling |
| **EPBD** | Environmental Performance of Buildings Directive |
| **GHG** | Greenhouse Gas Emission |
| **IEA** | International Energy Agency |
| **LCA** | Life Cycle Assessment |

# 1. Introduction

The achievement of goals to reduce operational and embodied environmental impacts in the life cycle of buildings as a contribution to sustainable development is linked to various prerequisites. One of them is the integration of calculation processes, design comparisons and evidence of achievement of the corresponding goals in the design and decision-making processes for new construction and refurbishment projects. This in turn is linked to the fact that the actors involved are aware of the problem and are motivated to devote themselves to this task, as well as are sufficiently qualified and have the necessary means and opportunities.

Developments in recent years and decades have led to the provision of various design and assessment principles, methods and tools. In particular, the use of LCA as an instrument for quantifying and assessing life cycle-based environmental impacts of buildings enables to determine and assess the operational and embodied impacts in context and to influence them in a targeted manner during the design process. In addition, there is the further development of:

– corresponding methods for calculation and assessment, including their harmonization through standardization activities with specific application reference for building products and buildings,
– the provision of data and databases with environmentally relevant information on products and processes on a uniform basis,
– the development of calculation and assessment tools from simple component catalogs to complex software solutions (including BIM).

Reliable databases, clear methods and practical tools are also prerequisites for the introduction of binding life cycle-based environmental requirements for buildings.

Several groups of actors are directly and indirectly involved in the development of goals and requirements of an individual, institutional or legislative nature as well as in the corresponding design and decision-making processes. Thus, it is the task of the state to preserve the natural basis of life in terms of safeguarding future generations. The real estate industry combines securing the future viability of its companies with assuming responsibility for the environment and society, which has corresponding consequences for the formulation of the task for new construction and refurbishment projects and the management of building stocks. Increasingly, environmentally relevant features and properties are included in the valuation and the determination of financing conditions (e.g. TAXONOMY in Europe), which leads to a demand for corresponding information. According to the ideas of the European Commission (draft for the EPBD, 2021), the life cycle GHG emissions should be included as information in the mandatory energy certificate. On the other hand, the industry is increasingly willing to provide the required LCA data for building products of all kinds on a harmonized basis. The need for the exchange of information between actors along the value chain becomes clear.

Ultimately, the first goal is to influence the design of new construction and refurbishment projects in terms of resource conservation and climate protection - as additional requirements in an already complex target system. Calculations using the applied LCA are required, in which information from the quantity determination is linked to lifecycle-based environmental data of building products, services and processes. It is currently being discussed which groups of actors can fulfill these tasks. Sustainability auditors, energy consultants, cost surveyors and other service providers who can take on these tasks are under discussion. They would then have to prepare their results for the designers and be in close contact with them. But which tasks can the designers take on directly and are they adequately prepared for them and are the necessary framework conditions in place? What is the status of preparation for tasks that require the creation of an LCA and to what extent are such tasks already performed?

Answering these questions was the subject of a specific part of a survey prepared by IEA EBC Annex 72 that was carried out in several A72 participating countries and then assessed. Important results are presented here; otherwise, reference is made to the published results and conference papers:

– *Survey results on acceptance and use of Life Cycle Assessment among designers in world regions: IEA EBC Annex 72* (Balouktsi et al., 2022) – conference paper summarizing selected results of the survey
– *Drivers, barriers and development needs for LCA in the Nordic building sector: a survey among professionals* (Rasmussen et al. 2020) - conference paper summarizing selected Danish and Swedish results of the survey
– *Attitude Towards LCA in Hungary and Czechia: Results of a Survey among Building Design Professionals* (Szalay & Lupísek, 2022) - conference paper summarizing selected Hungarian and Czech results of the survey
– *The level of knowledge, use and acceptance of LCA among designers in Germany: A contribution to IEA EBC Annex 72* (Lützkendorf & Balouktsi, 2022) – conference paper summarizing selected results of the full report below
– *Integration of environmental aspects in the design process of buildings - state of knowledge, degree of implementation, proposals for action* (Integration von Umweltaspekten in den Planungsprozess von Gebäuden – Kenntnisstand, Umsetzungsgrad, Handlungsvorschläge) (Lützkendorf et al. 2020) – national report

The results of this survey can be combined with the results of other previous surveys on this topic, also in terms of tracking the progress made in some particular regions (e.g. see Table 1).

**Table 1**: Overview of selected previous surveys concerning the use of LCA in the building sector (Adapted from: Balouktsi et al., 2022)

| Author | Topic | Target group | Geographic scope | No. of respondents |
|---|---|---|---|---|
| **Klingele et al. (2007)** | Environmental aspects and life cycle data in the building design | Architects & planners | Germany | 305 |
| **Sibiude et al. (2014)** | LCA-related needs of building stakeholders to feed back LCA tool developers | AEC community & public policy experts | France | 121 |
| **Han & Srebric (2015)** | Role of LCA in building system design process | Building system designers | US | 96 |
| **Olinzock et al. (2015)** | LCA use in the North American building community | AEC community | US | 250 |
| **Schlanbusch et al. (2016)** | Knowledge gaps and issues in building LCA and the role of BIM, need for collaboration between the Nordic countries | Wide range of stakeholders in the building industry | Nordic countries | 57 |
| **WBCSD (2016)** | Use of life cycle metrics | AEC community | World | 69 |
| **Jusselme et al. (2020)** | LCA at early building design stages | Architects & engineers | Europe | 495 |
| **A72 survey** | Dissemination and status of application of LCA | Architects & engineers | World | 1166 (Europe: 956) |

# 2. Method and Survey Design

This report focuses on the level of acceptance of LCA as useful tools/processes and the status of current application in the daily practice, as well as the identification of barriers/problems/gaps from the practitioner's point of view. To collect the viewpoint of building design professionals and consultants on these aspects in an effective and economical way, Annex 72 conducted an online questionnaire survey using Lime Survey software. The survey was disseminated in 23 countries using different instruments to increase visibility (e.g. mailing lists of association of architects, social networks and newsletters). The survey was also translated in 9 languages. Since the survey was web-based and adapted to the local language where necessary, responses could be effectively collected from a large number of design professionals. A total of 1166 answers were gathered after at least two successive reminders per country from 11/15/2018 and 12/15/2019.

The questionnaire was primarily composed of three types of questions: (a) single-selection multiple-choice questions (b) multiple-selection multiple-choice questions, (c) free textbox questions. Most of the multiple-choice questions also included a textbox where respondents could provide information beyond the pre-defined response categories. The whole survey had four parts, as illustrated in Figure 1, and it started with a welcome page that briefly explains the purpose, structure and duration of the survey, the procedures to be followed as well as that the survey is voluntary and confidential. In overall, the questionnaire survey was comprised of 48 questions. Acknowledging its significant length as a potential reason for abandoning it before its completion, the survey was designed in a flexible way so that participants can choose between a long and a short version.

Once individuals have chosen whether to continue with the short or long version, the first question concerns whether participants consider environmental performance requirements and assessment results in their design decisions. This first branching separates those respondents who are currently applying such assessments (regularly or occasionally) from those who are not. These two groups follow different questions in part A of the survey up to the first questions of part B where a second branching occurs that separates those respondents who also apply LCA from the basic "green designers". Then, all "branches" occurring are directly guided toward the questions in the second half of part B of the survey dealing with the application of BIM. After the completion of Part B of the survey, respondents can clearly be grouped into six groups (see Figure 1), with the most advanced being "BIM-LCA frontrunners", i.e. designers who are currently integrating both LCA and BIM into their decision-making process. The last four parts of the survey (C, D, E & F) are followed by all respondents.

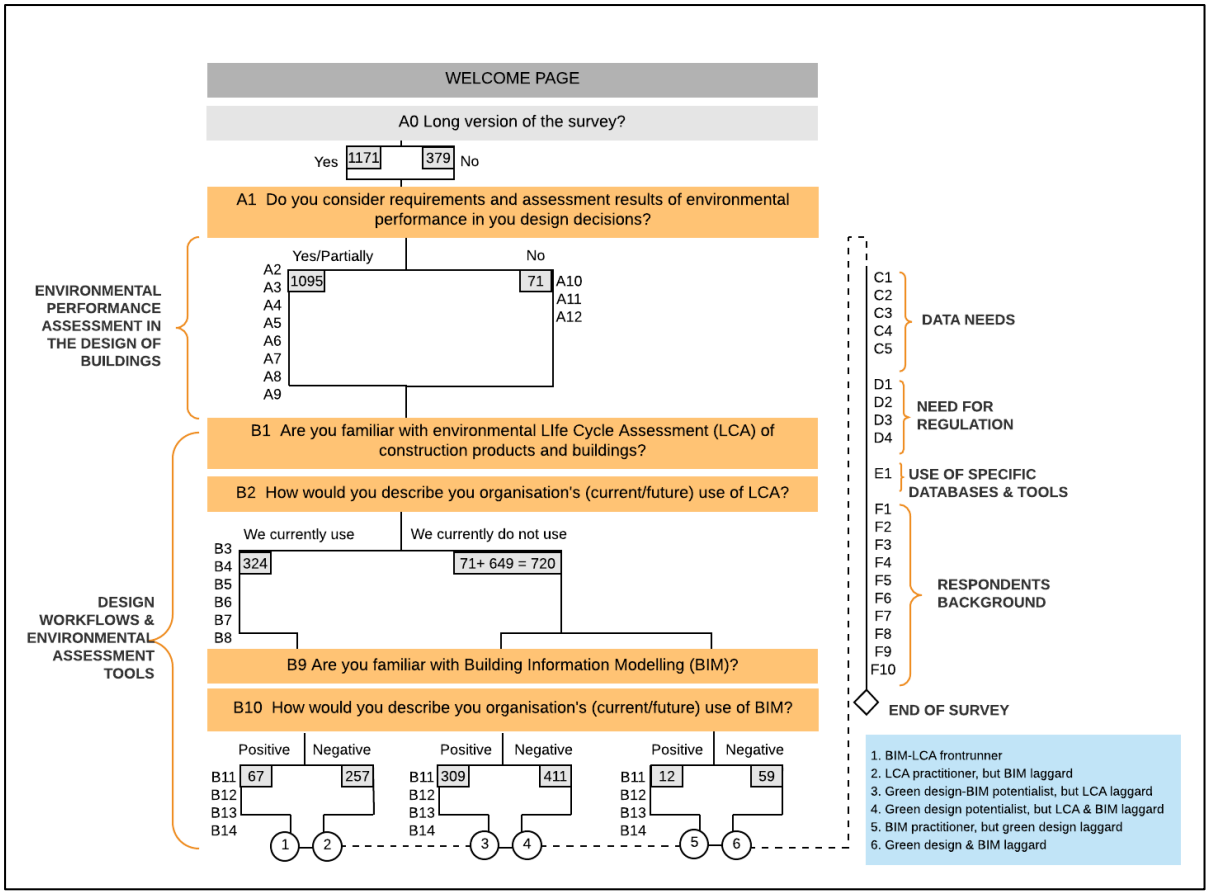


**Figure 1**: Schematic overview of the overall survey. The numbers in the rectangular grey boxes correspond to the number of respondents that followed each critical point of the survey. (Source: Balouktsi et al., 2022)

# 3. Key Results and Recommendations

First of all, it should be stated that the development of projects to reduce or avoid undesired effects on the global environment and the conservation of natural resources is a task of the government in its role as a legislator. In the case of a specific construction project, compliance and implementation is the responsibility of the clients, for whom the law stipulates the minimum requirements, but who also must live up to their responsibility towards the environment and society. Usually, clients are supported by designers. This results in close cooperation, which leads to the determination of design goals in early project phases. In addition to the requirements for technical and functional performance, goals for environmental, social and economic performance should also be defined and agreed upon – the principles for this are already part of the European standards. Environmental impact and resource use reduction thus becomes a design goal. It is therefore natural that these goals must be considered and achieved during design. This results in specific tasks for specific phases or steps of building design - see also report by Passer et al. (2022).

The situation in the individual countries, as well as in a country comparison, proved to be extremely heterogeneous, at least up to the date of responses to the survey. Dealing with life cycle assessment (LCA) tasks in the design was dependent on, among other things (from most important to least important on overage):

– level of demand by client
– the size of the design office/ in-house expertise
– the availability of information/data
– the existing regulations and incentives
– amount of time effort
– the previous training and further education on the subject

Looking at regions individually the significance of each factor changes based on the conditions in place. For example, the answers of DACH region are dominated by participants from Germany, where the availability of information is freely accessible (therefore less participants indicated this as a barrier).

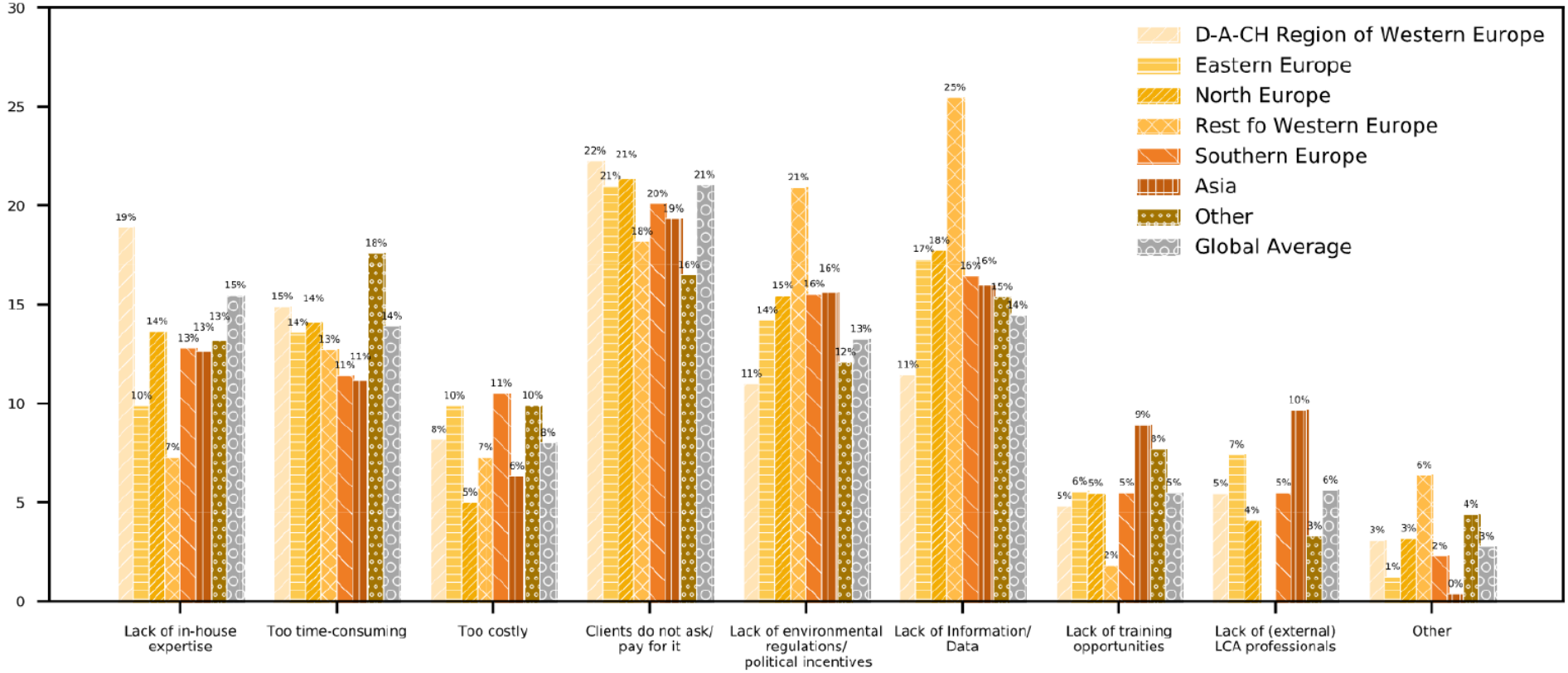


**Figure 2**: Answers to the question "What do you consider the main barriers to using LCA?", including a division into regions. Note 1: based on 1044 respondents; multiple answers allowed; Note 2: The countries representing each region are (order starting with the higher number of respondents): DACH Region = DE + AT + CH, Asia = CN + IN, Southern Europe = ES + PT + IT + SI, Northern Europe = DK + SE + NO + FI, Eastern Europe = HU + CZ, Rest of Western Europe = FR + NL + UK, Other = CA + US + AU + NZ (Source: Balouktsi et al., 2022)

It became clear that there are big differences in:

– **the level of knowledge of the basics and details of an LCA**: The survey showed that many respondents are familiar with the basics of LCA but there is important lack of knowledge about its detailed application (about one third of respondents, see Figure 3).
– **the level of knowledge and application of relevant standards:** although over the last decade, strong support for LCA has been given by both international and European standardization activities, an impressively high number of respondents indicated that, not only they do not refer to international standards in their daily practice (which was expected), but they have not even heard of them (almost 60% of respondents).
– **the level of knowledge and use of existing tools:** Most respondents are not familiar with the different LCA databases and tools. As an average, less than one fourth applies such tools in the daily practice. When it comes to BIM as certain type of instrument gaining in importance in architectural practice, only a small share of respondents reported to currently apply BIM for integrating LCA data, while already one third of respondents use BIM for quantities extraction (see: Balouktsi et al., 2022).
– **the type and scope of personal experience with LCA**: although less than one third of the respondents are currently using LCA in their decision-making on average (Figure 4)[1], this share ranges from more 10% (Asia: CN + IN) to more than 70% (Western Europe: FR + NL + UK). The latter percentage is assumed to be high due to the legal requirements in place in France and the Netherlands (Lützkendorf, & Balouktsi, 2022). Positively, more than half of respondents are planning to use LCA in the medium-term future, on average.

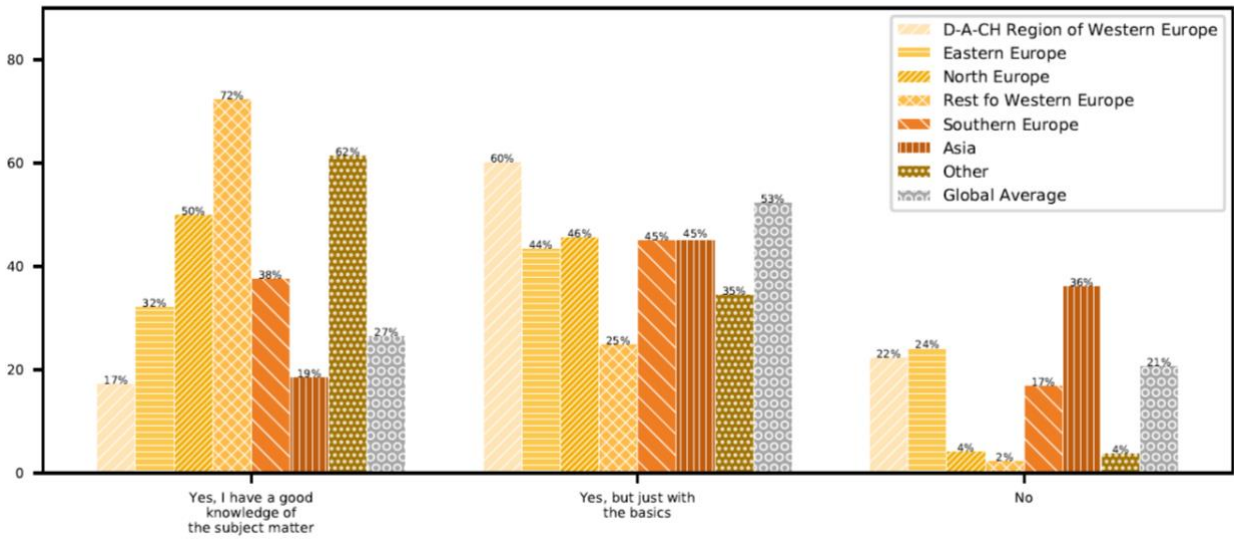


**Figure 3**: Answers to the question "Are you familiar with environmental Life Cycle Assessment (LCA) of construction products and buildings?", including a division into regions. Note 1: based on 720 respondents; Note 2: The countries representing each region are (order starting with the higher number of respondents): DACH Region = DE + AT + CH, Asia = CN + IN, Southern Europe = ES + PT + IT + SI, Northern Europe = DK + SE + NO + FI, Eastern Europe = HU + CZ, Rest of Western Europe = FR + NL + UK, Other = CA + US + AU + NZ (Source: Balouktsi et al., 2022)

[1] It should be noted that the average share of designers regularly using LCA is influenced by the sample: DACH has by far the most respondents and a larger share of designers (after Asia) with no or little knowledge on LCA.

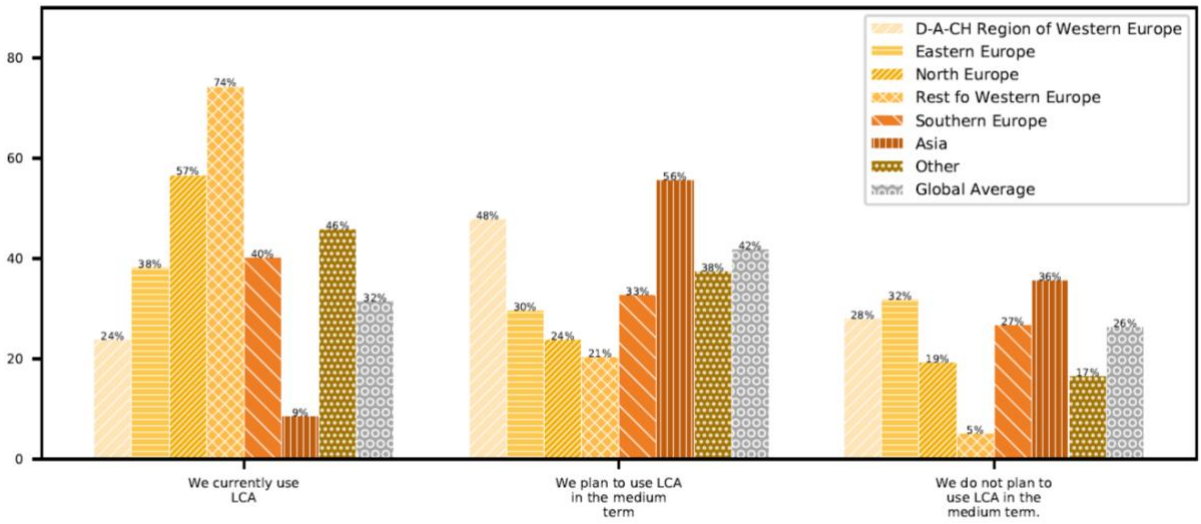


**Figure 4**: Answers to the question “How would you describe your organisation's (future) use of LCA?”, including a division into regions. Note 1: based on 720 respondents; Note 2: The countries representing each region are (order starting with the higher number of respondents): DACH Region = DE + AT + CH, Asia = CN + IN, Southern Europe = ES + PT + IT + SI, Northern Europe = DK + SE + NO + FI, Eastern Europe = HU + CZ, Rest of Western Europe = FR + NL + UK, Other = CA + US + AU + NZ (Source: Balouktsi et al., 2022)

As a result, some of the designers are already preparing LCA and others are preparing to be able to offer this in the near future. Another part of the respondents would like to subcontract such tasks. Only a small proportion of designers do not want to get involved in this area of responsibility in the medium term.

In particular, the - planned or already implemented - introduction of relevant funding programs and/or legal requirements means that the demand for corresponding expertise and authorization is growing rapidly. Requirement values will be tightened to such an extent that subsequent calculations by experts will not suffice. The need for design-accompanying use is therefore once again pointed out.

The situation will improve in the medium term. Comparable to the tasks involved in determining costs, reference values and experiences emerge that will make the designer's work easier until they can fall back on knowledge they have gained themselves.

The tasks of the designers are seen, among other things, in:

– If assessment of existing buildings with regard to energy consumption, emissions, convertibility, refurbishability
– Advising clients on finding and setting goals, advising on legal requirements and funding programs
– Creation of LCAs as part of design in the context of building and component optimization and to support variant comparisons
– Creation of evidence that the client makes available to third parties (including building supervision, bank, valuation professionals)

The following recommendations can be given for the expansion of possibilities for the design-accompanying use of the applied LCA:

– Integration of the determination, assessment and targeted influencing of the environmental impacts of buildings as well as the provision of the required evidence in the service profile of the building design with instructions for individual work phases - see the related work by Royal Institute of British Architects (RIBA)[2], among others.
– Assignment by the client and appropriate remuneration including the provision of time and fee funds for variant comparisons
– Legal requirements to limit the use of resources and the undesirable effects on the environment in the life cycle of buildings; if necessary, it is recommended to start by including binding requirements in funding programs (package of methods, databases, calculation and verification rules) – e.g. this has been the most recent approach in Germany[3].
– Provision of easily accessible and generally recognised/tested calculation values/databases for the creation of life cycle assessments, such as the German database Ökobau.dat and the Swiss databases KBOB.
– Provision of practical design and assessment tools of varying complexity (software, component catalogues)
– Offers for training and further education
– Expansion of the range of services offered by specialist designers, consultants and life cycle assessment experts

Note: This summary includes insights that were gained up to early 2020. Attention is drawn to the high dynamics of the development of this topic.

[2] For details, see: https://www.architecture.com/knowledge-and-resources/resources-landing-page/riba-plan-of-work, as well as, https://riba-prd-assets.azureedge.net/-/media/GatherContent/Test-resources-page/Additional-Documents/RIBASustainableOutcomesGuide2019pdf.pdf?rev=5013ea18b10949f1af0a14cb439fcb32

[3] E.g. see information on the QNG label (only in German): https://www.nachhaltigesbauen.de/austausch/beg/

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