"Piloting the Common Metrics", a research project of the Sustainable Building Alliance

Julien HANS, Sylviane NIBEL, Anne Claire FREYD[1], Ana CUNHA[2], Daniel DORAN[3],Tim BARROW WILLIAMS[3], Hannele AHVENNIEMI[4], Pekka HUOVILA[4], Jiri SOBOLA[5], Martin VONKA[5], Antonin LUPISECK[5], Eva SCHMINCKE[6], Katrin LENZ[6], Teresa SOTO VICARIO[7], Scot HORST[8], Chris PYKE[8], Jeff KUZIEMKO[8] and Lauren RIGGS[8]

Abstract

For new buildings the consumption of energy in a 50-year period is as much as the impact of the manufacturing and construction processes, hence assessment and comparison methodologies encompassing the whole building life-cycle are required. As studies about the environmental performance of buildings also address issues related to waste, water or other resources and emissions, Life Cycle Assessment (LCA) has become a recognized assessment method.

LCA is being integrated in building certification schemes worldwide for assessing the life-cycle environmental impacts. Several standards have been developed in Europe and worldwide, but finding agreement on life cycle stages, contributors and indicators is necessary for comparing and harmonizing obtained LCA results. The main goal of the 'SBA Common Metrics' project is reaching this agreement.

In particular, the project aims at setting up a common approach for calculating a set of indicators according to common rules, parameters, elements, building phases and local features. This approach should be integrated in the existing certification schemes to promote comparability worldwide.

During 2009 and 2010, the 'Indicators Core Group' of the Sustainable Building Alliance (SBA) selected a set of environmental indicators, the 'SBA Common Metrics', and developed a 'Framework for Common Metrics'. The document provides a method for calculating, using and communicating the chosen indicators: global warming potential, use of non-renewable primary energy, water use, solid waste and indoor environment quality, in compliance with the CEN TC 350 standardization work.

In 2011, The 'Framework for Common Metrics' was pilot-tested in projects involving real buildings to analyse its feasibility concerning data availability, calculation, comparability of results and integration in the existing rating schemes (HANS et al, SBA report phase 1

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[1] CSTB, France , [2] QUALITEL, France,[3] BRE, UK, [4] VTT, Finland, [5] TZUS, Czech Republic, [6] Fraunhofer IBP, Germany, [7] IVE, Spain, [8] USGBC, USA

(2012)). The pilot-test indicated that despite some differences due to national specifics, the integration of these SBA metrics within (existing) building assessment schemes(BREEAM, HQE, DGNB, …) will be possible, although this will occur according to the ‘ambition level’ of each country.

Finally, the consistency and comparability of the ‘Common Metrics’ which was studied in 2012, will, together with the pilot-test results, enable the SB Alliance to improve the ‘Framework for Common Metrics’. This paper presents the research results.

Keywords: Building life cycle assessment, Sustainable buildings, building performance indicators, green building, harmonisation.

1. Introduction

The construction sector is now irreversibly turned towards design, construction, maintenance and renovation of sustainable buildings. Thus, the LCA (Life Cycle Assessment) methodology has been recognized as a systematic tool for assessing the environmental performance of buildings. In this context, this project is aimed at ensuring the operational harmonization and comparability of current LCA methodology for assessing the environmental performance of buildings.

The study of the environmental performance of buildings involves analysis in terms of the following scales:

- Temporal scale, as the impacts of the buildings are now studied along its full life cycle;

- Spatial scale, as the building is taken into account as a part of the neighborhood and of the city, by analyzing the transport induced during the in-use phase, or the local energy production or storage;

- Complexity scale, as the environmental assessment is a multi-criteria analysis, taking into account energy (non renewable, renewable, etc.), waste (hazardous, non hazardous, inert, etc.), resources, air pollution, global warming potential, water consumption. Furthermore, it is necessary to assess these impacts regarding the functionality provided by different building contributors or specific requirements (comfort, safety, accessibility etc.).

Under these perspectives, LCA methodology is used increasingly in certification schemes all around the world in order to account for the overall impacts of the different stages of the building lifecycle. Recent standards (EN 15978), methodologies or guidelines (such as EeBGuide (2012)) have been developed in several European countries and at an international level. However, there is still a strong need to reach agreement on processes or elements included within the system boundaries (life cycle stages, contributors considered, etc.). All these items form “the engine” of this project.

2. Work description

The goal of this project is not to develop a single new assessment system, but to cooperate for the development of a group of indicators that would be calculated in the same manner and considering the same parameters and life cycle stages. This common calculation approach should be integrated in the existing certification schemes for the promotion of comparability worldwide.

During 2009 and 2010, the SBA working group “Indicators Core Group” (composed of BRE, CSTB, DGNB, QUALITEL and VTT) prepared a draft Framework for Common Metrics to be calculated, used and communicated in a common way for the assessment of buildings.

As a first stage, the Common Metrics draft currently includes the following indicators (Figure 1), in compliance with CEN TC 350 standardization work:

- Global Warming Potential (GWP)
- Use of non-renewable primary energy
- Water use
- Solid waste production
- Indoor environment quality (IEQ) (currently considering thermal comfort, indoor air CO_2 concentration and formaldehyde concentration)

Figure 1: The six indicators developed in the Framework for Common Metrics (2010)

Since the certification systems imply different calculation and assessment methods, a distinction between the LCA-oriented indicators (GWP, energy, water and waste) and the indoor environment indicators was made.

In 2011 the Framework for Common Metrics was pilot-tested within existing assessment systems and in real projects, in order to analyze its feasibility consistency and comparability.

Among other aspects the feasibility analysis consisted of checking the existence of efficient and practical tools, methodologies as well as LCA data, such as provided via environmental product declarations (EPD), which offer necessary input data on material level for the calculation of indicators for all the life-cycle stages of buildings. Practical tests and modeling of the SBA common metrics framework were also performed by each member country to illustrate operational feasibility and applicability (Figure2).

Figure 2: Some of the projects modelled in the SBA project

The consistency and comparability analysis focused on the assessment of LCA results of the previously mentioned practical tests and the evaluation of minimum requirements for LCA modeling. The analysis identified differences in existing calculations and potential improvements to be made, for example with regard to the type of environmental data such as the type of EPD (cradle to gate and cradle to grave, different standard…), the contributors that are taken into account in the Building LCA calculation for each country (for instance, availability of data for equipment), the type of operational energy related services available for the modeling, etc.

In 2012, the Framework for Common Metrics was also checked in greater depth on a single building to clearly identify the necessary improvements in terms of the contributors' scope and the service life data of the building elements.

As a result, a document of recommendations will be written for an improved version of the SBA common metrics framework to move forward towards compliant and adapted certification systems for buildings.

3. Results

3.1 Feasibility analysis

To reach the goal of implementation within existing building certification systems, the SBA Framework for Common Metrics had to be first evaluated with regard to feasibility aspects. A clear understanding of the indicators defined and a thorough investigation of the framework by each partner formed the basis for analysis. The focus was set on the complexity of the framework itself, and the LCA-oriented approach for environmental indicators as well as on the diversity of methods, data and tools linked to existing certification schemes among the countries involved.

Consequently, it was found to be necessary to distinguish between “technical” feasibility and “operational” feasibility:

- Technical feasibility indicates the availability of tools, data and methodologies (scenarios, etc.) to assess the impact of the contributor on the indicators either on the market or in the R&D sectors;
- Operational feasibility indicates how the impact of the contributor on the indicators is taken into account in the existing certification schemes (as DGNB, HQE, LEED, BREEAM, Perfil de Calidad, PromisE, SBToolC, etc.). The goal was to analyze the current capability of calculating the indicators in the existing schemes, (tools, data, methodology and scenarios used).

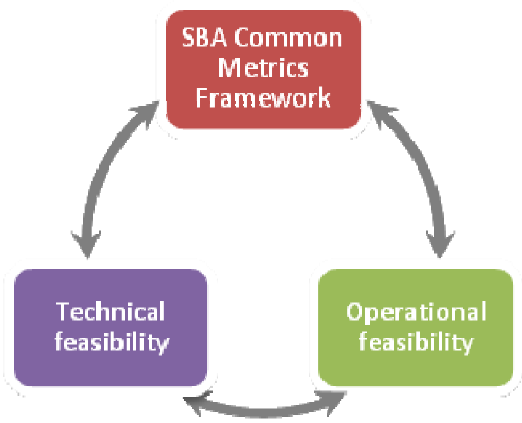

Figure 3: Establishment of the SBA metrics framework on the basis of metrics in current certification schemes (operational feasibility) potential metrics according to availability of data and tools (technical feasibility)

3.1.1 Methodology

The group decided to work through detailed feasibility tables, to be completed by each member. The principles and structure of the tables were defined collectively.

Three feasibility tables were developed:

- The first table aiming at showing the availability of data, tools and methodologies for calculating the LCA-related indicators for each building contributor, as well as their consideration in each rating scheme, including additional information;

- The second one aiming at specifying the availability of environmental data (EPD) in the different life-cycle stages of buildings and for each contributor and metric, as well as their involvement in each rating scheme.

- The last one explaining in qualitative terms, but as precisely as possible, the availability of data and tools regarding the IEQ indicators and their inclusion in each certification scheme.

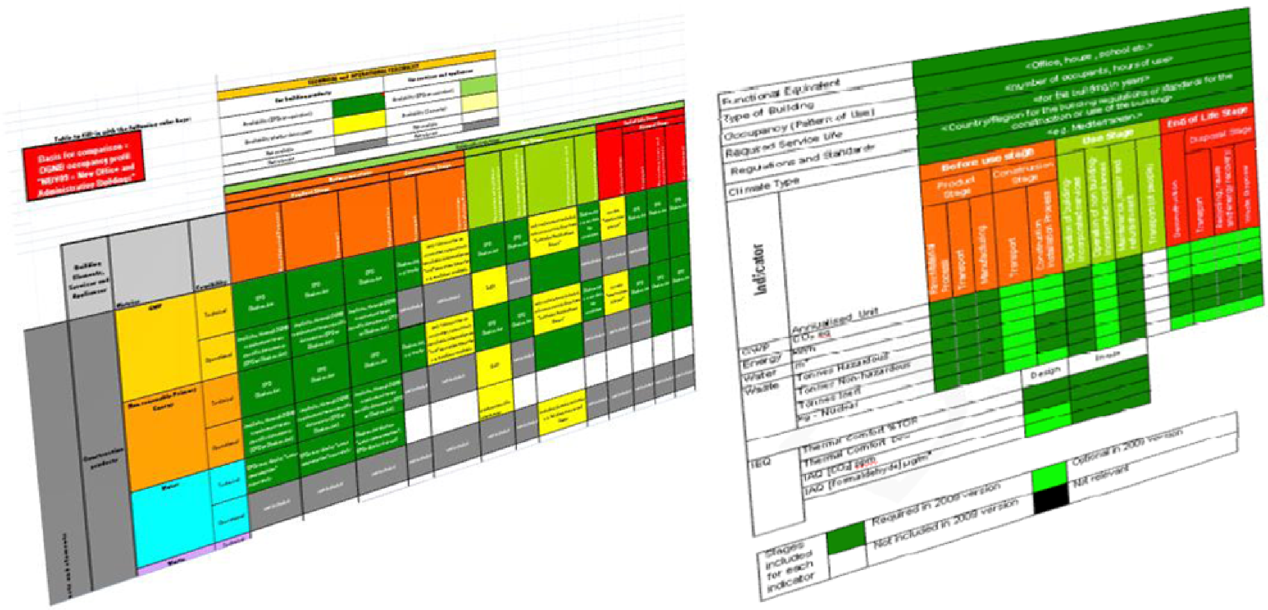

Figure 4: Overview of the two first feasibility tables

3.1.2 Results

The detailed feasibility tables allowed the definition of a common list of building contributors; this was a key aspect for the comparability of the results. Each participating country provided its own national tables and feasibility analysis corresponding to its rating scheme, together with data sources and data availability details.

For easier reading, the main information was gathered in summary tables, as shown in Figure 5. The detailed results are available in the report (HANS et al, SBA report phase 1,(2012)).

	Feasibility based on availability			Conditions for a harmonized practice of SBA Common Metrics	
	Methods availability	Data availability	Tools availability	Conditions and time needed for an optimal feasibility in certification schemes	How SBA framework for Common Metrics needs to evolve?
Contributors for the assessment of environmental impacts (GHG, energy, water, waste)					
Building products / elements (LCA)					
Products (mandatory)	Yes, as LCA is a recognized method (basis: International standard ISO 14040 & 14044) to quantify environmental impacts of building products (basis: European standard EN 15804), systems and buildings (basis: European standard EN 15978)	Data with good quality & coverage available on building products, structural parts or systems for all life cycle stages Increasing availability of EPDs (approx. 200 up to now) and a national data base on construction products available (Ökobau.dat) "DGNB navigator" as database on building products which offers free available information (e.g. also for harmful substances within products Producer specific information	Yes, e.g. "GaBi Software & databases" for conducting the LCA of building products or equipment e.g. "GaBi Build-It" and "LEGEP" for conducting the LCA of buildings by using available data e.g. "simple user-specific Excel-tools" implementing calculation rules acc. to DGNB	DGNB system should expand their indicators mainly for "waste and water" to be consistent with SBA Metrics More input data for the assessment of indicators "waste" & "water" have to be made available, e.g. through increasing the number of EPDs, where such information is given DGNB system should be expanded for the system boundaries (e.g. transport product to construction side)	No evolvement of SBA framework necessary for the implementation of SBA Common Metrics within Germany for the environmental part of sustainability.
Products (optional)					Suggestion to include decorative wall finishes/coatings, doors, heating/cooling systems within mandatory elements
Equipment (optional)					
Aggregation at the building scale	Yes, pre-defined calculation rules available incl. the use of security factors for neglecting specific building parts (e.g. only boiler is accounted for heating HVAC)				
Energy services					
Main building-related appliances	National calculation method: Energieeinsparverordnung (EnEV)	Data available through ENEV calculations, technical data on heating, cooling systems etc	Yes, e.g. "LEGEP", "ennovatis ENEV", TRNSYS, …		
Other building-related appliances	Not available within DGNB system				
Non-building related appliances	Not available within DGNB system	Sporadic EPDs			
Water services					
Building related appliances		Increasing availability of EPDs (approx. 200 up to now) Producer-specific data available		DGNB system should be adapted to include operational and energy related information about water services	
Non-building related appliances					
Assessment of Indoor Environment Quality (design and operation)					
Thermal comfort	building simulation (According to EN 15251, EN 12831,ISO 13792, ISO 13791) Heiz-/ Kühllastberechnung (DIN EN 12831) VDI 2078	Not applicable	Yes, Building Simulation Tools, e.g. Trnsys EnergyPlus Excel - Tools	DGNB is more detailed	Adapt requirements from DGNB
CO_2 concentration	EN 15242 available	Not applicable	Yes, Building Simulation Tools, e.g. TrnFlow	DGNB requirements similar to SBA	
Formaldehyde concentration	Standardized Measurements during operation	Increasing availability of EPDs (approx. 200 up to now) indicating if products contain TVOC or formaldehyde		DGNB requirements equal to SBA	

Figure 5: Feasibility summary results, illustrated for DGNB scheme, for LCA based indicators (GWP, primary energy, water and waste) and IEQ indicators

Relevant differences, for each contributor, in the availability of methods, data, tools and their consideration in the certification schemes have been identified as being due to different conventions. However harmonization of these differences will be possible. The differences highlight the importance of sharing EPD based on a common standard using a methodology at an international level and encompassing the same life cycle stages. On very practical aspects, they also display the need to use a common way to describe buildings and extract the quantity take off(?). The degree of harmonization will be clearly associated to the concept of level of ambition in the number of common contributors taken into account in the framework. For example, it is known that equipment impacts on the SBA metrics, but it is difficult to have access to EPD for equipment in each country and so initiallythe common metrics have to be envisaged without these types of construction products.

3.2 Practical LCA modeling to assess the SBA metrics

In parallel to the technical and operational feasibility work, each partner analyzed at least one building based on the SBA common metrics and with regard to LCA-oriented indicators. The selected buildings met the current standards of sustainable construction, as defined by respective existing national building certification schemes. The objective was to study the applicability of SBA Common Metrics to real buildings, using available input data in each participating country.

The applicability of the calculation rules of the SBA framework was achieved for some indicators (e.g. energy use) but varied in a relevant manner for other indicators (e.g. water use, waste). The modelling exercise also displayed quantitative results for indicators which enabled the estimation of the deviations due to different modeling conventions.

3.2.1 Illustration with the French case study

The general approach for LCA modelling is illustrated by the example of the French case study in the following paragraphs.

In total, 74 real buildings were tested in practical application and calculation of SBA indicators, comparing their results and framework to the practical application of “HQE Performance” Indicators in France. Indeed, 74 buildings (commercial, offices, residential, etc.) were tested using the HQE Performance framework and ELODIE LCA calculation tool, with the help of the HQE certification bodies (QUALITEL subsidiaries and Certivéa) from the period of January to July 2011.

Ultimately, 8 of these buildings were equally modelled and tested under SBA framework which allowed the comparison of the results obtained when considering HQE Performance indicators (that cover a larger perimeter of contributors than SBA), and when considering the SBA indicators with and without its optional contributors (contributors = elements that enter in the calculation process of the indicator).

Today, the integration of life-cycle analysis processes in the building certification procedures may currently present some operational difficulties. This highlighted the importance of the Building Modelling stage in the SBA pilot test: the modelling of real buildings operated by real HQE certified clients, by the certification bodies (CERQUAL–QUALITEL) and by research centre (CSTB) identified difficulties and/or progress already achieved in France in terms of:

- Result of the training of professionals in LCA tools, such as ELODIE®, including the appropriation and generalization of its use by the market stakeholders.

- Data Input process: Recovery of data about products' quantities and products' environmental impacts (EPD, etc.), as well as the identification of the potential difficulties in terms of description and modelling of Buildings;

- Identification of the time needed for data gathering, organization and analysis of that data (regarding the eventual needs of additional information and time, when compared to market normal practice);

- Identification of the necessary procedures and time for the control of the modelled building projects and of the accuracy of the results obtained for each indicator calculated (for third-party certification purposes).

To promote the national and international convergence of approaches and in order to test the integration of the SBA Indicators in the French HQE certification reference frameworks, the French modelling of real buildings was voluntarily done looking at 3 different perimeters of contributors, namely:

- HQE Performance, with all its environmental indicators (17) and its larger amount of contributors (elements taken into account in the calculation of each indicator);

- SB Alliance Indicators, including in the calculation all the mandatory and optional contributors, as detailed in the SBA Indicators Framework (2009);

- SB Alliance Indicators, including only the mandatory elements, and excluding all the optional contributors, which consequently has a specific impact in the accuracy of the values obtained.

The Key Elements for the Modelling process

The modelling process necessarily required the life-cycle analysis of each pilot building, for each of the following stages, referred in the SB Alliance and HQE Performance frameworks:

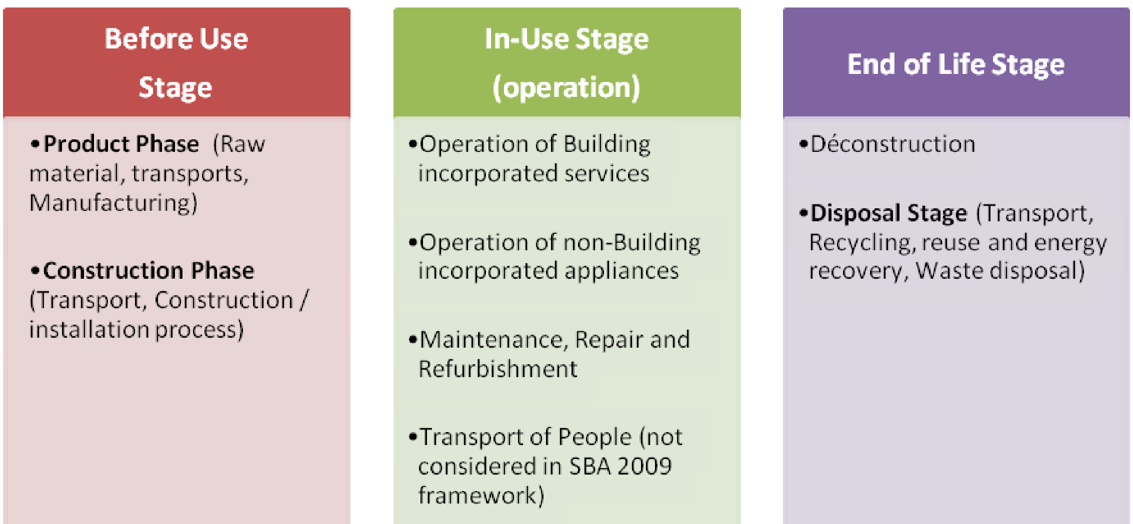

Figure 6: Stages of the building life cycle for the SBA evaluation scheme contributors

By gathering the necessary elements (written pieces of the detailed project, thermal and energy study, drawings, etc.) and by using a life-cycle analysis tool (ELODIE), the detailed modelling of the building was possible, as well as the analysis of its impact regarding each of the indicators.

The main guiding aspects were the following:

- Choice of the estimated service life: 50 or 100 years.
- Building Modelling and Environmental impact analyses done with ELODIE®, which is a software tool, developed by CSTB that allows the calculation of the environmental performance of a building project. This tool is connected to the French database INIES, containing construction products EPD. ELODIE was used by the HQE certification bodies for the HQE Performance and SB Alliance pilot tests.

3.2.2 Case studies results

The aim of this paper is to illustrate the process and the methodology, as well as the results in terms of the decision to build up a common framework of metrics, although the results in terms of the LCA calculation cannot be described. The detailed results are available on the SBA report.

Table 1 below shows the results obtained when calculating the **SBA indicators**, with its perimeter of **mandatory and optional** contributors.

It is interesting to note that Primary non-renewable energy consumption 'at Product stage' consumes 38.2 kWh_{ep}/m^2.year which corresponds to almost 35% of the total non-renewable primary energy consumed during all the life cycle of the building.

Also note that the construction stage is rather negligible but, considering the general absence of data about this building stage and taking into account that some parameters were not filled in the modelling tool, it is hard to appreciate the impact at this stage.

Table 1: Calculation of SBA indicators, with mandatory and optional contributors

Environmental Impacts Summary Table			ALL life-cycle and ALL Modules			ALL Life-cycle : module COMPONENTS (products and materials)			ALL Life-cycle : module ENERGY			ALL Life-cycle : module WATER			ALL Life-cycle : module CONSTRUCTION SITE		
			Total	per year	per occupier	Total	per year	per occupier	Total	per year	per occupier	Total	per year	per occupier	Total	per year	per occupier
Non renewble primary energy		(kWh / m² SHON)	5490	110	289	1908	38,2	100	3374	67,5	178	88,5	1,77	4,66	60,2	1,20	3,17
Water Consumption		(L / m² SHON)	52960	1059	2787	7948	159	418	1086	21,7	57,1	43484	870	2289	221	4,43	11,6
Waste	Hazardous	(kg / m² SHON)	13,7	0,27	0,72	1,71	0,03	0,09	0,0051	0,0001	0,0003	11,93	0,2385	0,6276	0,0229	0,0005	0,0012
	Non-Hazardous	(kg / m² SHON)	527	10,53	27,7	517	10,3	27,2	0,8817	0,0176	0,0464	8,52	0,1703	0,4483	0,0493	0,0010	0,0026
	Inert	(kg / m² SHON)	2685	53,71	141	2572	51,4	135	83,7	1,67	4,41	22,3	0,447	1,18	3,53	0,07	0,19
	Nuclear	(kg / m² SHON)	0,1096	0,0022	0,0058	0,0487	0,0010	0,0026	0,0542	0,0011	0,0029	0,0022	0,0000	0,0001	0,0023	0,00005	0,0001
Global Warming Potential		(kg équivalent CO2 / m² SHON)	1049	21,0	55,2	539	10,8	28,4	479	9,59	25,2	26,5	0,5297	1,39	2,32	0,0463	0,1219

4. Conclusions

The modeling exercise offered an insight on how the definition of the building contributors or life cycle stages (considered according to the first draft of the SBA framework) influenced the accuracy, and consequently, the comparability of results, and how these definitions depend on the philosophy and scope of the rating tools and calculation methods. By using results from real buildings, the pilot test has permitted the proposal of recommendations on how to consolidate the indicators for the participating rating tools as well as a robust development of further common indicators. It is also remarkable that the availability of homogeneous EPD in each country will mean that as many contributors as possible can be takeninto account .

Regarding the feasibility and modelling results and their relative heterogeneity, different levels of SBA common metrics were suggested, that may be called "Ambition Levels", allowing an improvement of maturity versus time as described in Figure 7.

	Non-renewable Primary Energy	GHG emission	Water	Waste (Hazardous, Non-Hazardous, Inert, Nuclear)	Comment
Building products and equipments (LCA)	Significant	Significant	Negligible	Very significant	Mandatory contributors to be specified
Operational energy-related services	Very significant	Very significant	Negligible	Negligible excepted Nuclear waste	Mandatory energy uses to be specified
Operational water-related services	Negligible	Negligible	Very significant	Negligible excepted Hazardous waste	Environmental profiles to be developed more

Key:
- Level 1
- to be added for Level 2
- to be added for Level 3
- to be added for Level 4

Note : the significance has to be interpreted relatively to each column

Figure 7: Levels of ambition proposed for the SBA scheme

Starting with the current and strict intersection between all the partners' results, it appears as a very narrow frame, including only non-renewable primary energy and GHG emissions and only during the operational phase. This is the minimum common core, named "Level 1". As these 2 issues are of course of great importance for every country, it should be necessary to go more deeply in the conventions and calculation rules, in order to ensure a high degree of comparability between rating systems. The study also shows that the contribution of building products and equipment is significant on three LCA indicators (energy, GWP, waste). This is crucial with energy efficient buildings and even more with plus-energy buildings. Furthermore, regarding the water indicator, the first short term aim is to develop an accurate and harmonized method for quantifying operational water use.

Upon completion of this research towards a framework of common metrics, it is anticipated that better harmonization between rating tools will pave the way for cross-tool comparability, for example, using a common core of (SB Alliance) indicators. Once a common methodology is agreed, these scientifically measured indicators could constitute a future “environmental building declaration” – a stable basis shared by various rating tools.

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