The Business Case for the Use of Life Cycle Metrics

in Construction & Real Estate

wbcsd materials

CONTENTS

This report is the product of these progressive WBCSD member companies driving deeper sustainability in the built environment:

Akzo-Nobel, LafargeHolcim, Metsa Group, Saint-Gobain, Skanska, Arcadis (consultant), WBCSD.

1 INTRODUCTION

The World Business Council for Sustainable Development (WBCSD) and member companies active in shaping the built environment are participating in the development of a business solution to mainstream the use of life cycle information in the construction and real estate value chain. The Working Group's objective is to integrate life cycle factors into stakeholder decisions by establishing a common language. Identifying the environmental life cycle metrics that resonate across the entire value chain would enable the definition of this shared language.

Stakeholders at each stage (Figure 1) of the built environment value chain have different priorities and incentives. There is an information break between the Developer/Investor group and the Design & Construction portions of the value chain. Embedded environmental impacts of building material manufacturing and building construction are not typically accounted for in real estate finance. This explains why Developers and Investors do not request this information in project documents from the beginning. It also underpins why the environmental information provided by the Construction team at project turnover often remains filed and unreferenced thereon.
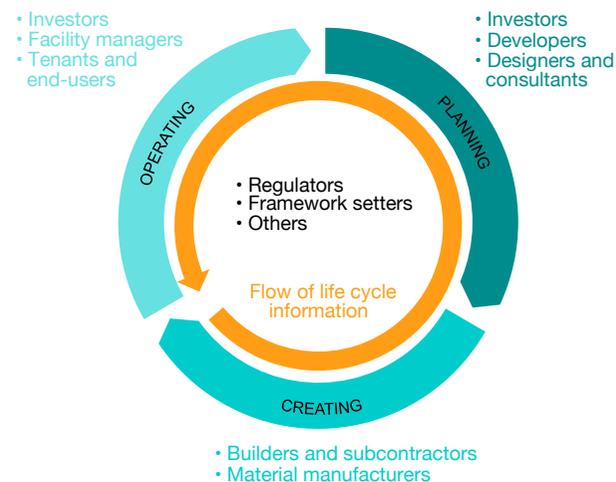
Life cycle assessment (LCA) aims at assessing environmental impacts of a product or service along its entire life cycle (sometimes equivocated with the value chain). As a methodology, several international standards

exist on sustainability in building construction and LCA[1]. However, there are a number of challenges that inhibit mainstream LCA use. Perceived complexity, resource intensity (time and money), lack of quality data and others all serve as significant barriers.

This report outlines the business case to account for environmental life cycle impacts in construction and real estate. The findings and conclusions are a result of an on-line survey and multiple interviews with several key stakeholders. The report presents insight into the following questions:

Figure 1: The design, construction and real estate value chain

- Investors
- Facility managers
- Tenants and end-users

OPERATING

PLANNING

- Investors
- Developers
- Designers and consultants

- Regulators
- Framework setters
- Others

Flow of life cycle information

CREATING

- Builders and subcontractors
- Material manufacturers

1 Which stakeholders of the built environment sector are using environmental life cycle indicators in their decision-making processes today?
2 What environmental life cycle indicators are these stakeholders using?
3 What is the business case for existing environmental life cycle indicators?
4 How have life cycle indicators been adopted into organizational operations?
5 How might stakeholders benefit from accounting for environmental life cycle indicators in their decision-making processes?
6 What are the risks that stakeholders face by not accounting for environmental life cycle indicators?
7 What are the barriers to consistently apply LCA in the decision making processes along the whole real estate value chain?
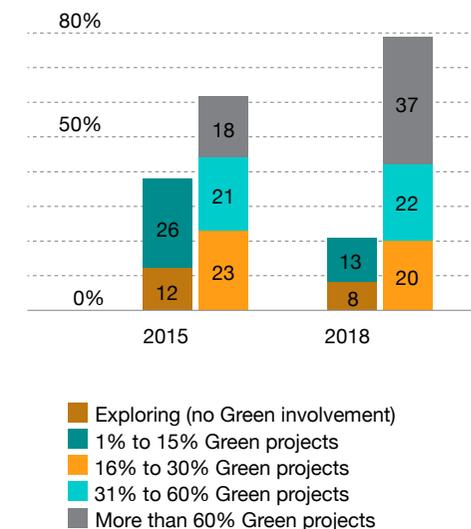
TRENDS IN SUSTAINABLE BUILDING

This section aims at exploring the major trends occurring in the sustainable building field. "Sustainable building" includes the three pillars of sustainable development: economic, social and environmental performances. Each of these dimensions are of equal importance. However, this report focuses on the environmental performance and its two related areas of protection, for ecosystems and resources. "Sustainable building" therefore refers to a construction project in which environmental-preferential design, construction, maintenance features or health and comfort qualities were strategically integrated. The mention of "sustainable building" does not imply any minimum level of performance.

Sustainable building trends cannot be seen on their own. They are part of larger movement towards a more sustainable way of living. Energy efficiency and energy savings were among the first drivers for the development of sustainable building activity, mainly due to financial attractiveness and relatively quick return on investments. Volatile energy prices, development of cost-effective solutions, better understanding of anthropogenic climate change, pending legislation and other factors ultimately lead to a rise of the sustainable building activity, as described in Figure 2 adjacent.

The building sector is one of the most resource consuming sectors in the EU[2]. In the United States alone, the building sector accounts for almost 40% of national CO_2 emissions[3]. Given the magnitude of the sector's environmental impacts, growing public pressure has resulted in rise of industry initiatives (i.e. Architecture2030), and legislation. Local, national, and international regulations are now calling for greater transparency and more accountability in both buildings and construction materials. For example, in France, a draft order includes the obligation for buildings up to 2,000 m[2] (offices, retail and schools) to implement an energy audit and define an action plan targeting a 25% reduction in emission by 2020. In addition, suppliers of construction products (also referred to as "materials" in this report) for the building sector now have to produce Environmental Product Declarations (EPD's).

Global awareness of the urgency to protect the environment and the rise of worldwide events calling for a more sustainable world (i.e. Conferences of Parties, Sustainable Development Goals, etc.) are undeniable. Simultaneously, the discussion of the built environment's environmental impacts has extended beyond solely energy. Greenhouse gas emissions, water consumption, material consumption, health impacts, occupant well-being, and other sustainability metrics have been introduced into the discussion.

Figure 2: Level of Green Building Activity, World Green Building Trends 2016 report, Dodge Data & Analytics, 2016

Legend:
- Exploring (no Green involvement)
- 1% to 15% Green projects
- 16% to 30% Green projects
- 31% to 60% Green projects
- More than 60% Green projects

However, this introduced another level of complexity in evaluating environmental performance. In response to this issue, the European Commission is currently running a consultation on its draft proposals for a common EU framework of core indicators for the sustainability performance of buildings. In parallel, the European Committee for Standardization published CEN/TC 350 "Sustainability of Construction Works", providing a standardized methodology for assessing the sustainability aspects of new and existing construction as well as EPDs for construction products.

Sustainable building rating and certification systems have continued to gain momentum. A wide range of rating and certification systems have emerged in the last decade.

The sustainable building market is moving towards more certified buildings to allow stakeholders to promote and provide verification of the 'green' nature of their projects. However, the emergence of local sustainable building rating systems around the world has resulted in a cacophony of information and data collected, methodologies as well as standards, tools, and databases. A sample of the diversity in the sustainable building instruments commonly referenced is listed in the table below. The evolution of these programs presents an opportunity for the harmonization of methods, data, and reporting.

According to the Whole Building Design Guide (WBGD)[4], an additional trend to be noted over the last several years is the shift away from a prescriptive approach to sustainable design toward the scientific evaluation of environmental impact through Life Cycle Assessments. As rating systems such as LEED, Green Star, BREEAM, DGNB and EDGE reward projects for conducting parts of or entire LCAs, there is also a trend toward requiring life cycle thinking and improving the methods for conducting LCAs. The USGBC graphic (Figure 3) below demonstrates how the LEED program is evolving to incorporate life cycle thinking into their certification program[5].
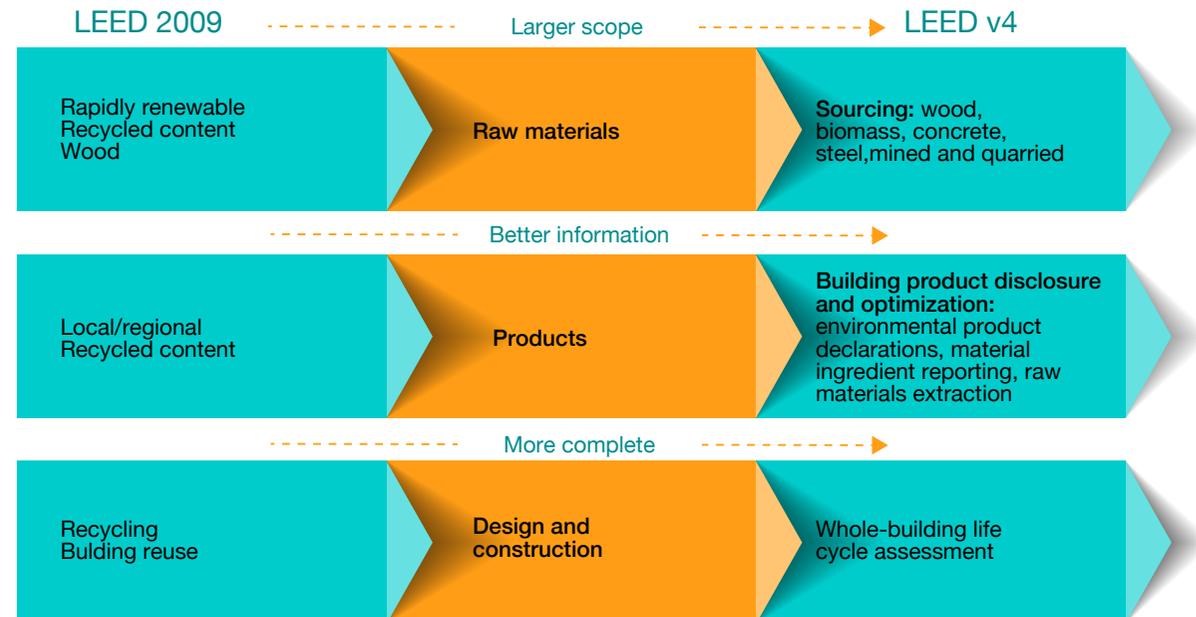
> *The road to sustainability runs through the world's towns and cities. By building sustainable towns and cities, you will build global sustainability."*
>
> Ban Ki Moon Secretary General of the United Nations

> *Green building is a global trend, but its implementation varies widely by country and region, including the pace of growth in green involvement, triggers and obstacles impacting that growth and even the degree of benefits noted by companies.*
>
> World Green Building Trends 2016 report

Table 1: Examples of major instruments currently available on the market

Rating systems	BREEAM, LEED, Living Building Challenges, HQE, EDGE, GRESB, Green Star, WELL Building Standard, DGNB, NZEB, BOMA 360, Green Globes, HERS, National Green Building Standard, BEAM, CASBEE, Pearl Rating System for Estidama, etc.
Standards & Initiatives	AEC Design Transparency, EeBGuide, SBA Common Metrics, the Global Alliance for Buildings and Construction, the Green Building Alliance, CEN/TC 350, Energy Star, Passive House
LCA databases	Quartz Database, Ökobau.dat, INIES, GIGA
Tools	Tally, Athena Impact Estimator, Athena EcoCalculator, ELODIE, EDGE Self-Assessment Tool

Figure 3: Evolution of the LEED program toward life cycle thinking

LEED 2009 — — — — — — Larger scope — — — — — → LEED v4

Rapidly renewable Recycled content Wood → **Raw materials** → **Sourcing:** wood, biomass, concrete, steel, mined and quarried

— — — — — — Better information — — — — — →

Local/regional Recycled content → **Products** → **Building product disclosure and optimization:** environmental product declarations, material ingredient reporting, raw materials extraction

— — — — — — More complete — — — — — →

Recycling Bulding reuse → **Design and construction** → Whole-building life cycle assessment
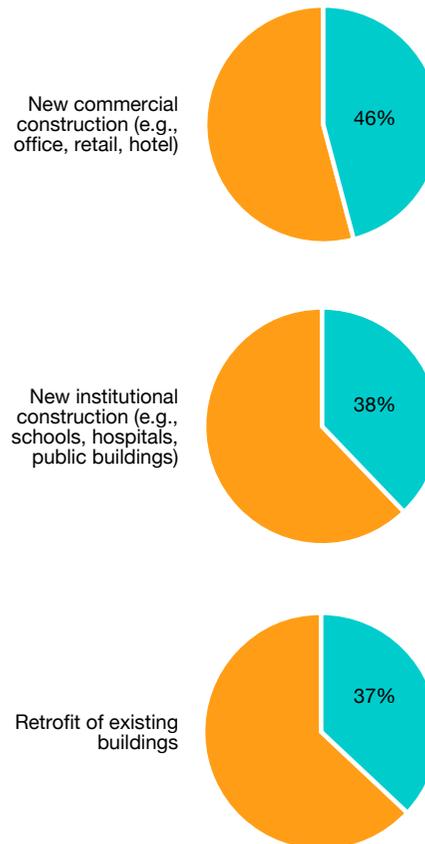
3

Although sustainable building is mature in the US and European markets, strong growth is still expected globally. Much of this growth will take place in developing countries, particularly though new commercial construction. Although much of this growth will take place in developing countries there is also opportunity in developed markets. It has been estimated that less than 0.5% of all buildings in the EU have undergone some kind of assessment beyond energy efficiency (Figure 4).

Sustainable building activity is increasingly adopted by broader environmental and socio-economic issues. The U.N. Sustainable Development Goal (SDG) 11, Sustainable Cities and Communities, calls for the society to make urban settlements "inclusive, safe, resilient, and sustainable". Aspects of sustainable building are also referenced in other SDGs such as SDG 6 "Clean Water and Sanitation", SDG 7 "Affordable and Clean Energy", SDG 9 "Industry, Innovation, and Infrastructure", and SDG 12 "Responsible Consumption and Production". Consequently, sustainable building is increasingly linked to wider issues such as:

• Natural capital accounting and environmental value,
• Circular economy and resource efficiency,
• Green bonds and ESG performance evaluation,
• Carbon emission reporting,
• Well-being and social economic factors.

All of these concepts have something in common: a focus on linking natural resources to financial capital. Financial capital is the status quo for defining value, however with the demands of an expanding and more prosperous global population, natural resources and ecosystems are becoming ever more taxed.

Figure 4: Sectors with planned green activity over the next three years (Dodge Data & Analytics, 2016)

New commercial construction (e.g., office, retail, hotel) — 46%

New institutional construction (e.g., schools, hospitals, public buildings) — 38%

Retrofit of existing buildings — 37%

Emerging economies like Brazil, India, Saudi Arabia and South Africa will be engines of green growth in the next three years, with development varying from twofold to six-fold over current green building levels.

World Green Building Trends 2016 report

The top sector for green building growth globally is commercial construction, with nearly half (46%) of all respondents expecting to do a green commercial project in the next three years. Sectors with planned green activity over the next three years

Dodge Data & Analytics, 2016

EXPLORING THE BUSINESS CASE

This chapter summarizes the results and initial findings of the stakeholder engagement process. Developed in accordance with the trends described above, the study included an online survey that was sent to a large number of stakeholders and multiple case studies based on interviews with key stakeholders across the buildings value chain. More information on the methodology is available in Appendices.

Survey results

Stakeholder engagement

To get a snapshot of which environmental life cycle indicators are used within the real estate sector and why, an online survey was launched and shared across the Working Group's network.

The survey was distributed amongst the building and real estate actors, including: material manufacturers & suppliers, investors, asset owners, designers, builders, developers, facility managers, tenants, consultants, policy representatives, among others. The survey was distributed across multiple organizations and social media platforms, targeting a global audience.
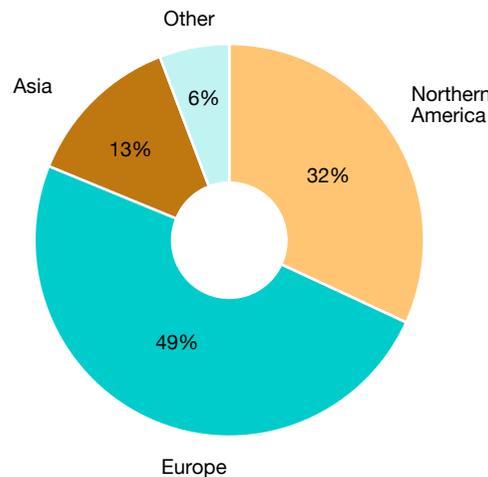
To complement the online survey, individual interviews were conducted with key stakeholders identified early in the project. These interviews not only provided further insight into the survey findings but also served as the basis for the case studies included later in the report.

Panel of respondents

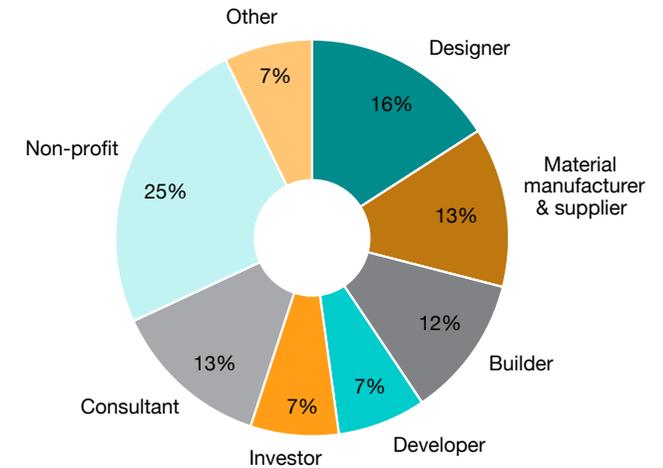The study included a random sample that is not statistically representative of the global real estate sector. The study therefore limits itself to the identification of trends, warranting further investigation. A total of 80 responses were received, of which 69 could be analyzed for the first section of questions. 36 respondents completed the survey in its entirety.

Figure 5: Number of respondents by continent (based on 69 results)

Most respondents to the survey came from Europe (49%), followed by Northern America (32%). Respondents from Asia accounted for 13% of the total. The largest number of respondents by country were from the United States, followed by the United Kingdom, Belgium, the Netherlands and Singapore. Continents from which less than 5 respondents participated were combined in the category 'Other'. This category includes respondents from Argentina, Togo and Colombia.

Figure 6: Number of respondents to the survey by sector (based on 69 results)

The high response rate for designers, material manufacturers and suppliers, consultants and builders is in line with the expectation that these sectors are most familiar with the application of life cycle indicators. The majority of the respondents of the non-profit sector comprises of environmental organizations, which are also more familiar with life cycle indicators.

Two methodological limits should be noted here:

1. The number of interviewees was small;

2. Most survey respondents were familiar with LCA and life cycle thinking, and thus general percentages should not be assumed as representative of the industry.

With regard to industry sectors, most respondents identified themselves as designers (16%) followed by consultants and construction products manufacturers and suppliers (each 13%). The category 'non-profit', which represents the respondents of NGO's, environmental organizations and the public and research sector, accounts for 25% of the total respondents. Sectors that were represented by less than 5 respondents were combined in the category 'Other', which includes responses from facility managers, other sectors and a framework setter (Figure 6).

Survey analysis – Which drivers are referenced for the use of environmental indicator?

Open questions on the drivers were analyzed through coding, a research methodology frequently used in social sciences (see appendix for further details on the methodology).
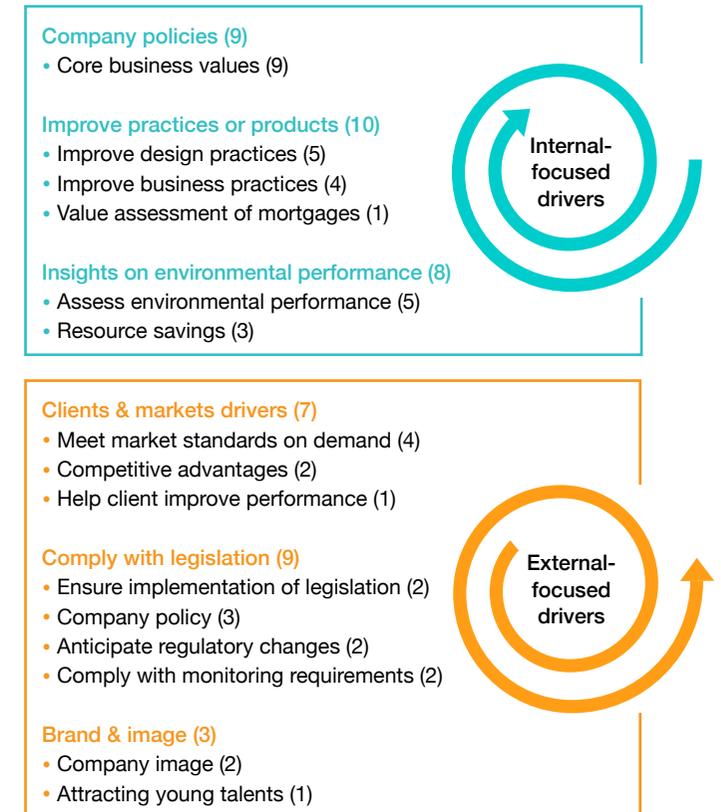
Drivers were grouped into six categories based on expert judgment (see Figure 7).

In addition to the results of the survey, it can be assumed that the demand for building environmental performance assessment results, as well as for environmental and health-related information on construction products, is influenced by:

• Internal reasons: company mission, sustainability reporting, product and process optimization, risk minimization;

• External reasons: reporting requirements and obligations, sustainability assessment of buildings, customer demand, third party demand (e.g. banks), legislation, competitive pressure, standards.

It becomes clear that internal and external reasons are closely linked. Sustainability reporting, for example, can be a reaction to external requirements (reporting requirements/obligations, sustainability rating) as well as a way of actively demonstrating the acceptance of responsibility to society and the environment.

Figure 7: Key drivers for using life cycle indicators (based on the 36 complete surveys)

Company policies (9)
• Core business values (9)

Improve practices or products (10)
• Improve design practices (5)
• Improve business practices (4)
• Value assessment of mortgages (1)

Insights on environmental performance (8)
• Assess environmental performance (5)
• Resource savings (3)

Internal-focused drivers

Clients & markets drivers (7)
• Meet market standards on demand (4)
• Competitive advantages (2)
• Help client improve performance (1)

Comply with legislation (9)
• Ensure implementation of legislation (2)
• Company policy (3)
• Anticipate regulatory changes (2)
• Comply with monitoring requirements (2)

Brand & image (3)
• Company image (2)
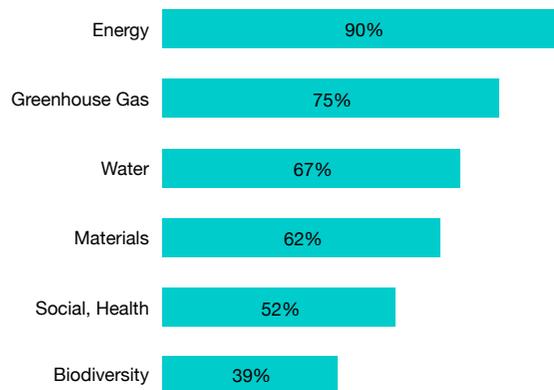• Attracting young talents (1)

External-focused drivers

Respondents had the opportunity to select more than one driver, explaining why the total number of drivers mentioned is equal to 46.

Survey analysis – Which categories of indicators matter for building and real estate actors?

The results of the survey show a clear distinction between the use of the different categories of life cycle indicators. Energy and greenhouse gas emissions are the most applied indicators categories, at 90% and 75% respectively. These two categories are closely followed by water (67%) and materials (62%). The results also showed that the biodiversity category is least familiar. This is likely due to the uncertainty around biodiversity metrics and measurement today. Indicators related to social impact and health/well-being are used by around half of the respondents. This is less surprising given the growing trend in sustainable building of health and well-being, as demonstrated in WELL Certification and the Living Building Challenge (Figure 8).

This strong distinction of the different categories of indicators remains visible once the results are split up per continent, although the balance between the categories changes. Respondents from Europe demonstrate a high familiarity with the use of life cycle indicators. They are closely followed by Northern America and Asia, respectively. Europe and Northern America show the strongest results for energy and greenhouse gas emissions. However, respondents from Asia appear to be most concerned with the application of energy and water related indicators. This difference can be attributed to the varying environmental priorities that these continents face. Another noteworthy observation is the high use rate (74%) of social and health indicators in Europe, more than doubling North America's rate (Figure 9).

This analysis also shows a strong distinction between the familiarity with life cycle indicators across different stakeholder groups.

Manufacturers & suppliers – This stakeholder group comes out as the strongest user group for life cycle indicators. They always have the highest percentage of use for each indicator categories compared to other stakeholder groups. Their results show a strong score for all energy, greenhouse gas, water, and material indicators (100%). Notably, manufacturers and suppliers were least familiar with biodiversity and socio-economic and health indicators (67%) of all indicators. The analysis included 9 respondents from the material manufacturers and suppliers.

Designers – Similar to the previous results, this stakeholder most commonly uses energy (82%) and greenhouse gas indicators (64%), followed by water and materials (55% each). Biodiversity is also the least applied indicator category (27%) for designers. Interestingly, designers have the second lowest usage rates for social and health indicators at 45% (33% for consultants). The analysis included 11 responses from designers.

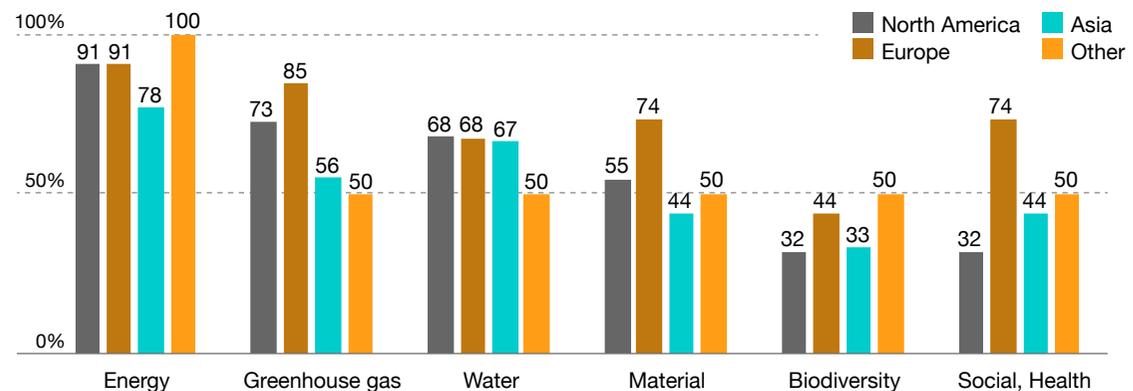Figure 8: Total number of respondents per category of indicators (based on 69 responses)

The percentage of positive responses are indicated in blue. See Table 3 for information on the indicators included under each category.

Figure 9: Use of indicator categories per continent (based on 69 responses)

The category 'Other' comprises of 5 respondents from Argentina, Togo and Colombia.

Builders – This stakeholder group again demonstrates strong familiarity with energy and greenhouse gas indicators, with a clear preference for the energy category. Builders more frequently use socio-economic and health indicators (i.e. safety) than materials and water. In line with the earlier results, biodiversity indicators are infrequently applied by this stakeholder group. The analysis included 9 responses from the construction sector.

Developers – This stakeholder group demonstrates the highest familiarity with energy, water and material indicators (80%). Interestingly, the results of both the biodiversity and socio-economic/health indicators score as high as the greenhouse gas indicators (60%). One hypothesis is that developers are more familiar with biodiversity indicators because they have to address land use issues through their urban development activities. The analysis included 5 responses from developers.
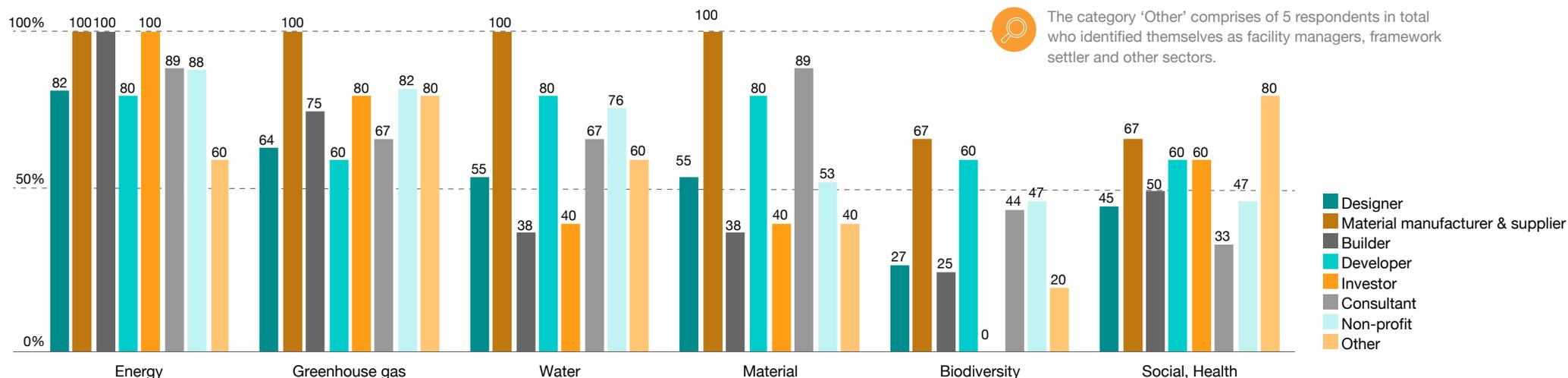
Investors – The results for this stakeholder group are very much in line with the overall results; both the energy and greenhouse gas indicators score very high (respectively 100% and 80%). The water and materials scores are both notably lower at 40%. Interestingly, this sector demonstrates no use of biodiversity indicators and an unusually high result for the socio-economic and health indicators (60%). The analysis included 5 responses from investors.

Consultants – Similar to the previous stakeholder groups, consultants demonstrate a high familiarity with energy (89%) and greenhouse gas indicators (67%). The score for water indicators is the same (67%). Interestingly, the consultants use material indicators more frequently than for greenhouse gas or water (89%). Also striking is the fact that the biodiversity indicators (44%) have a higher score than the socio-economic and health indicators (33%). The analysis included 9 responses from consultants.

Non-profit – The non-profit category was consolidated with the results of several categories: NGOs, governments, research and environmental organizations. This last group constitute the largest part of the group. Energy, greenhouse gas and water indicators are the highest (respectively 88%, 82% and 76%). Materials follow closely with a score of 53%. It's noteworthy that this group shows the same score for biodiversity and socio-economic and health indicators. The analysis included 17 responses from the non-profit sector.

Other – This category included facility managers and respondents from framework setter and another sectors. Due to the low number of responses per sector, the results were not processed further (Figure 10).

Figure 10: Use of categories of indicators per sector (based on 69 responses)

The category 'Other' comprises of 5 respondents in total who identified themselves as facility managers, framework settler and other sectors.

Survey analysis – Which indicators within the different categories?

The survey results provide some insight into the indicators that are most common within each indicator category. These indicators a highlighted at the top of each category listed in Table 2.

Energy consumption (98%), energy efficiency (98%) and waste generation (96%) are applied most often. The percentages represent the number of respondents who indicated use of a specific indicator as a proportion of all survey respondents.

As a result of the survey and data analysis in Table 2, it was observed that participants have not yet developed a uniform understanding of relevant indicators. This jeopardizes the exchange of information along the value chain. Additionally, there is a clear emphasis on the importance of the categories "energy consumption" in the sense of resource use and "greenhouse effect" in the sense of undesirable effects on the global environment. It is therefore proposed to discuss and test the consistency of life-cycle environmental information along the value chain using the example of the indicators "energy use, non-renewable/ resource depletion, fossil" and "GHG emissions/ global warming potential".

It should be noted that not only the type of the reporting/ measurement of resource consumption and effects on the environment must be considered, but also the type of the respective reference base, e.g. construction product/ building component/ building or company. The respective data must therefore not only be generated, but also transformed and interpreted along the value chain.

In addition to these five indicator categories, the survey provided respondents with the possibility to report the use of other life cycle indicators. Among the answers received were notably mentioned: sickness rate, well-being, building certification, ozone depletion, photochemical ozone creation, or plantation and grazing management for recovery of degraded ecosystems.

Table 2: Number of respondents that indicated a type of use for each indicator

Category	Indicator	Use
Energy (41 respondents)	Energy consumption	98%
	Energy efficiency	98%
	Renewable energy	95%
	Energy use intensity	80%
	Non-renewable energy	80%
Greenhouse gas (35 respondents)	Carbon intensity	83%
	Embodied carbon	74%
	Global warming potential	71%
Water (28 respondents)	Freshwater consumption	89%
	Water use efficiency	79%
	Water use intensity	68%
	Water acidification	46%
	Eutrophication	43%
Materials (27 respondents)	Waste generation	96%
	Material consumption	89%
	Renewable materials consumption	89%
	Non-renewable materials	85%
	Hazardous materials	85%
	Hazardous waste generation	74%
Biodiversity and others (16 respondents)	Land Use	94%
	Land Use Change	88%
	Biodiversity	88%
	Light pollution	56%

Out of the 27 survey respondents that declared the use of life cycle metrics within the Materials category, 26 of them confirmed the use of *Waste Generation* as an indicator used. Social, Health category is not included in this chart as specific indicators were not requested in the survey.

Focus on embodied carbon – Are the indicators used specific to the use phase only (carbon intensity) or to the whole life cycle (embodied carbon)?

Embodied carbon, carbon emissions emitted throughout the entire life cycle of a building and its construction materials, is a common life cycle indicator used. A closer look into the data behind this indicator can provide more insight into the drivers behind the use of life cycle indicators. Table 2 showed that 74% of the respondents using GHG indicators were using embodied carbon (26 out of 35 declared using embodied carbon). Table 3 highlights that a majority of the respondents that indicated using embodied carbon as an indicator were Manufacturers and Suppliers within Europe.

Figure 11 shows that embodied carbon is most often applied indicator for reporting (50%) and benchmarking (46%). The indicator is used least frequently for the purpose of due diligence (12%). These results are consistent with the results for the other specified indicators. Seven respondents provided an additional form of usage to this answer. Examples of additional usages that were indicated are customer requested Product Carbon Footprints, marketing, research and the CO_2 ladder (an assessment tool provided developed by SKAO).

The comparison of the type of usage of the embodied carbon indicator per continent demonstrates that stakeholders from Europe are the strongest users of embodied carbon (see Figure 12 on the next page). This is most likely due to the fact that most of the stakeholders that answered the question originate in Europe. There is, however, one exception: Northern America and Asia both seem stronger in the application of embodied carbon in the design process.

A comparison of the type of usage of the embodied carbon indicator per stakeholder group shows strong interest in using embodied carbon for benchmarking. It has been indicated as a common application by all stakeholder groups, especially the non-profit sector (54%), manufacturers (35%), designers (27%), builders (23%) and consultants (23%). The non-profit sector especially stands out as its declaration for the other type of usages are very low (less than 10%). Benchmarking is potentially an important driver for them. This could be linked to the fact that the non-profit sector includes many environmental organizations. Another interesting result is the fact that designers score relatively high for due diligence (12%) but have no score for design process. Suppliers, on the contrary, have indicated the design process (23%) as an important reason for understanding embodied carbon.

Table 3: Number of respondents declaring using embodied carbon per continent and stakeholder category (based on the 26 respondents declaring using embodied carbon)

	Europe	North America	Asia	Other	Total
Builder	3	0	0	0	3
Manufacturers	7	0	0	0	7
Developer	0	1	2	0	3
Designer	1	1	1	0	3
Investor	2	0	0	0	2
Consultant	0	3	0	0	3
Other	0	0	0	0	0
Non-profit	3	2	0	0	5
Total	16	7	3	0	26

Figure 11: Frequency of embodied carbon application by type (based on 26 respondents who declared the use of embodied carbon)

50% Reporting
46% Benchmarking
38% Certification programs
38% Communication
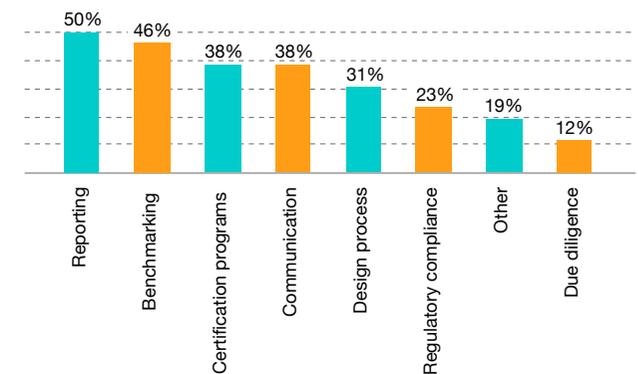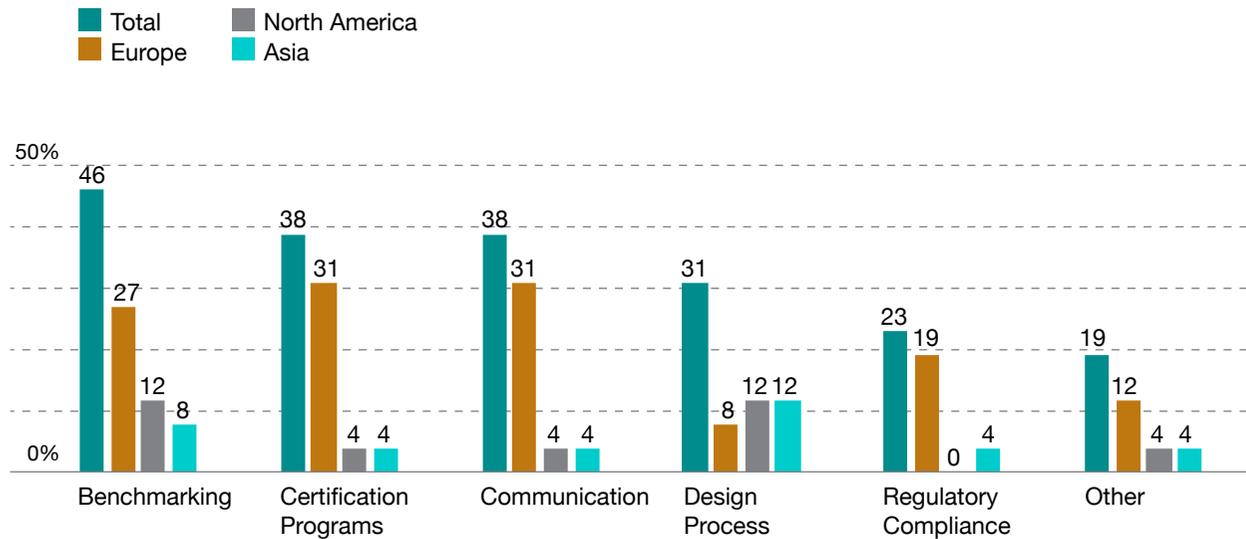31% Design process
23% Regulatory compliance
19% Other
12% Due diligence

Figure 12: Percentage of respondents per continent and type of use for embodied carbon (respondents declaring the use of embodied carbon)

Legend:
- Total
- Europe
- North America
- Asia

Data (Total, Europe, North America, Asia):
- Benchmarking: 46, 27, 12, 8
- Certification Programs: 38, 31, 4, 4
- Communication: 38, 31, 4, 4
- Design Process: 31, 8, 12, 12
- Regulatory Compliance: 23, 19, 0, 4
- Other: 19, 12, 4, 4

Survey analysis – Among the users, how far are the indicators applied in projects?

The survey also inquired after the average application rate among the users of each indicator categories. Two pieces of information are provided in Table 4 below: the percentage of users applying indicator categories in all of their projects and the average application rate. For example: among the 41 respondents who stated they use energy indicators, 24% stated that they apply energy indicators in 100% of their projects. In average, they declared applying energy indicators in 66% of their project.

The results show that the indicators are on average applied in between 50-65% of the projects.
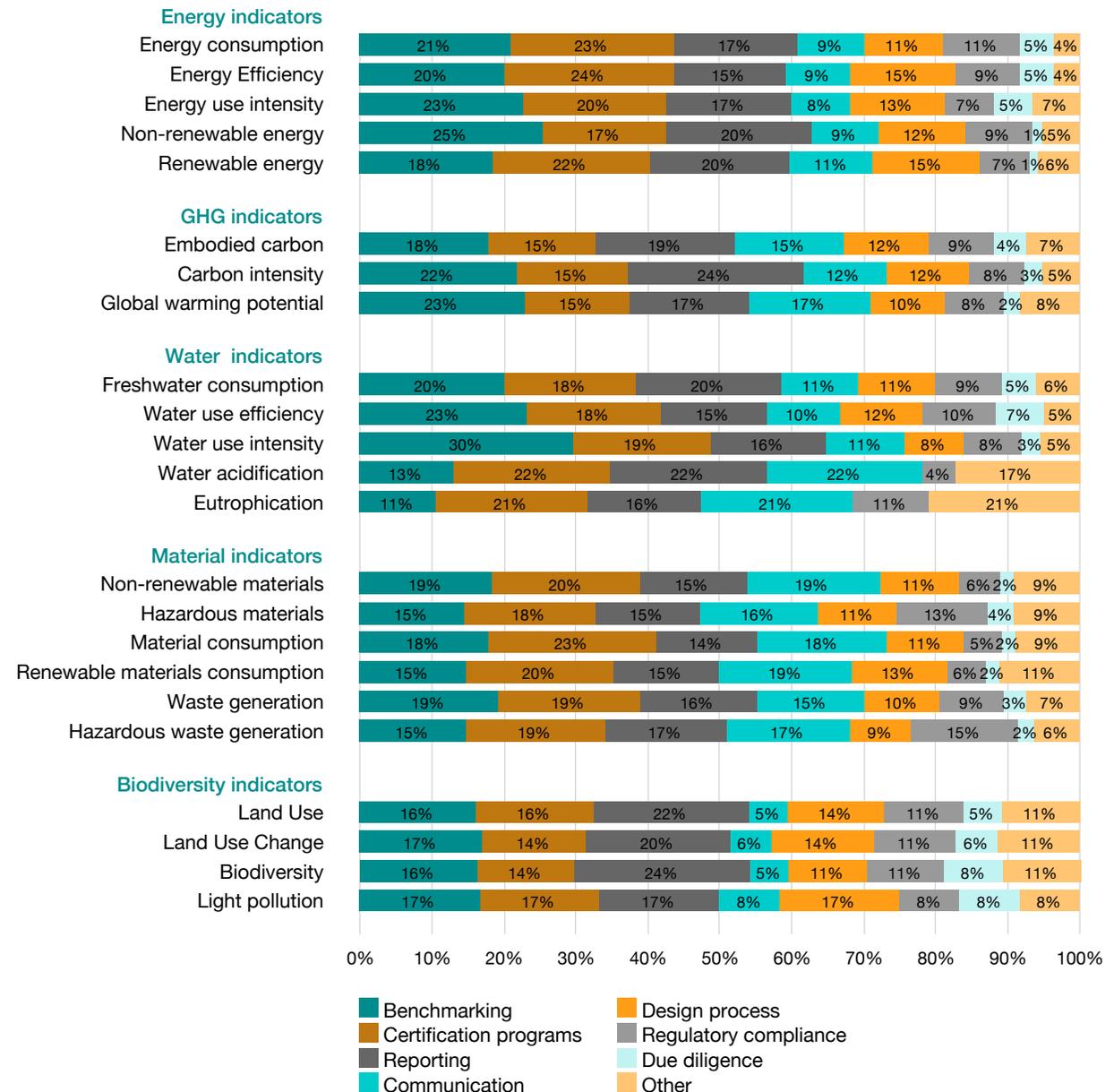
Table 4: Average use of indicators in projects

Category	Percentage of respondents applying the category indicators in all of their projects	Average application rate in projects
Energy (41 respondents)	24%	66%
Greenhouse gas (35 respondents)	14%	52%
Water (28 respondents)	14%	51%
Materials (27 respondents)	30%	61%
Biodiversity (16 respondents)	31%	66%

Survey analysis – What are the environmental indicators used for?

A comparison of the types of indicators usage shows (Figure 13) that benchmarking, certification programs and reporting are frequent applications for all indicators. Benchmarking, certification and reporting have the highest score for energy efficiency (respectively 54%, 63% and 41%) and energy consumption (respectively 56%, 61% and 46%). Benchmarking and certification appear frequently for all top indicator categories: energy, greenhouse gas and water. Other observations include:

- While the results of the survey indicate there is a range of uses for life cycle information, the most frequent application is benchmarking. Certification programs and reporting are the next two most common uses.

- Communication (30-37%) is an important type of use for materials indicators, followed by benchmarking (26-48%) and certification programs (33-48%).

- Reporting is another common use, especially for waste generation (41%). Reporting is most often indicated as a type of usage for biodiversity indicators (25-56%).

- Due diligence is another type of usage that has been indicated most for the biodiversity indicators (13-19%), while the scores for the other categories are considerably lower.

- The design process seems to be most relevant for renewable energy (32%), land use (31%) and land use change (31%). This is likely due to the planning that's required for projects specifying renewable energy installation or landscape alteration.

- Regulatory compliance is most frequently indicated as an application for energy consumption (29%), hazardous materials (26%) and hazardous waste generation (26%). Given the policy environment around hazardous materials and waste, it's easy to understand why.

Figure 13: Type of use per indicator

Case studies based on interviews

LCA indicators

Energy

Carbon (GHG) Emissions

Water

Materials

Biodiversity

Other

B+H

Designer

Name: B+H Architects

Description: B+H Architects is one of the largest architecture, interior design and urban planning firms in the world. It was founded in 1953. Since then it has focused on developing its expertise in design innovation. Sustainability has been specifically integrated into the core values since 1980. Environmental life cycle indicators are an important way for the company to communicate the performance of its designed buildings to their clients.

Category: Designer

Size: 350+

Location: Canada, USA, United Arab Emirates, China, Hong Kong (SAR), Vietnam, Singapore

Contact: Ms Lisa Bate, Regional Managing Principal, North America

Indicators used:

Drivers for the use of life cycle indicators

The application of life cycle assessments aligns with the core values of B+H Architects. Environmental life cycle indicators are an important way for B+H Architects to communicate the performance of its designed buildings to their clients and the client's end users. Although initial requests came mainly from clients in the education and healthcare sectors, the demand from the commercial sector is developing as the request for insight into the environmental performance of buildings is growing. The indicators are frequently used in the conversation with the client to make it easier to discuss the vision, the desired outcomes and program of the project. It also promotes a continuous strive towards building performance optimization throughout the different aspects of the design process.

What life cycle indicators to focus on

B+H Architects applies energy, CO_2 (greenhouse gas), water and waste life cycle indicators in their design process. The company has found that not all environmental life cycle indicators are applied equally. Carbon is not yet being counted in most jurisdictions but will become common place. Biodiversity indicators are for example not the focus for most clients as the biodiversity is too abstract and does not resonate. However, B+H anticipates future adoption of biodiversity, health, and social life cycle indicators.

Implementation

To obtain information on the environmental performance of their products, B+H Architects has made use of building monitoring for over a decade. Since 2014, they have implemented the database materials and monitoring systems of GIGA (www.gigabase.org) across their master specifications and studios. This database is a global cloud-based platform that currently provides (environmental) data on 85,000 materials. GIGA is maintained by an external party and accessed upon subscription. It includes product information sorted by international material rating systems or materials and chemical composition. GIGA also creates data sheets that link to details, drawings, and specifications.

The database is an instrument which makes it less time consuming to collect the necessary data on life cycle indicators. B+H Architects also make use of the GIGA database to encourage their clients to install monitoring devices within the finished buildings. GIGA actively stimulates the measurement capacity of the suppliers in their database. GIGA offers building monitoring devices, allowing the tenant to understand the impacts of their decisions in real-time while generating more data for the system as a whole. This allows them to better calibrate their systems for the health and well-being of occupants and manage their performance.

Benefits & recommendations

B+H Architects perceives the importance of life cycle indicators to their business as rapidly increasing. The use of a concrete tool, such as the GIGA database, is appreciated by clients. They are especially interested in the opportunity to measure their invested capital into the project versus the payback time. B+H Architects is also starting to see an interest of clients to get the data around their invested energy, water, waste commitment to aim for reduction or net zero. They value the opportunity to have direct access to the performance data of their buildings through monitoring.

Developer clients are trying to meet owner and tenant demand. Due to a general increase in attention for health and environment, users of buildings are becoming increasingly aware of the effects of the environment on their health, productivity and well-being. One example is air quality, which is becoming popular in Shanghai and Beijing due to the bad performance levels. Employees are increasingly demanding information on the air quality in their direct work environment. Poor air quality is known to have adverse effects on cognitive and performance capacity in addition to longer-term health impacts. Chinese employers are under increasing pressure to demonstrate a healthy indoor environment to their workers.

Developer/Investor

Name: Ascendas-Singbridge

Description: Ascendas-Singbridge is one of Asia's leading providers of sustainable urban and business space solutions. The company develops real estate, manages real estate funds and undertakes urbanization projects spanning townships, mixed-use developments and business/industrial parks. Sustainability is an essential part of Ascendas-Singbridge's long term development strategy. Most of the company's projects have a strong sustainable component.

Category: Developer/Investor

Size: 1,200

Location: Australia, China, India, Southeast Asia, Singapore and South Korea

Contact: Mr. Alex Ng, Assistant Vice President, Development Planning & Design

Indicators used:

Drivers for the use of life cycle indicators

Ascendas-Singbridge's vision is to be a leader in sustainable urban development that catalyzes economic transformation and enriches lives. The use of sustainable products is strongly supported by management. Life cycle indicators are mainly used to facilitate benchmarking the performance of buildings in the company's portfolio.

What life cycle indicators to focus on

Ascendas-Singbridge has applied indicators in the following categories:

- Energy (e.g. energy consumption, energy efficiency, energy use intensity, non-renewable energy)
- Greenhouse gas (e.g. embodied carbon, carbon intensity, global warming, carbon emissions)
- Water (e.g. freshwater consumption, water use efficiency, water use intensity)
- Materials (e.g. renewable and non-renewable materials, hazardous materials, material consumption, waste generation)
- Biodiversity (e.g. land use, land use change, biodiversity, light pollution)

Ascendas-Singbridge finds that the reporting of life cycle information on energy and water use is successful. Other life cycle information is more difficult to measure and to report on. For example, project impacts on biodiversity and detailed information about the sourcing of materials is scarce. Although they

can demand their suppliers to deliver this information, it would limit the list of suppliers. If this information is more widely available and reported on, it can be used in the construction process.

Implementation

Ascendas-Singbridge uses a life cycle costing method for most of their mechanical and electrical equipment, especially for chiller replacement projects. Ascendas-Singbridge also focuses on the reuse of aggregate materials, such as recycled concrete aggregates (RCA), and the implementation of innovative products from startups, such as building integrated photovoltaics (BIPV). All materials are scrutinized for their quality, characteristics and sustainable performance by the organization's design and project teams before use.

Ascendas-Singbridge has a Green committee to assess the sustainability performance of the organization and the degree to which the strategic sustainability goals are met. It comprises of members of management and is established to govern the performance of various sustainability aspects.

The Ascendas Operation Center (AOC), an initiative introduced by the Green committee, monitors and remotely tracks the buildings' performances. The data is collected in an online database, which is used to monitor the electricity and water consumption within the common areas of the company's properties and parks.

Benefits & recommendations

Life cycle indicators generally help to drive the business to operate in a more sustainable way. It leads to lower life cycle costs, which is a positive benefit for business parks and individual buildings. In some regions, the implementation of sustainable solutions also helps to obtain additional funding, which enables governments to stimulate the market to develop more sustainable buildings.

Ascendas-Singbridge collects building data in an online database with life cycle information. This database is used to monitor the performance of buildings and helps the group to improve the energy and water performance of buildings. It is recommended that other organizations also track the performance of their buildings, which will make it easier for building managers to monitor and manage the performance of buildings and to benchmark the performance of different buildings. Companies can use a Building Information Model (BIM) to collect and structure the data.

Ascendas-Singbridge collaborates with institutes of higher learning and invites tenants to participate in green buildings survey to compare the Indoor Environmental Quality (IEQ) of green buildings and non-green buildings. The survey results and reports on the IEQ of the premises are later shared with the end users, which help in facilitating occupant satisfaction and productivity study.

Mahindra LIFESPACES

Developer/Investor

Name: Mahindra Lifespaces

Description: Mahindra Lifespaces is India's first Green Homes developer. Green Design and Healthy Living are the foundations for all of the organization's projects. Mahindra was one of the first companies to obtain a Platinum rated green homes pre-certification from the Indian Green Building Council (IGBC). Today all residential projects are pre-certified by IGBC.

Category: Developer/Investor

Size: 250

Location: India

Contact: Mr Vishal Bhavsar, DGM Sustainability

Indicators used:

Drivers for the use of life cycle indicators

Mahindra Lifespaces started working with life cycle assessments when they realized the large impact residential housing has throughout the life cycle. They are eager to contribute to their community and consider sustainable urban development, an important part of their core values. The reporting on life cycle information helps to benchmark the company's building portfolio and compare their sustainable performance to competitors. However, this data is mainly used to drive enhancements to the efficiency and quality of projects.

What life cycle indicators to focus on

Mahindra Lifespaces reports on the following life cycle indicator categories:

- Energy (e.g. energy consumption, energy efficiency, energy use intensity, renewable and non-renewable energy)
- Greenhouse gas (e.g. embodied carbon, carbon intensity)
- Water (e.g. fresh water consumption, water use efficiency, water use intensity, acidification, eutrophication)
- Materials (e.g. non-renewable materials, material consumption, renewable material consumption, waste generation, hazardous waste generation)
- Ecosystems (e.g. biodiversity)

Water scarcity is currently a major problem in India and therefore receives special attention from Mahindra Lifespaces. The company obliges contractors to track their water use and supports them in the implementation of water reduction measures. For example, they initiate an annual meeting where contractors can share their best practices for the optimization of their production processes.

Implementation

Life cycle assessments were introduced at Mahindra Lifespaces in 2015. This process initially focused on the identification of the impact and reduction potential of materials in the supply chain. It has proven especially difficult to obtain the data on material performance. Therefore, Mahindra Lifespaces actively purchases local materials and supports local enterprises in learning about a material's production processes and transportation costs.

Through one of their studies, Mahindra Lifespaces discovered that the 'use' phase of a building is accountable for a significant impact on sustainable performance. Therefore, the company has taken several measures to directly empower the users of the buildings, such as the supplying them with a green manual at their occupation of the building.

Benefits & recommendations

The use of life cycle indicators is becoming more mainstream. Mahindra Lifespaces therefore expects that it should create more market opportunities, especially as consumers are starting to show an interest in sustainable and zero energy homes. Life cycle indicators are going to make it possible for the players active in the marketplace to differentiate their products.

Mahindra Lifespaces identified three benefits for using life cycle information. Firstly, life cycle information helps reduces material use and increases the re-use of materials. Secondly, it helps to meet the growing demand for sustainable buildings. Lastly, the use of indicators has strengthened the green brand of Mahindra, helping to differentiate the company from its competitors.

Mahindra Lifespaces finds that there still lies a challenge in aligning the way in which life cycle data is reported. Currently there are a lot of different formats and types of indicators used, making external comparisons difficult. Uniformity of data and platforms could help to improve life cycle assessment implementation.

STRABAG

Builder

Name: Strabag

Description: Strabag is an international construction firm with a large number of operating locations throughout Europe. The organization is aware of their responsibility as a builder of infrastructure projects, which extends beyond construction. Strabag continuously looks for a balance between man, the environment and society through the application of new techniques and materials, renewal of their operations, and adaptation of their policies and processes with respect to corporate social responsibility.

Category: Builder

Size: 76,100

Location: Netherlands, Belgium, Russia, Latvia, Denmark, Norway, Finland, Sweden, Germany, Poland, Switzerland, Austria, Italy, Czech Republic, Hungary, Slovakia, Romania, Bulgaria, Serbia, Ukraine

Contact: Mr Luc Van Thienen, QHSE Manager Benelux

Indicators used:

Drivers for the use of life cycle indicators

The two main drivers of Strabag for using life cycle information are client demand and the reporting standards for listed companies. A client's request for certification helps Strabag shift to a more sustainable way of working and enforces its request for information to suppliers.

What life cycle indicators to focus on

Strabag reports on the following life cycle indicator categories:

- Energy (e.g. energy consumption, energy efficiency, energy use intensity, renewable and non-renewable energy, percentage of green energy used on construction sites)
- Greenhouse gas (e.g. embodied carbon, carbon intensity, global warming)
- Materials (e.g. waste production and waste separation)
- Others (Sickness ratings in company)

Strabag's focus regarding life cycle indicators lies primarily on the monitoring and reduction of CO_2 emissions. The company is certified as a level 5 on the CO_2 performance ladder (highest level of a CO_2 rating system used in the Netherlands). This management system provides insight into CO_2 emissions and opportunities for reduction.

Strabag is interested in obtaining information on the life cycle analysis of construction materials. In particular they look at CO_2 emissions of construction

materials and their production processes as well as the recycling opportunities for waste.

Implementation

Strabag applied LCAs in new BREEAM 2013 projects. The company has carried out several assessments with progressive clients. Specific themes, such as CO_2 and energy, have been included for assessment in projects upon client request. These mainly concern projects in the Netherlands where CO_2 is an important topic.

Strabag has found it especially difficult to collect life cycle information on products and materials. The company did try to collect information from prefabricated concrete suppliers. However, this has proven to be challenging without a legal requirement for sharing the information. Suppliers are reluctant to share data they consider to be sensitive or not readily available. It has proven especially difficult to collect information from small and midsize organizations, which form the majority of the construction industry.

Data on the safety of materials has accelerated over the past 20 years. Much of this is due to the large chemical and petrochemical companies that were certified according to the LCC-checklist (VCA-checklist). A similar boost could be provided for life cycle assessments if clients required life cycle information with product submittals through specification language or contracts.

Benefits & recommendations

Currently life cycle indicators are not an important factor for Strabag in the acquisition of new project. However, they see the potential for this to change in the future. A wider availability of more detailed information from suppliers and uniformity of reporting standards are essential for the further application of life cycle indicator assessments. Currently data collection requires too much time and effort. A database with life cycle information could help to make the necessary data more readily available.

CALLISONRTKL
A DESIGN CONSULTANCY OF ARCADIS

Designer

Name: CallisonRTKL

Description: In the past 50 years CallisonRTKL has created some of the world's most memorable and successful environments for developers, retailers, investors, institutions and public entities. Today, the company is one of the largest design practices globally, and a member of the Arcadis group. CallisonRTKL is committed to advancing their clients' businesses and enhancing quality of life through their design practices.

Category: Designer

Size: 2,000+

Location: United States, China, Hong Kong, United Kingdom, United Arab Emirates, Saudi Arabia, Mexico

Contact: Ms. Amber Richane, Performance Driven DesignSM (PDD) Lead

Indicators used:

Drivers for the use of life cycle indicators

Sustainability is a core value of CallisonRTKL and an important driver for attracting clients. More than half of the generated business is closely linked to the sustainability principles of the company. The majority of clients approach CallisonRTKL because they either seek a specific look that they know will be backed up by sustainable principles or because they look for reliable sustainable design expertise. Client demand is an important motivation for CallisonRTKL to invest in the application of LCA.

What life cycle indicators to focus on

CallisonRTKL uses life cycle indicators to picture the environmental performance of buildings throughout their design process. Currently the focus lies on the following indicators:

- Energy
- GHG emissions
- Materials
- Health and safety data (e.g. hazardous chemicals in building materials)
- Water
- Biodiversity (e.g. green roofs, open space factor, conservation of local flora and fauna)

Implementation

CallisonRTKL obtains life cycle information from several external databases, such as Pharros and Mindful Materials. Their data is provided by users of the database, which can be both suppliers and designers. CallisonRTKL provides life cycle information to clients and construction companies.

The company plans to start collecting information from end-users via surveys within the next couple of years. However, suppliers and manufacturers are traditionally not eager to share information on their materials. This data has become easier to obtain thanks to certification programs as LEED & BREEAM.

CallisonRTKL has developed a culture of sustainability which has been integrated into the daily practice through several different approaches:

- Internal educational campaign
- Initiation of conversations on sustainability in offices
- Internal database of best practices and reference projects
- An in-house librarian specialized in materials
- Access to multiple databases with information on materials

The aim of these initiatives is to ensure that every staff member has the minimum level of knowledge necessary to discuss sustainable performance with the client. CallisonRTKL also has a team that focuses on the expansion and distribution of the knowledge base on sustainability performance.

CallisonRTKL has different ways of sharing information on life cycle indicators, including: an evaluation of a client's preference suppliers list, direct input into a client's in-house tracking system, or the creation of an energy use intensity (EUI) model. In some cases, the client provides a product list with selected materials that can be used in the design, which is reviewed by CallisonRTKL on their sustainability characteristics.

Benefits & recommendations

LCA is essential to demonstrate the sustainable performance of a design and communicate with the client and other stakeholders. Clients are interested in tracking and quantifying the sustainable performance of their buildings due to four main benefits:

- Obligations to report sustainability data as a condition of sustainable stock indices, e.g. the Dow Jones Sustainability Index (DJSI)
- Growing trend of investors that are specifically looking for sustainable businesses
- Report on greenhouse gas emissions in the client's sustainability report
- Reduce costs of building operation.

Currently there are several different databases from which data on materials needs to be obtained. Although this is not creating a barrier for the application of life cycle indicators, standardization of the available data would help to make the application process less time consuming.

4 RESULTS & DISCUSSION

This section aims at presenting the major findings and results drawn from the survey and case studies analysis.

Reminder on the trends and drivers for sustainable buildings

According to the "World Green Building Trends" latest report issued in 2016, client demand and environmental regulations were the most important drivers for the development of green activity (respectively 40% and 35%). The report states that they have been increasingly important since 2008. Market demand and client altruism are following closely (respectively 30% and 25%) but losing importance over the years[6].

Why using LCA indicators in the built environment value chain?

This study investigated who, what, why, where, and how environmental life cycle information is used throughout the building construction and real estate value chain. The following key drivers were observed.

1. A balanced of internal and external drivers

The interviewed stakeholders cited a mix of internal and external drivers for the use of life cycle indicators, with around 60% on internal drivers and 40% on external drivers. Companies report on life cycle information for branding purposes, customer demand, and associated financial savings.

Internal processes stem from the objective of improving the practices, processes and environmental performance. The case studies reveal that core business values are an important internal process driver. The motivation for reporting on indicators differs according to organizations, making it ambiguous and difficult to attribute to one specific factor. However, these internal processes, responsible of the application of life cycle indicators, are in most cases themselves driven by external factors.

The following are major external pressures impacting the use of life cycle assessment within the real estate value chain: client & market demand, regulations with the need to comply with and anticipate legislation and brand and image.

Client and market demand is seen as a driver for 15% of respondents. Clients select, among other aspects, design companies on their sustainability profile. The reason for this demand is an increasing awareness among the future users of the buildings.

Compliance with regulation is also seen as a driver for almost 20% of respondents. Organizations indeed have to comply with local or national or wider regulations related to product reporting, energy efficiency or extra-financial communication.

2. Different applications are driving the needs

The top three applications for life cycle indicators in the built environment are benchmarking, certification programs, and extra-financial reporting.

Benchmarking is frequently indicated as a way to apply life cycle indicators (37% application rate). Benchmarking is usually used by companies wanting to assess or rate their performance compared to competitors. The results of the case studies, however, demonstrated a mostly internal use of benchmarking within the real estate sector, aiming at comparing the (environmental) performance of different buildings within a company's own portfolio. Two major reasons explain this trend:

- A direct driver: the company needs to collect data (and sometimes store it in private on-line databases) on the performance of the buildings in its portfolio,

- An indirect driver: the company collects data on the building's performance to satisfy the demand of the client, who in turn is trying to satisfy the demand of the end-user. Another reason why the real estate sector favors internal use benchmarking is that building performance analysis can be done upon various (and/or undisclosed) methodologies, making it difficult to compare. External benchmarking among peers is challenged by this difficulty to compare assessment methods.

Certification programs are another important driver of life cycle indicators use. According to the survey analysis, certification is a familiar and well-used instrument to apply environmental life cycle indicators, with around 36% of respondents indicating its application. However, it should be noted that categories and scope of life cycle indicators are not equally represented. Greenhouse gas emissions and energy are often mentioned among the indicators used whereas water, materials, biodiversity and land-use are less common.

Extra-financial reporting was indicated as a reason to use environmental life cycle indicators by 35% of the respondents. The majority of respondents indicated that they use life cycle information for both internal and external reporting. Interestingly, reporting does not show a strong relation with regulatory compliance, suggesting that the main driver for reporting is not legislation-based. Other types of reporting mentioned are certification, client reports and scientific publications. In a subsequent study, it could be interesting to further investigate in which types of reports life cycle indicators are disclosed within.

What indicators are used?

1. The use of life cycle indicators is diversified

Life cycle indicators are not equally applied. 90% of the respondents indicated they use energy related indicators, followed by GHG, water and materials indicators. While energy, greenhouse gas and water indicators are widely represented, biodiversity indicators (eutrophication, biodiversity, land use, etc.) are not often mentioned. As suggested by the case studies, a possible reason for this indicator application gap is the lack familiarity with the concepts or no consensus on measurement.

Additionally, the type and number of indicators used varies by company. Energy and GHG are among the most used categories reported. Each of these categories gathers several underlying indicators (such as embodied carbon, carbon intensity, GWP, or energy consumption, energy use, renewable energy). Companies are therefore left with a choice in terms of indicators to use. Some rating systems can influence these choices, such as IFC's EDGE requiring accountability for embedded carbon of building materials.

2. Energy and GHG as the most popular life cycle categories of indicators

As mentioned above, life cycle indicators are not equally applied. The following hierarchy can be highlighted from the survey analysis and the case studies results:

- The top 2 categories of indicators are energy and greenhouse gases: with respectively 90%, 75% of respondents declaring to use related indicators.
- Water and materials related indicators are gaining increased understanding: with respectively 67% and 62% of respondents declaring to use related indicators.

- Biodiversity related indicators are emerging: with 39% of respondents declaring to use related indicators.
- Health and socio-economic related indicators are growing in adoption: 52% of the respondents declared use of these indicators.

3. A different appropriation according to stakeholders…

A comparison of the use of environmental life cycle indicators between the different stakeholders provided surprising results.

Material suppliers seem to be the best users of information on environmental life cycle data in the real estate value chain. In fact, 67% of these respondents declared using biodiversity and land-use related indicators, much more than other members of the value chain.

These is an opportunity to enhance the awareness of biodiversity indicators among designers as this sector scores especially low for this category. As the number of respondents per sector was very small, further analysis is needed to confirm if these results also apply to a larger sample.

4. Or continents.

The analysis highlights a difference in the application of life cycle indicators between North America, the EU and Asia. Although likely founded in varying regional priorities on environmental issues, further study could uncover whether other factors play into the inconsistency of indicator applications globally.

Again energy and greenhouse gas appear to be well used indicators in both North America and the EU. 91% of

the respondents in the Europe and in the United States-Canada indicated using energy indicators within their business practices.

There is a gap in regional biodiversity and socio-economic indicator application. 44% of the respondents in Europe apply biodiversity and land-use indicators against 32% in the United States and Canada. The bridge is even bigger when looking at socio-economic and health indicators (74% in the EU versus 32% in the US).

In Asia, stakeholders are concentrating efforts on water and energy indicators due to local environmental pressures. Water and electricity shortages may be a cause of indicator adoption, as suggested during the interviews.

How LCA indicators are used?

1. The use of tools, databases or other information flow is needed

The survey demonstrated the need for consistent methods and instruments to assess sustainable building activity (Table 5).

The instruments mentioned by respondents in connection to the assessment of life cycle indicators varied widely: certification programs, databases, methods, tools, and sustainable buildings initiatives.

Standards provided through regulation also seem to be an important reference for the assessment of life cycle indicators.

The instruments are often region specific. Respondents from Asia mentioned water related parameters while respondents from the US and Europe (e.g. EEI, LEED) appear to mention more energy related instruments.

The instruments include in-house developed programs, national initiatives (e.g. SSSI Scotland, PUB Singapore), international accepted standards (ISO 14040/44) and both private (e.g. ASB Maintainability and Sustainability guidebook) and publicly (e.g. EPD, LCA for DGNB) developed standards.

Even standards on environmental management (ISO 14001) or product labels (e.g. FSC, PEFC/SFI) were mentioned.

Table 5: Life cycle instruments mentioned in the survey

Category	Instruments
Certification and rating systems	• LEED certification • Other sustainable building certification (not specified) • Singapore national standards (PUB)
Initiatives	• Regulatory requirements India for rain water harvesting (India) • ASB Maintainability and Sustainability guidebook (Singapore) • ASB Green policy and checklist (Singapore) • ATP in-house material screening tool (Germany) • ASB Detailed Design Review Committee (Singapore) • Sites of Special Scientific Interest, SSSI (Scotland)
LCA and other assessment methods (buildings and products)	• Environmental product declaration (EPD) • Product specific calculations • Energy Efficiency Index (EEI) • RICS methods • B Corp/ B Lab Assessment • LCA for DGNB certification • Actual data measurements • Consumer feedback through reporting • BIM in combination with LCA methodology • Life Cycle costing
Databases	• GIGA
Other instruments mentioned	• EnEv (DIN 18599) calculation • ISO 14001: environmental management system • FSC & PEFC: certified wood

2. Some challenges, difficulties & barriers remain

Not accounting for life cycle environmental indicators ignores material risk, threatening the whole built environment and real estate value chain. Failing to address supply chain impacts and dependencies, chasing changes in legislation, or finding your organization at a competitive disadvantage due to rigidness in adapting to changing market demand all exemplify the types of economic risk that life cycle thinking can begin to mitigate. Another risk is the break in information flow that prevents the construction and real estate sector from a continuous communication between stakeholders.

However, challenges remain. The major barrier faced by stakeholders in the application of life cycle indicators is the inconsistency in definitions and assessment methods. The number and discrete characteristic of each of these instruments make data consistency and information flow highly challenging. In addition, some indicators are easier to use than others.

With respect to life cycle databases, three problems surface:

- Availability and accessibility: in addition to the fact that databases are not always free and open-sourced, the absence of data is also an issue.
- Quality: when the data exist, its quality can be questioned based on whether the data is primary, secondary, out-of-date, regionally-specific, or based on assumptions.
- Consistency: issues of common definitions, scopes, assessment methods remains.

An additional challenge is the difficulty to get information from the suppliers of construction products. This is driven by the lack of a common language along the value chain. There is currently no common tool used by all stakeholders to easily share environmental life cycle performance data. This serves not just as a barrier, but as an opportunity for industry collaboration.

Summary of the views per value chain actors

The diagram on the next page (Table 6) demonstrates which drivers, indicators, instruments, and benefits for each value chain player. Through this table, we are able to make a few observations.

- All stakeholders show a real interest in certification, as it is mentioned by almost all categories and along the chain;
- The need of LCA assessment methods does not resonate with end users, who are expecting information in relation to the building performance;
- LCA specific tools, such as BIM, are only commonly referenced the in the beginning of the value chain (from the supplier to the builders). EPD use is even more restricted with an apparent interest limited to suppliers and architects.
- Some tools are exclusive to a single stakeholder group. This is the case with the GRESB rating system and its focus on REITs and equity investors.

Table 6: Summary of the views per value chain actors

	Material manufacturing and suppliers	Designers and Architects	Developers	Builders	Owners and Investors	Facility managers	End user	Framework settlers & others (e.g. consultants)
Key drivers for using life cycle indicators (as mentioned in the survey and interviews)	• market demand for EPD • EPD regulation • internal and regulatory reporting • performance assessment • company image	• performance assessment • minimize impact • certification • company core values • regulatory demand	• product added value • internal CSR policy • planning process requirement	• regulatory demand • market & client demand • planning process requirement	• minimizing risks • company image • regulatory demand • performance assessment	• client demand • performance assessment • company image	• performance assessment • compliance • image	• internal CSR policy • company image • reporting obligations
Indicators used (as mentioned in the survey, higher than 50% of answers)	energy, ghg, water, materials, biodiversity, social & health	energy, ghg, water, materials	energy, ghg, water, materials, biodiversity, social & health	energy, ghg, social & health	energy, ghg, social & health	energy, ghg, social & health	energy, ghg, water, materials	energy, materials
Instruments used (as mentioned in the survey)	Sustainable building certification	Sustainable building certification	Sustainable building certification	Sustainable building certification	Sustainable building certification	Sustainable building certification	Feedback from building performance database	set of various instruments
	BIM information	BIM information		BIM information			Consumer feedback through reporting	
	Environment and health related product information (EPD, etc.)	Environment and health related product information (EPD, etc.)			GRESB			
Main benefits (as stated in the survey and business cases)	• anticipate client demand • promote sustainable products • meet company sustainability policies	• facilitate the discussion with clients about design process • databases saving time to collect data • increases possibilities for collaboration with client • seen as a real «plus» for clients	• help businesses in operating in a more sustainable way • lower buildings life cycle costs • acquiring additional funding	• shift toward more sustainable way of working • ease the data collection • ease the implementation of new business processes	• increase project efficiency • attract and bind consumers • strengthen the brand image	• reduce impacts & costs • improve quality of life • contribute to external communication & image	• reduce impacts & costs • improve quality of life	• define & implement public policies • promote & facilitate the use of sustainable buildings • align with sustainability goals

Legend: energy, ghg, water, materials, biodiversity, social & health

4 CONCLUSIONS AND PERSPECTIVES

Conclusion

This report demonstrates the opportunities for integrating life cycle thinking along the construction and real estate value chain. It also outlines the risks that the industry and companies face by ignoring the embodied environmental impacts of their supply chain. Energy is no longer the single focus of what defines a sustainable building. While there are many environmental impacts and dependencies that the built environment has, it is critical to establish a common currency that aligns the building value chain. However, the industry perspectives collected repeated a number of challenges to establishing a common language based on LCA.

To ensure materiality and avoid burden-shifting, at least four environmental life cycle indicator categories should be used. In assessing whole building life cycle impacts, the four indicators that not only address a diverse range of issues but also are utilized by many value chain members today are energy, greenhouse gas emissions, water and materials. Emerging health and socio-economic indicators will need to be increasingly integrated as public awareness and demand grow. While biodiversity is adopted by a number of stakeholder groups, agreement on indictors and measurement methodology are needed for further pick-up.

Of course, more holistic views could be made, targeting more than these four categories of indicators. However, to guarantee a successful application, the focus should be narrowed first, and special attention given to the flow of information between stakeholders (from demand and supply sides, and despite the breaks observed in Table 6). Other industry initiatives are moving in this direction, such as the Sustainable Building Alliance's draft "Framework for Common Metrics" and "Common EU framework of core indicators for the environmental performance of EU buildings". This report complements these initiatives in augmenting the case for the businesses to integrate life cycle thinking into their operations.

Once indicators are identified, collaboration and consensus on whole building life cycle methodology and standardization will be a formidable but necessary next step. Despite the clear trend of increasing awareness and use of life cycle approach, it also appears that only a handful of actors, "leaders", have embraced these methods and practices internally. This is due to the challenges discussed earlier in the report.

The supply chain has a common interest to share information to reduce risk and mitigate environmental impact, and may align along this logic to a degree. To scale-up the adoption of life cycle assessments and indicators, the definition of a robust and simple common language is essential, connecting the entire value chain.

Expert point of view: Thomas Lützkendorf, from KIT

The method of Life Cycle Assessment (LCA) is a suitable tool for the development of information/ data on the use of resources, as well as for the undesirable effects on the local and global environment. There are generally recognized categories (impact categories), that can be interpreted as indicators. Environmental product declarations (EPD's) and related databases are nowadays available. Work is currently focused on data exchange formats and their consideration in BIM.

If such information is passed on in connection with the supply of products and services along the value chain, the decision-makers of the subsequent stages can use this information without having to create a new LCA for the related product. Their work consists of combining data from data sources and interpreting the results. This saves time and money and decreases the inhibition threshold when dealing with life cycle assessment.

Along the value chain, the supplier becomes the information provider, the customer becomes the demander. This role can change. A building owner or designer requests, on the one hand, information about construction products, but provides, on the other hand, information about the building to the valuation professional or the bank.

Call for action

These conclusions and trends allow us to suggest a few next-steps for the WBCSD Working Group and the construction and real estate industry as a whole.

First, a robust and common language should be defined. This means selecting indicators and definitions that all construction and real estate stakeholders could agree on. Consensus must also be established on a standardized technical ruling for the use of life cycle assessments, including common:

• definitions, scope and methods
• databases
• assessment tools

Second, this language should be simple to use and communicate. It is also important to note that using already existing metrics would ease data production". To guarantee the continuity of use, these actors must share information and data with each other through an easy and accessible channel. Such a conduit still needs to be developed and scaled.

Thirdly, the flow of specific life cycle information must be established along the value chain. This implies working with a limited selection of indicators categories. Energy and greenhouse gas are the most commonly used indicators with the least controversial definitions and methodologies. This requires working on the integration of life cycle thinking into the design process, notably through:

• clarifying how specific environmental indicators apply to various levels of a company structure (i.e. building material/product, building system, building/asset, portfolio, company, conglomerate, etc.);
• using the link between environmental data flows and BIM methodology.

Additionally, the indicators, databases, and tools should all connect to broader, active initiatives (such as Natural Capital, and its recently published Natural Capital Protocol[7]). Collaboration with government, NGOs, and academia should also be a priority, notably through:

• WBCSD Sustainable Cities program
• Collaboration with ongoing public initiatives
• SBA Framework for Common Metrics
• Public procurement policies

There is also a need to benchmark metrics on buildings environmental performance. Currently, it is not clear what good LCA performance for a whole building looks like. The industry needs average or conventional construction performance scores for life cycle assessments to understand relative impacts of their design and construction decisions. This would be based on common methods to assess key metrics, typical buildings categories, and regional areas. An industry example today is the U.S. Environmental Protection Agency ENERGY STAR score, which is based on Commercial Buildings Energy Consumption Survey (CBECS) data.

Finally, a pilot project could be developed to measure the drivers, benefits, outcomes (environmental performance) the challenges of whole building LCA. This should evaluate whole building performance and consider the contribution of each value chain actor.

The industry can only improve on what it measures. Until we understand the entire life cycle impacts of our built assets we cannot holistically address the environmental consequences of the spaces we inhabit. Until then, the construction and real estate sector will remain one that withdraws on natural capital more than it contributes.

Company point of view: LafargeHolcim

LafargeHolcim has a long history of assessing the environmental impacts of cement and concrete production, starting in 2007-2008 with the 'Getting the numbers right' (GNR) initiative under the Cement Sustainability Initiative (CSI) on carbon emission reporting for cement. However, this approach is in-house focused and primarily driven by production process related improvements and our sustainability reporting.

It goes without saying that any construction solution's performance, be it environmental, social or economic, can only be assessed in the context of a construction's full life cycle, including the end-of-life scenario. Environmental Product Declarations are a first step, but they need to be consolidated in the holistic picture of a construction. We are very keen to create transparency and demonstrate our products' and solutions' performance over the full building lifecycle.

Our ultimate objective remains to stimulate and enable the performance based decision-making process for construction types and solutions as early as possible in a design process. To take sound decisions, the life cycle assessment must become easier (in terms of complexity and effort) while maintaining a robust enough level of data validity. In addition, the available data, be it embodied, operational or end-of-life, must become consistent to enable the free exchange and flow of LCA performance information.

Company point of view: Skanska

Skanska sees defining and reducing environmental impacts as a core differentiator for its business, to enable this Skanska has developed the color palette™ and the "Journey to Deep Green"©. This incorporates a range of targets from legal compliance to zero/near zero environmental impact, relating to carbon, energy, water and materials.

However, for Skanska to meet the requirements of the color palette, integration with the whole value chain is essential. From engaging with clients to understand and support their needs, liaising with design houses so the right information is available to make informed choices and working with the supply chain for innovation and primary data.

LCA plays an integral role for Skanska in meeting the requirements of both a sector wide approach to sustainability and its internal color palette. However, the industry average data used during the design/build phase must eventually be substituted with primary data directly from the supply chain.

5 APPENDICES

Acknowledgments

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WBCSD working group companies:

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Glossary

BEAM	Building Environmental Assessment Method (Hong-Kong)
BIM	Building Information Model
BOMA 360	Building Owners and Managers Association
BREEAM	Building Research Establishment Environmental Assessment Method
CASBEE	Comprehensive Assessment System for Built Environment Efficiency (Japan)
DGNB	Deutsche Gesellschaft für Nachhaltiges Bauen (Germany)
DJSI	Dow Jones Sustainability Indices
EDGE	Excellence in Design for Greater Efficiencies
EPD	Environmental Product Declarations
ESG	Environmental, Social and Governance
EUI	Energy Use Intensity
GHG	Greenhouse Gas
GRESB	Global Real Estate Sustainability Benchmark
GWP	Global Warning Potential
HERS	Home Energy Rating System
HQE	Haute Qualité Environnementale (France)
IGBC	Indian Green Building Council
INIES	Environmental and Health Reference Data for Building
ISO	International Standard Organization
LCA	Life Cycle Assessment
LCC	Life Cycle Costing
LEED	Leadership in Energy & Environmental Design
NZEB	Net Zero Energy Building
SDG	Sustainable Development Goals

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ISO 14040:2006 – Environmental management – Life cycle assessment – Principles and framework, 2006-07-01, lastly reviewed and confirmed in 2016.

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Websites

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http://ec.europa.eu/environment/eussd/buildings.htm

The Whole Building Design Guide (WBDG), a program of the National Institute of Building Sciences
https://www.wbdg.org/resources/gbs.php

The Green Building Alliance
https://www.go-gba.org/resources/building-product-certifications/

The US Green Building Council
http://www.usgbc.org

The Natural Capital Coalition
http://naturalcapitalcoalition.org/protocol/

RAMSES, Sciences for cities in transition
http://www.ramses-cities.eu/

Methodological background on the survey

Survey set-up

To get a general idea of which environmental life cycle indicators are used within the real estate sector and why, an online survey was launched and shared among the network of the WBCSD. The survey was based on a mix of open and closed questions to ensure a minimal completion time. At first, the respondents were asked to indicate for 5 different categories of indicators whether they have applied life cycle indicators within their business practices or not. Depending on their responses, the respondents were then sent through 2 different routes of the survey; in case the respondents indicated not to use any environmental life cycle indicators, they were directly forwarded to a set of questions inquiring after the reason(s). In case the respondents indicated that they did use indicators in one or more categories, they were directly forwarded to a page inquiring after more detailed information on these indicators and their reasons for using environmental life cycle indicators. Both routes eventually were brought back together in two questions inquiring after the general approach to sustainability of the company.

Survey dissemination channels

The survey has been distributed through the WBCSD, WBCSD companies and Arcadis network and social media.

Architecture2030

BCSD Singapore

BOMA International

Business in the Community Ireland

Carbon Leadership Forum

Changi Airport

Curacao BCSD

DPA

Green Real Estate Investor Group

Greenbiz

LEED Accredited Professional

LEED Professionals and Users

Philippine Business for the Environment

Singapore GBC

SPLC – C&R TAG

Sustainability Professionals

The Shift (BE)

UK BCSD

USGBC

USGBC

WBCSD

WGBC

World Green Building Council

The use of coding

The survey was analyzed through coding, which is a research methodology that is frequently used in social sciences.

Coding is an analysis method that can be used to derive theories from texts or survey results. Codes are categories (keywords, phrases, mnemonics and numbers) which are assigned to a text segment.

The coding analysis was done following a three-phase approach:

1. Development of codes while reading the text
2. First grouping of codes based on their connection
3. Second grouping of codes based on their connection

Code list and frequency

Core business values (9)

Company policy (3)

Improve design practices (5)

Improve business practices (4)

Value assessment of mortgages (1)

Assess environmental performance (5)

Resource savings (3)

Meet market standards on demand (4)

Competitive advantages (2)

Help client improve performance (1)

Ensure implementation of legislation (2)

Anticipate regulatory changes (2)

Comply with monitoring requirements (2)

Company image (2)

Attracting young talents (1)

The codes that were developed and used after the first phase are listed in the table on the previous page.

Closed questions were analyzed through univariate analysis looking at the frequency of an answer. Open questions were analyzed through the application of the coding method.

The relationship between the variables was interpreted through internal expert judgement, which allowed us to implement two successive relevant groupings (phases 2 and 3), leading to the final grouping presented in the survey. A set of assumptions/ trends/ hypotheses were then identified and further investigated through the interviews.

Case studies approach

Five case studies were conducted in order to verify the data obtained from the survey and the initial interviews. The case studies were developed based on five interviews with frontrunners in the industry and representative of the different roles within the value chain.

The final selection of the organizations that were interviewed for the case studies was determined by the Working Group within the WBCSD.

Within the case studies the focus was on answering the following questions:
- Which innovations or best practices regarding life cycle information does your organization implement? How do these work and why are they successful?
- Which environmental life cycle indicators does your organization use?
- Why and how does the organization use these indicators?
- How do you gather the information from suppliers?
- How do you see the flow of information with the other actors in the real estate value chain (developers, engineers, operators, investors …)?
- What successes and failures did the organization encounter implementing life cycle indicators?
- What are the benefits for using life cycle indicators for the organization? Are you able to quantify these?
- What should be done to promote the use of life cycle information/indicators?
- What would they recommend other organizations?

The answers to these questions were processed into a concise report. The case studies are included on the following page.

Footnotes

1. ISO 21931 for sustainability in building construction; ISO 14040 and ISO 14044 for LCA
2. European Commission
3. US Green Building Council, http://www.usgbc.org/articles/green-building-facts
4. Green Building Standards and Certification Systems, by Stephanie Vierra, Assoc. AIA, LEED AP BD+C, Vierra Design & Education Services, LLC – https://www.wbdg.org/resources/gbs.php
5. http://www.usgbc.org/articles/closer-look-materials-resources-leed-v4
6. See page 5 of the 2016 "World Green Building Trends" report for more information
7. Download the Natural Capital Protocol here: http://naturalcapitalcoalition.org/protocol/

www.wbcsd.org