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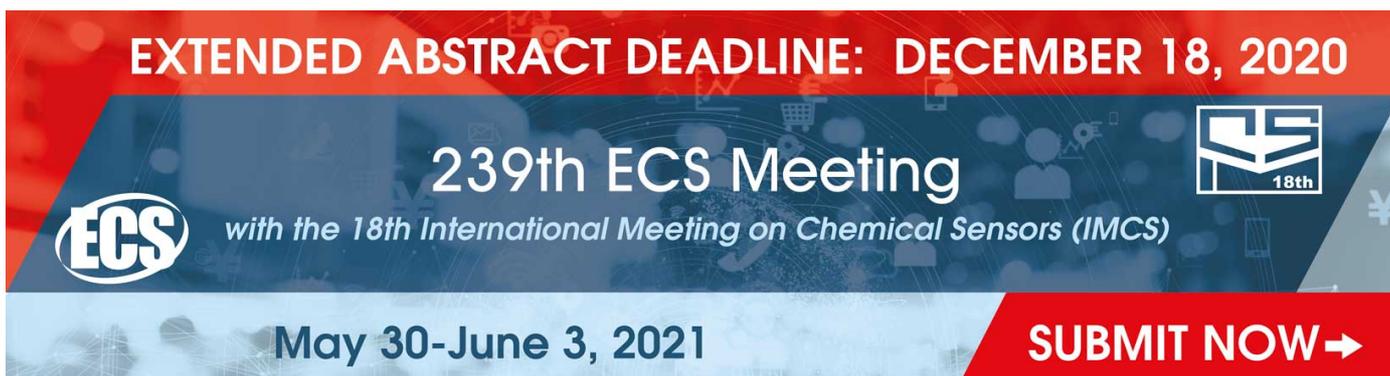
The level of knowledge, use and acceptance of LCA among designers in Germany: A contribution to IEA EBC Annex 72

T Lützkendorf[1] and M Balouktsi[1]

[1]Centre for Real Estate, Karlsruhe Institute of Technology, Germany

thomas.luetzkendorf@kit.edu

Abstract. Architects and engineers have become more concerned about the environmental consequences of their design solutions. Knowledge about Life Cycle Assessment (LCA) is crucial for the necessary building sector decarbonisation, as well as for mitigating other negative environmental impacts. In Germany, designers' attitudes towards LCA have not been analysed since 2005. However, since then, certain developments – such as the establishment of the sustainability assessment systems BNB and DGNB – have taken place. In 2019, as part of the project IEA EBC Annex 72, a survey was conducted amongst designers in Germany. The paper presents the current status to identify the progress being made since 2005 and provides recommendations to overcome barriers to LCA dissemination. The results show that although German designers are currently doing a lot with regard to environmental performance assessment, the most critical aspects are considered in a more qualitative way, except for the mandatory operational energy performance calculations. LCA-know-how and application still lags behind expectation. To support an increased use of LCA during building design, not only the provision of related data and design/assessment tools is necessary, but also the establishment of standards and regulations. The latter will drive the also necessary client demand.

1. Introduction

By adopting the Graz Declaration on Climate Protection in the Building Sector [1], hundreds of scientists and practitioners are calling for the introduction of binding requirements to limit greenhouse gas (GHG) emissions in the life cycle of buildings by 2025. This will make the identification, assessment and management of buildings' life cycle carbon footprint along the design process a common task for all building projects. Prerequisites are the availability of suitable methodological foundations, reliable data, assessment tools and benchmarks. These preconditions are already largely in place for the study area in this paper, i.e. Germany: Ökobau.dat provides freely available LCA data on construction products, the assessment of the GHG emissions in the life cycle has been carried out within the national sustainability assessment systems BNB and DGNB already since 10 years now, as well as there are suitable design tools, including eLCA [2], LEGEP [3] and CAALA [4]. Currently, the development of top-down target values on the basis of national or international climate protection goals is also being discussed [5].

To achieve a transition from considering the sustainability for particular types of buildings to a legally required proof of carbon footprint that must be provided for all projects, further preconditions must be met. To influence the carbon footprint in the design according to specific targets requires its continuous determination and interpretation along the full decision making process. This raises issues about whether design practitioners have a sufficient level of LCA knowledge and are ready to apply it.

The aim of this paper is therefore threefold: 1) to present the current status of the application of the LCA-method among designers in Germany; 2) to identify and analyse the progress being made since a last survey in 2005; 3) to provide recommendations on how to overcome barriers to using LCA during the design process.

2. Method

Within the scope of the works of subtask 1 (ST1) and subtask 2 (ST2) of IEA EBC Annex 72 "Assessing life cycle related environmental impacts caused by buildings" an online survey was launched and disseminated among the members of the 16 regional Chambers of Architects in Germany in 2018/2019 using Lime Survey software. This was made possible with the support of the Federal Chamber of German Architects (Bundesarchitektenkammer - BAK). The survey was primarily based on semi-closed, multiple-choice questions. Where possible, the results of the recent survey are compared to an older survey (2004/2005) [6]. The questionnaire was tested several times before its use and coordinated with the chambers of architects of the federal states. In order to improve the probability of answering the questions, a long version and a short version were developed and offered. The purpose of the questionnaire was not only to assess the status of dissemination and acceptance, but also to give the participants the opportunity to point out still prevailing barriers on the one hand, and necessary conditions to be created on the other hand. In overall, the questionnaire was comprised of 42 questions; due to the space limitations only selected questions are analysed here (see Table 1). Some of the questions were based on the 2004/2005 questionnaire to ensure comparability, other questions were newly included to respond to current issues.

Table 1. Selected questions of the survey among designers in Germany

Topic		Question
I. Application of environmental performance assessment	a)	Do you consider requirements and assessment results of environmental performance in your design decisions?
	b)	With which typical environmental indicators from the list below are you familiar, and which ones do you already apply in your design decisions?
II. Application of LCA	a)	Are you familiar with environmental Life Cycle Assessment (LCA) of construction products and buildings?
	b)	How would you describe your organization's (current/future) use of LCA?
	c)	What are the barriers to using LCA?
III. Application of BIM	a)	How would you describe your organisation's (current/future) use of BIM?
	b)	Do you use BIM model's capability to integrate information on the following aspects?
IV. Driving forces	a)	From your point of view, should life cycle-related requirements in the area of environmental performance be defined /introduced into building codes and laws in future, if not already the case?

3. Selected survey results

A total of 849 individuals clicked the survey link, of which 547 responded to the first question. However, only 15% of respondents (83 out of 547) selected to work through the long version of the questionnaire, of which more than half (46 out of 83) completed the survey in its entirety. In the case of the short version of the questionnaire, the completion rate was higher, with more than 80% of respondents (393 out of 467) completed it to the end. The number of overall responses was somewhat higher than previous similar surveys conducted in Germany [6]. A full survey analysis will be published (together with other reports) after the completion of IEA EBC Annex 72 in 2021. Below, selected results are presented.

3.1. Profile of respondents

In overall, basic background information on respondents to determine their profile allows a better interpretation of the answers. Figure 1 provides a summary of profile of respondents in relation to which

occupation group they belong to, their professional experience length, and their organisation size. Regarding the first one, the overwhelming majority of respondents identified themselves as "architects" (90%). Since the total number of architects in Germany is close to 111.000 [7], the survey respondents represent 0.3% of this number. In respect with the second one, Figure 1 shows that the majority of respondents had more than 20 years' experience (72%). Furthermore, especially younger generations of architects, i.e. professionals having 10 years of experience or less, are underrepresented (6%), although, according to official statistics, this group constitutes 15% of the population of German architects [7]. The same applies to the middle group in the experience spectrum (i.e. 10-20 years' experience) which constituted only one fifth of the sample (21%), while it accounts for more than 30% of the architects' in Germany [7]. This implies that the sample is not statistical representative of the German architectural population both in terms of the small size and the constitution of the sample. The present authors assume that that respondents at least represent a reasonable sample for the innovative part of the professional group.
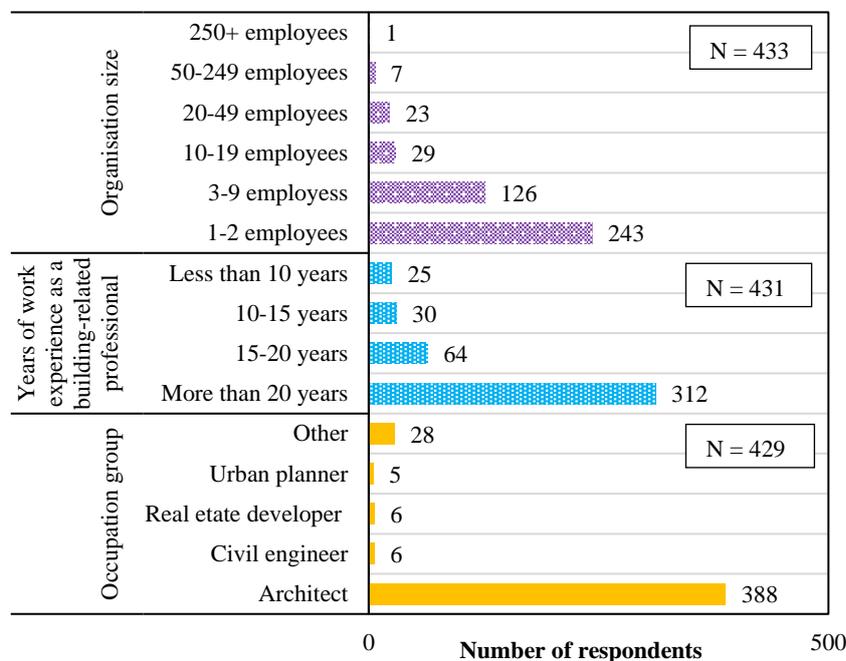
Figure 1. Summary of profile of respondents in relation to which occupation group they belong to, the years of professional experience, and their organisation size (where N = total number of respondents).

In terms of the organisation size, the vast majority of respondents are employed (or employers) at micro-enterprises, i.e. organisations with up to 10 employees (86%). Two thirds of these micro-enterprises are limited partnerships with just one or two employees (57%). The small-enterprises, i.e. enterprises with up to 50 employees, account for the rest (14%), while the share of medium- and large-sized organisations is insignificant (<2%). The survey was therefore mainly answered by architects in small planning offices with long professional experience.

3.2. Trends in application of environmental performance assessment in the design stage
Almost half (49%) of respondents are regularly considering environmental requirements and related assessment results in their decision-making (Figure 2, Question I/a). This indicates a slow but positive development, since this share nearly doubled compared to 2005 (25%) [6]. However, the influence of clients is notable in more than one fourth of the respondents (26%), who only consider such aspects in their design decisions when the client demands it. Interestingly, although energy efficiency regulations exist in Germany, 8% of respondents indicated that environmental performance requirements and assessments never constitute an element of their design decisions. This could be justified by the profile of respondents, since one tenth of them do not belong to the group of architects (see Figure 1).
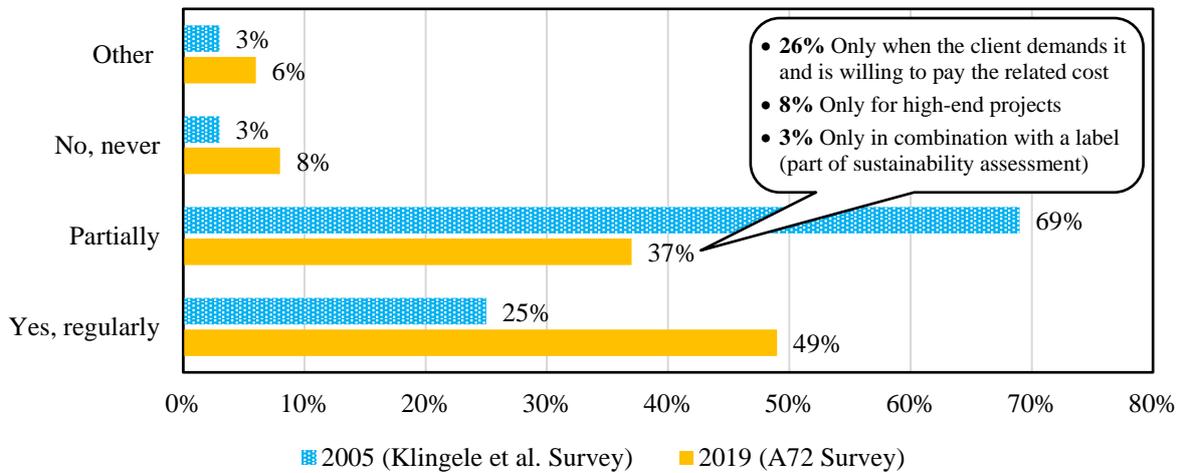
Figure 2. Change in application of environmental performance assessments of buildings in Germany since 2005. (A72 survey: based on 548 respondents; Klingele et al. survey: based on 305 respondents)

A comparison of level of indicator usage shows that 73% of respondents are applying indicators quantifying operational energy (Figure 3, Question I/b).
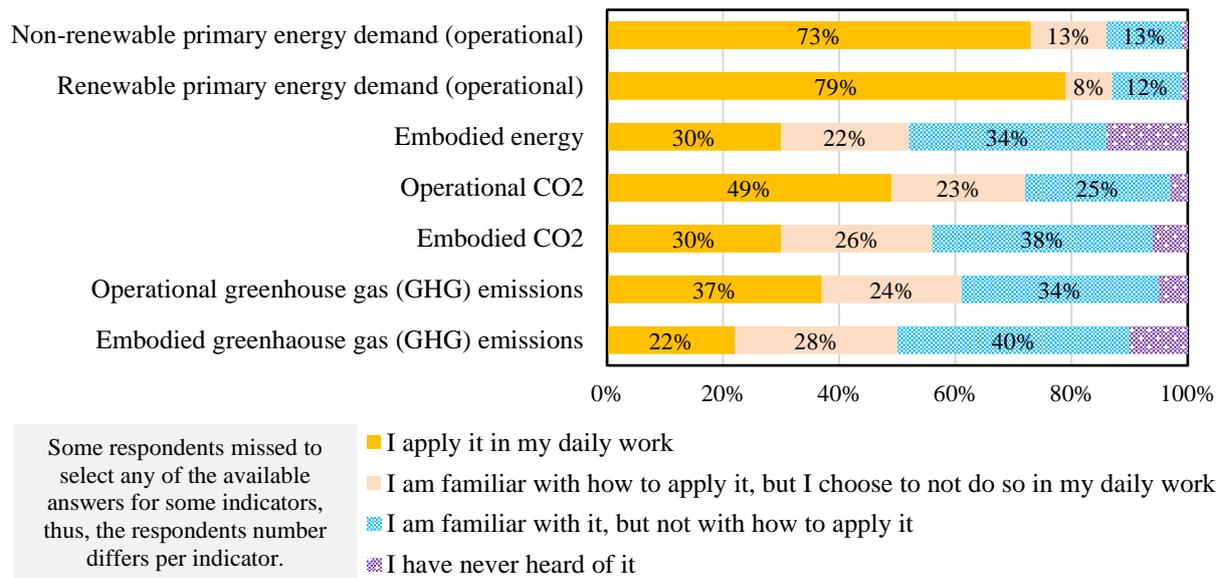
Figure 3. Percentage of current familiarity and application of different typical environmental indicators in Germany according to A72 survey results (based on 409-425 respondents depending on the indicator).

Since Germany has related regulations already since 2002, one would expect an almost 100% percentage. However, the majority of respondents do not use embodied energy indicator, either out of conviction (22%), or lack of knowledge about its application (34%) or non-familiarity with the concept itself (14%). In the case of GHG-related indicators, the percentage of use of operational CO_2 emissions (49%) as an indicator is lower by more than 20% than the one of operational energy demand. Indeed, the determination of CO_2 emissions of buildings has not been required so far. However, the share of respondents using "embodied energy" (29%) is of similar magnitude with the share of respondents using "embodied CO_2 emissions" (29%) and "embodied GHG emissions" (22%), implying that participants following a life cycle approach usually do not restrict themselves to energy indicators.

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

In Germany, a significant rate of LCA-know-how is still not observed among designers (Figure 4, Question II/a). Nearly two thirds of respondents had only basic LCA knowledge (62%). A percentage of 14% of respondents reported having a good LCA knowledge (i.e. being LCA practitioners). Approximately one fourth of respondents indicated having no LCA knowledge at all (24%). However, this marks a significant positive development since 2005, where more than three fourths of respondents (76%) responded negatively to a similar question.

   The survey acknowledges that knowledge does not always equal application – it rather shows possibility. Application presupposes the existence of tools and other means that allow this knowledge to be applied in a practical fashion. Additional results of the survey show that although less than one quarter of the respondents (16%) are currently using LCA in their decision-making – which is a share close to the one representing the respondents with a good knowledge of the subject matter (Figure 4) – more than half of respondents (53%) is planning to use LCA in future (Table 2, Question II/b).
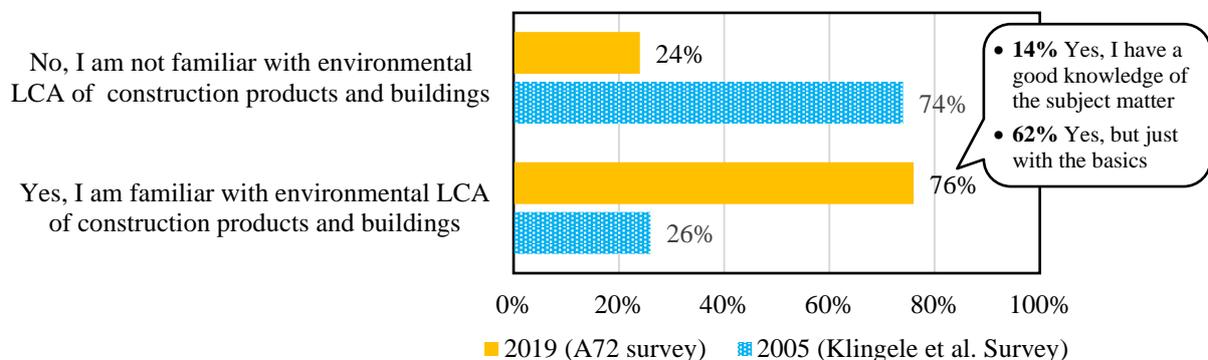
Figure 4. Change in familiarity with environmental LCA of buildings in Germany since 2005 (A72 survey: based on 486 respondents; Klingele et al. survey: based on 300 respondents).

Table 2. Current and potentially future status of LCA application (based on 485 respondents)

Answer	Number of respondents	% of respondents
We currently use LCA	267	16%
We plan to use LCA in the medium tern	199	31%
We do not plan to use LCA in the medium tern	132	53%

In regard to barriers to using LCA, the lack of client demand is the top one, as indicated by nearly two thirds of respondents (66%) (Figure 5, Question II/c). This demonstrates how critical it is to create financial or other incentives (e.g. taxonomy [8]) or establish environmental regulations, since these are factors that drive clients to make investments in environmentally friendly buildings from a life cycle perspective. The lack of in-house expertise was the second top barrier selected by more than half of all respondents (56%). This was expected considering that the majority of respondents represent micro-enterprise of one or two employees (see Figure 1) and do not have themselves a good knowledge of LCA (see Figure 4). This barrier can be overcome by increasing the capacity building and dissemination of LCA among designers through the development and provision of guidelines and training. On top of that, the provision of easy-to-use LCA tools as well as of information on environmental impacts of building products, services and processes can surmount the next two top barriers in the ranking, being the significant time expenditure needed to perform LCA analyses (42%) and the lack of information/data (34%). Significantly less than one third of respondents (28%) indicated lack of environmental regulations and political incentives as a barrier to using LCA. However, legally or politically established minimum performance standards highly affect clients' and building owners' attitudes towards taking on

low impact buildings and requesting LCA results, who, on their side, constitute the main driving force and motivation for designers.
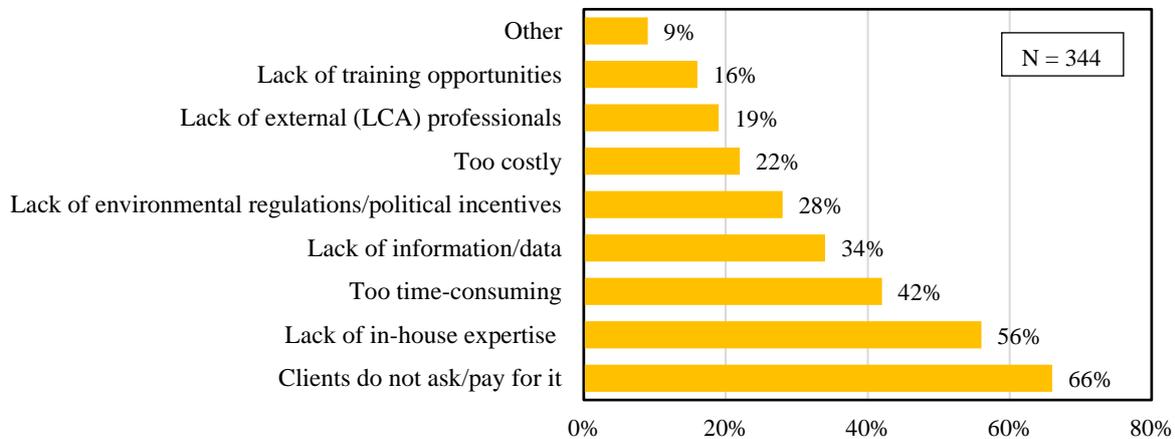
Figure 5. Number of respondents choosing each given barrier to using LCA in Germany (based on 344 respondents). Note: Respondents had the opportunity to select more than one answers, explaining why the values do not add up to 344.

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

In general, in A72 survey, close to two thirds of respondents indicated themselves as being familiar with BIM (65%), among who only a small proportion indicated themselves as BIM-literate (9%). However, from those being familiar with BIM, only 30% of respondents stated to have experience in applying BIM in practice (see Figure 6, Question III/a). This is either as "BIM is the standard method for planning and sharing data" (18%) or because participants have been involved "in several BIM driven projects" (12%). A substantial proportion of respondents plans to start using BIM in the "medium term" (39%), while nearly one third "do not plan to use BIM in the medium term" (31%). The comparison with a related, much larger survey (more than 15.000 participants) conducted in 2017 by the Federal Chamber of German Architects reveals a similar trend in relation to the share of architects planning to use BIM in the medium term [9].
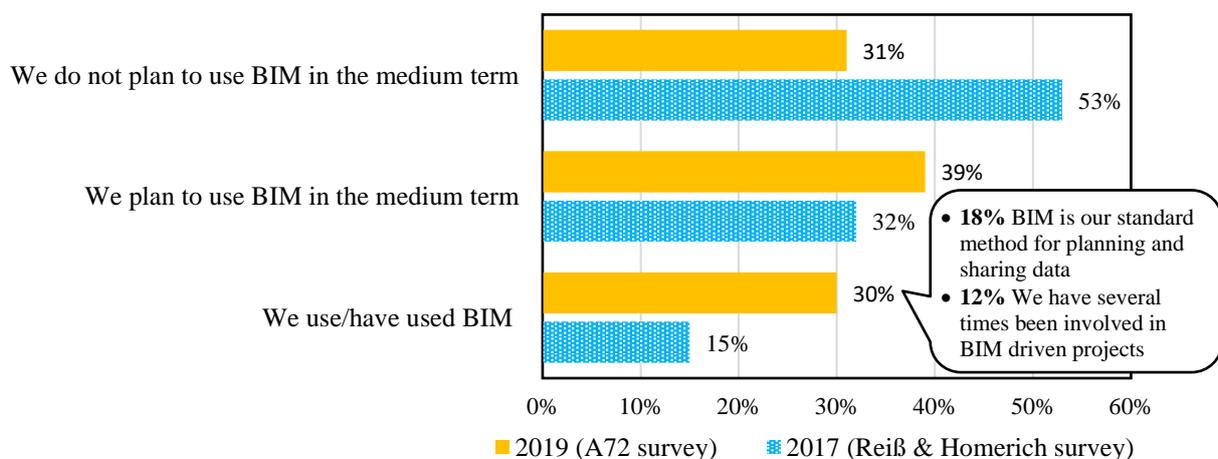
Figure 6. Current (and future) status of application of BIM in Germany (based on 306 respondents) and comparison with the results of a recent but older survey conducted by the Federal Chamber of German Architects (based on 15.206 respondents).

To analyse the potentials of integrating LCA in the design process through coupling it with BIM-based design workflows in more detail, respondents were also asked about their currently utilized BIM functionalities (Question III/b). Figure 7 shows only some selected functionaries included in this question. Currently, only 4% of respondents reported to apply BIM for integrating LCA data, although already nearly one third of respondents use BIM to extract 'Quantities of construction materials and elements" (30%). In respect to respondent's intent to use functionalities or integrate such information in the future, less than half of respondents indicate that they do plan to use BIM for integrating LCA data (42%) and in general environmental impacts of building materials and elements.
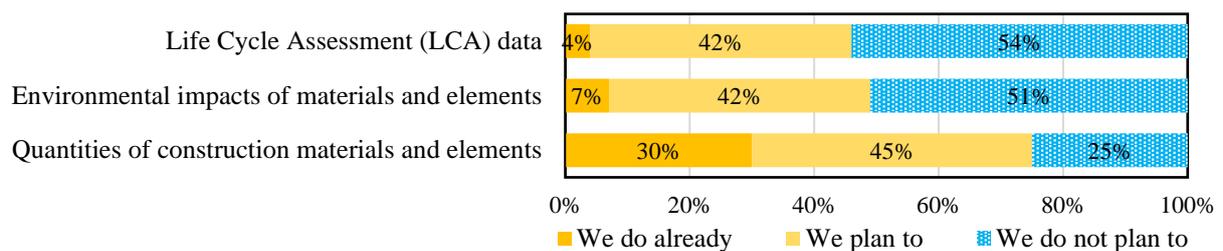
Figure 7. Currently applied BIM functionality reported by respondents (based on 283 respondents).

It becomes clear that the integration of LCA in BIM can be a way to introduce the life cycle analysis to design practitioners and allow them perform such analyses in the background in parallel with traditional design tasks. BIM itself is already prepared for such tasks [10-12].

3.5. Attitude towards the introduction of binding life cycle- related requirements for buildings
It is clear that the participants in the survey are more concerned with issues related to resource efficiency and de-constructability/recyclability than the life cycle carbon footprint of buildings (Table 3, Question IV/a). The "carbon footprint" approach is therefore less known and widespread than assumed at the moment.

Table 3. Number and percentage of respondents choosing each given binding requirement from their perspective (based on 485 respondents).

Answer	Number of respondents	% of respondents
Yes, in relation to de-constructability /recyclability	267	55%
Yes, in relation to resource efficiency	199	41%
Yes, in relation to life cycle carbon footprint	132	27%
No	117	24%
Other	11	2%

Note: Respondents had the opportunity to select more than one answers, explaining why the values do not add up to 485.

4. Discussion and Conclusions
The present authors assume that requirements to limit building's life cycle carbon footprint will be introduced in Germany at least in the medium term. However, as things stand today, this will not happen until 2025. In addition to creating other favorable conditions, this time can be used to prepare designers for such a task. It cannot and does not have to be assumed that all designers should become familiar with the methodological principles of LCA in detail. Rather, it is sufficient if they know relevant indicators, can interpret the calculation results on impact categories as they are produced by different tools and understand how design decisions influence the assessment results. The impetus for the

increased use of LCA must either come from building owners (again inspired by incentives such as green finance) or through binding legal requirements. The education and training of design professionals and consultants should deal more with questions of applied LCA. References to standards such as ISO 14040 are less helpful here than the presentation of specific design tools and databases. The adaptation of the curricula at universities must begin immediately. Considering the large number of small design offices, it must be assumed that in future they will either use third-party services or complex design and assessment tools with integrated LCA. 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.

Acknowledgments

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