Survey results on acceptance and use of Life Cycle Assessment among designers in world regions: IEA EBC Annex 72

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Abstract. Design practitioners' knowledge about Life Cycle Assessment (LCA) is crucial for the necessary decarbonisation of the built environment as well as the mitigation of other negative environmental impacts. Designers' attitudes towards LCA have so far been rarely analysed. In 2019, as part of the project IEA EBC Annex 72 "Assessing life cycle related environmental impacts caused by buildings", a global survey was conducted amongst design professionals within 23 countries. The aim was to investigate the level of awareness and acceptance of environmental performance assessment and LCA of buildings, the use of related information sources and tools as well as the application of Building Information Modelling (BIM) in connection to LCA. The results show that less than one third of designers currently provides or uses LCA services. The ones who do not are mainly constrained by the lack of client demand. To support an increased use of LCA during building design, not only it is necessary to provide related data and design/assessment tools, but also to establish standards/regulations to drive client demand. It is particularly relevant to include such requirements already in the client's brief. In future, an increased demand for building LCA results by institutional investors is expected.

1. Introduction

Considering the full life cycle impacts of buildings is crucial for the necessary decarbonisation of this sector, while also mitigating other negative environmental impacts. Over the last decade, several developments have occurred towards promotion of Life Cycle Assessment (LCA) into the building sector. That is: (1) a rapidly growing academic research (and consequently literature) exploring the environmental impacts of buildings on the basis of in-depth case studies and the use of LCA [1-3]; (2) the publication of life cycle-oriented international and European standards – i.e. within ISO/TC 59/SC 17 and CEN TC 350 groups respectively – to assess the environmental performance of buildings; (3) a new stream of various publications by professional associations in the form of guidelines addressed to specific building-industry stakeholder groups attempting to interpret the standards and partially facilitate the practical application of LCA (or specific life cycle indicators) [4]; (4) the application of LCA in building certification schemes (e.g. BREEAM, BNB, DGNB, Minergie-eco etc.) in order to quantify and communicate buildings' environmental impacts [5]; (5) national plans in some European countries to incorporate mandatory requirements on carbon footprint of buildings into their legislative framework, such as Finland [6].

In parallel to the wide acknowledgement of the importance of using LCA already in the early design stages, building information modelling (BIM) has emerged as an effective platform/tool for overcoming some of the difficulties of acquiring the necessary building data in those stages [7,8]. Nevertheless, it is still questionable whether the increasing interest of architecture, engineering and construction (AEC) industry in LCA is currently translated into real LCA practice. Design practitioners' attitudes towards LCA have so far been rarely analysed, especially from a global viewpoint. The same applies to designers' attitudes towards BIM and its role in connection to LCA. To this end, in 2019, as part of the ongoing project IEA EBC Annex 72 "Assessing life cycle related environmental impacts caused by buildings", a global survey was conducted amongst design professionals within 23 countries. The aim was to investigate the level of awareness and acceptance of environmental performance assessment and LCA-method/approach of buildings, the use of related information sources and tools as well as the application of Building Information Modelling (BIM) in connection to LCA. To the authors' knowledge, this is the last decade's largest global survey on this topic. This also becomes evident in Table 1. In the following, selected results of the Annex 72 survey are presented, while a full analysis of the survey will be published after the completion of the project (http://annex72.iea-ebc.org/). A special evaluation of the situation in Germany is available in [9].

Table 1. Overview of last decade's surveys concerning the use of LCA in the building sector.

Author	Topic	Target group	Geographic scope	No. of respondents
Sibiude et al. 2014 [10]	LCA-related needs of building stakeholders to feed back LCA tool developers	AEC community & public policy experts	France	121
Han & Srebric 2015 [11]	Role of LCA in building system design process	Building system designers	US	96
Olinzock et al. 2015 [12]	LCA use in the North American building community	AEC community	US	250
Schlanbusch et al. 2016 [8]	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 [13]	Use of life cycle metrics	AEC community	World	69
Jusselme et al 2020 [14]	LCA at early building design stages	Architects & engineers	Europe	495
Annex 72 survey (present paper)	Dissemination and status of application of LCA	Architects & engineers	World	1166 (Europe: 956)

2. Method and survey design

In this paper, the focus is 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 (compared to previous surveys as shown in Table 1). 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 were semi-closed, since they 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 (see Figure 1).

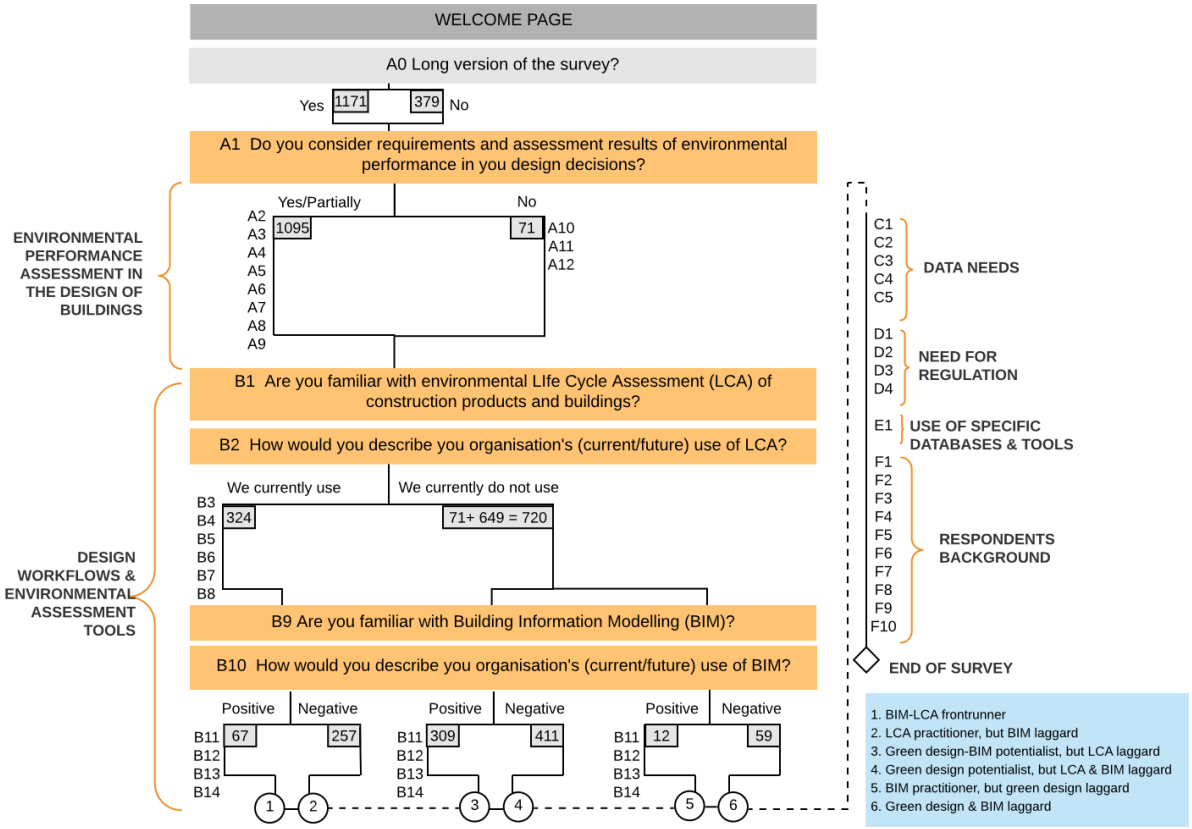

Figure 1. Schematic overview of the overall survey. The numbers in the rectangular grey boxes correspond to the number of respondents that followed each critical point of the survey.

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.

Due to the limited space in this paper, only selected questions are analysed, that is: (1) Question A1, as shown in Figure 1 (2) With which typical environmental indicators are you familiar, and which ones do you already apply in your design decisions? (3) Question B2, as shown in Figure 1 (4) What are the barriers to using LCA; (5) Question B10, as shown in Figure 1 (6) Do you use BIM model's capability to integrate LCA-related information? (7) From your point of view, should life cycle-related requirements be defined/introduced into building codes and laws in future, if not already the case? (8) Do you use related international standards (e.g. ISO 21929-1:2011 and ISO 21931-1:2010)?

3. Survey Results

3.1. Profile of respondents

More than 80% of the survey participants were located in Europe, with the overwhelming majority of them coming from the DACH region, i.e. Germany, Austria and Switzerland (see Figure 2). Furthermore, most of them belonged to the targeted population of architects (79%) and civil engineers (10%) (the shares of other professional groups were unimportant). However, the sample cannot be considered as statistical representative of the global architectural population both in terms of its small size and its geographical constitution. The present authors assume that that respondents at least represent the innovative part of the group of architects and civil engineers.

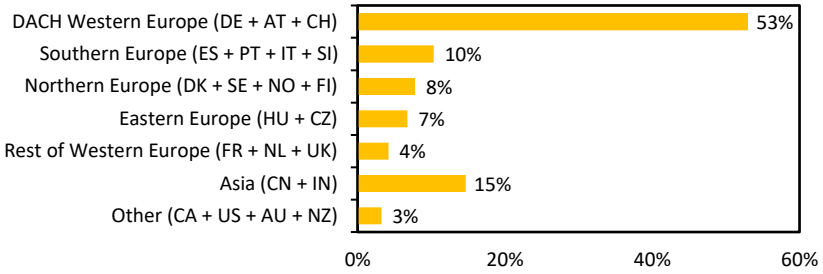

Figure 1. Share of respondents per world region, incl. the countries representing each region (country codes according to ISO 3166-1).

3.2. Trends in application of environmental performance assessment in the design of buildings

Figure 2 shows that architects and other stakeholders generally take environmental aspects into account (usually more than 90%), but some only under certain conditions. It can therefore be assumed that (almost) all of them are familiar with the topic. Asia is the only region where the number of respondents who consider such assessments under certain preconditions, i.e. “only for high-end projects”, “only when the client demands it…” and “only in combination with a label…”, exceeds the number of respondents who regularly consider environmental aspects (41%). In all regions without exception client demand is the most important driver for considering environmental aspects for those respondents who do not regularly do this.

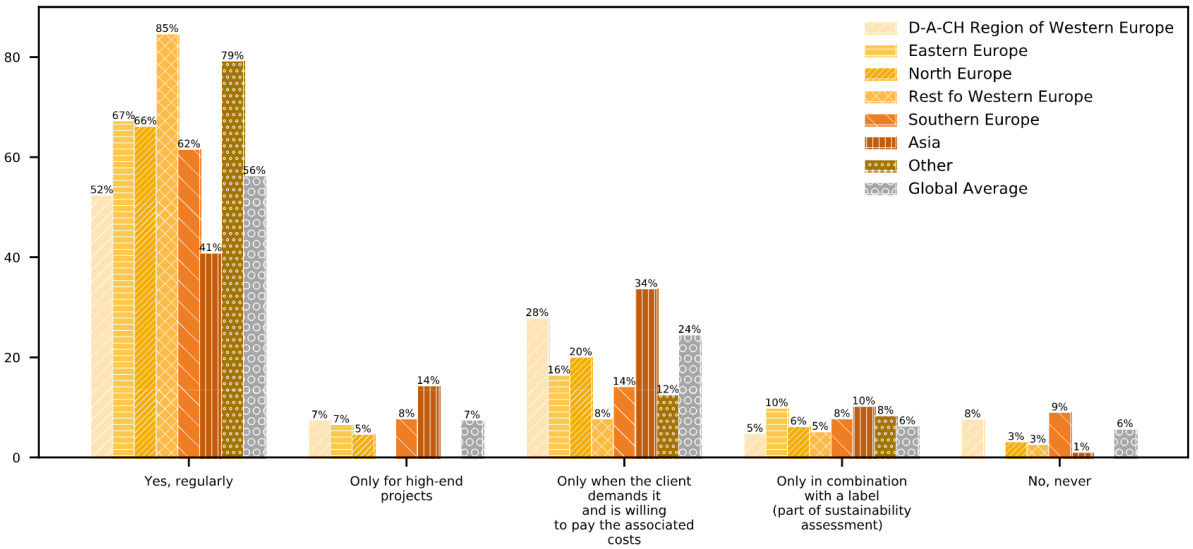

Figure 2. Current status of application of environmental performance assessments of buildings around the world, including a division into regions (based on 1166 respondents).

However, a comparison of the level of usage of selected typical environmental quantitative indicators shows that, broadly, while most respondents (61-65%) are applying indicators quantifying operational energy, only about one fourth of them follows a life cycle approach in their assessments and also apply indicators to quantify embodied energy and emissions (Figure 3). The prominent reason why respondents do not use indicators for assessing embodied impacts is lack of knowledge about their application (30-37%) and not so much their non-familiarity with the concept itself (10-13%). A second insight is that the percentages of use of operational GHG emissions as an indicator (37%) is lower by nearly 25%-points than the one of operational energy demand, non-renewable. It is worth noting that there are important deviations among some regions in relation to this question. Especially in Asia, it seems that such assessments have still a more qualitative direction; the share of respondents who are currently assessing operational energy demand, non-renewable (27%) and renewable (35%), are almost half compared to the average.

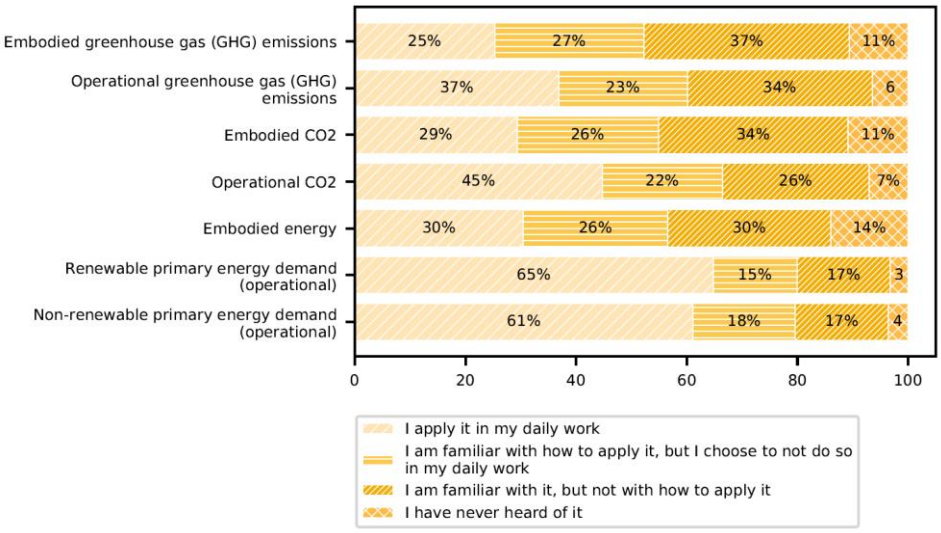

Figure 3. Average percentage of familiarity and application of different typical environmental indicators in the world (based on 1132 to 1166 respondents, depending on the indicator).

3.3. Trends in application of LCA in the design of buildings

The survey showed that although less than one third of the respondents (31%) are currently using LCA in their decision-making, almost half of respondents (42%) is planning to use LCA in future (Table 2). 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.

Table 2. Status of use of LCA around the world (based on 1044 respondents, single answer only).

Answers	Northern Europe	Eastern Europe	DACH Region	Western Europe	Southern Europe	Asia	Other	TOTAL (Avg)
We currently use LCA	57%	39%	24%	77%	37%	10%	45%	31%
We plan to use LCA (medium term)	24%	30%	48%	18%	37%	48%	41%	42%
We do not plan to use LCA (medium term)	19%	31%	28%	5%	26%	42%	14%	27%

The top three barriers to using LCA identified for most regions are lack of client demand (20%), lack of in-house expertise (15%) and lack of information/data (14%), as shown in Figure 4. Especially, the first one has been consistently reported among the top 3 by all regions. DACH region somewhat differs in its top three barriers from the other regions, as the client influence is followed by the lack of in-house expertise (18%) and the considerable time effort (15%) in popularity. Most likely, this result has to do

with the fact that 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), as well as there are many small architecture offices that typically do not have their own LCA practitioner.

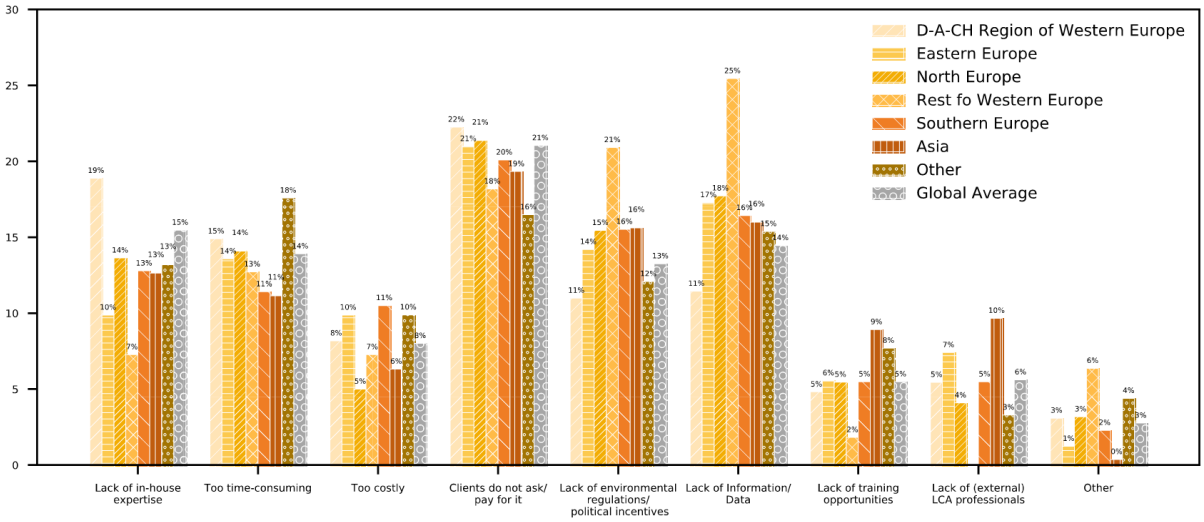

Figure 4. Barriers to using LCA, including a division into regions (based on 1044 respondents; multiple answers allowed).

3.4. Trends in application of BIM in the design of buildings

Regarding the current application of BIM as well as the related future trend, more than half of the respondents stated to have experience in applying BIM in practice, either because 'BIM is the standard method for planning and sharing data' (26%) or because participants have been involved 'in several BIM driven projects' (27%). A substantial number of respondents plan to start using BIM in the 'medium term' (32%), while only 15% of them 'do not plan to use BIM in the medium term'.

To analyse the potentials of integrating LCA in the design process through coupling it with BIM-based design workflows in more detail, A72 also asked respondents about their currently utilized BIM functionalities. Table 3 shows partial results only for the functionalities related to building LCA applications. Looking at the global average, only 9% of respondents reported to currently apply BIM for integrating LCA data, while already one third of respondents use BIM for quantities extraction (36%). Northern Europe is shown separately from the rest of Europe as its results for the latter significantly deviates from the other regions in Europe.

Table 3. Currently applied BIM functionalities that are useful for building LCA applications as reported by respondents (based on 721 to 747 respondents, single answer only).

	Northern Europe	Europe (rest)	Asia	Other	TOTAL (Avg)		
BIM functionalities	**We do already**	**We do already**	**We do already**	**We do already**	**We do already**	**We plan to**	**We do not plan to**
Life Cycle Assessment (LCA) data	11%	9%	19%	24%	9%	50%	41%
Quantities of construction materials and elements	74%	35%	33%	41%	37%	43%	20%

With respect to the respondents' intention to integrate such information in the future, half of them indicated that they do plan to use BIM (50%). This clearly signifies that the integration of LCA in BIM can be a way to introduce LCA to design practitioners and allow them to perform such analyses in the background in parallel with traditional design tasks.

3.5. Driving forces and demand for political instruments

Nowadays, the need for legal requirements on life cycle carbon footprint is well acknowledged among design practitioners (Table 4), however, not in all world regions. Surprisingly, DACH region is more concerned with issues related to resource efficiency and de-constructability/recyclability than the latter. The "carbon footprint" approach is therefore less known and widespread than assumed at the moment.

Table 4. Life cycle-related requirements to be defined/introduced into building codes and laws in future as reported by respondents (based on 1044 respondents, multiple answers allowed).

Answers	North Europe	Eastern Europe	DACH Europe	Rest of Western Europe	South Europe	Asia	Other	TOTAL (Avg)
Yes, in relation to life cycle related carbon footprint	67%	53%	33%	79%	61%	50%	67%	59%
Yes, in relation to resource efficiency	53%	45%	44%	58%	58%	49%	39%	49%
Yes, in relation to de-constructability/ recyclability	48%	53%	55%	52%	44%	33%	42%	47%
No	2%	12%	21%	0%	2%	4%	3%	6%
Other	9%	4%	3%	6%	3%	2%	6%	5%

As mentioned earlier, over the last decade, strong support for LCA has been given by both international and European standardization activities - e.g. ISO/TC 59/SC 17 and CEN TC 350. The IEA EBC Annex 72 survey also asked respondents to indicate whether they are aware of the ISO/TC 59/SC 17 standards (in addition to ISO 14040) and whether they apply them. Considering that only 32% of respondents currently use LCA, the low percentages of respondents using all these standards was expected. Impressively high is the number of respondents indicating that, not only they do not refer to international standards in their daily practice, but they have not even heard of them (almost 60%).

Table 5. Current status of use of international standards. Note that percentages represent the global average (based on 1044 respondents).

Answers	Yes	No	Unknown to me
Do you use ISO 15392 and ISO 21929 "Sustainability in building construction…"?	10%	34%	56%
Do you use ISO 21931 "Sustainability in building construction: Framework for…"?	7%	34%	59%
Do you use ISO 16745 "Sustainability in buildings and civil engineering works: Carbon metric…"?	7%	34%	59%
Do you use ISO 14040 "Environmental management: Life cycle assessment…"?	15%	32%	53%

4. Discussion and Conclusions

Lack of legislation leads to lack of clients' requests for LCA results, lack of clients' requests avoids building LCA expertise and knowledge and hinders the development of efficient assessment processes. Hence, momentum is created with legal requirements put in place within the next five years as stated in the Graz Declaration [15] as well as during the 71st LCA forum on environmental benchmarks for buildings [6]. In addition to legal requirements, an increased demand for building LCA results by institutional investors (e.g. banks) is also expected in the future. In the meantime, design professionals and consultants need to get prepared for such a task. However, to this end, it should not be assumed that all designers should become familiar with the methodological principles of LCA in detail. Rather, good knowledge on relevant indicators, ability to interpret the calculation results on impact categories as produced by different tools and a good understanding on how design decisions influence the assessment results are sufficient. Questions of how to best apply LCA should also form part of the official education and training of design professionals around the world, including their integration into university curricula. As part of the latter, references to standards such as ISO 14040 are less helpful than training

on how to use specific design tools and databases. The use of BIM solutions with integrated LCA offers a promising approach. Finally, the achievement of a decarbonized build environment as the ultimate goal is also influenced by qualifying designers and by providing the necessary basics, data and tools.

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