Analysis of five approaches to environmental assessment of building components in a whole building context

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The report at a glance

The study examines four international building certification schemes (BREEAM (UK), LEED (US), DGNB (DE) and HQE (FR)) as well as the so-called Cradle-to-Cradle concept.

On the overall level, a wide and heterogeneous array of material and building aspects and impacts are evaluated together In the labeling schemes studied, resulting in a loss of detail. Therefore, readers with a focus on material performance are suggested to study Environmental Product Declarations (EPDs) including the use stage of the building for the relevant materials.

The most important findings are:

- In all building certification schemes, the direct environmental life cycle performance of the selected building materials and products appears to be less important for the final rating than commonly thought, accounting at most for about 5% of the total score. The building materials and products may, however, also have a significant indirect influence on how the building performs in energy-related categories that are accounted for separately.
- The DGNB and the HQE schemes seem to follow the provisions in the upcoming European standards EN 15804 and EN 15978 as close as possible and they are therefore well suited to describe the material and building impacts during building lifetime.
- The US-based LEED scheme and the Cradle-to-Cradle concept do not use any kind of quantitative information about the life cycle environmental performance of materials and products. LEED, however, gives a small credit if EPDs are available.
- The HQE and DGNB schemes require that life cycle assessments (LCA) of building products are available. In DGNB, the LCAs are an integral part of calculating and rating the building performance, while HQE rewards the calculation of the contribution from building products, but not necessarily the results. However, if the life cycle results are used actively, e.g. in the choice of products, the overall rating of the building may improve
- The UK-based BREEAM scheme appears to use an LCA approach which is not in full accordance with international standards and practice.
- In a building lifetime perspective it should be remembered that differences with respect to “fitness for use” of building materials often are much more important than the differences measured by assessments in which their function is not considered. This information should be available from good quality Environmental Product Declarations, and it is obligatory to consider these aspects in the HQE scheme

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Executive summary

The study examines four international building certification schemes (BREEAM-UK, LEED, DGNB and HQE) as well as the so-called Cradle-to-Cradle concept.

The report provides an overview of two elements in building certification. As the first focus point it is examined how important it is to have quantitative information of the environmental impacts caused by construction product and materials. The importance is judged by looking at how high a score that can be achieved by having the "right" knowledge or by using the "best" products". Secondly, the study looks at the relationship between the format and content of the quantitative information used for building certification on the one hand and as input to relevant European buildings standards (EN 15804 and EN 15978) on the other. This relationship – or lack of same – is important for building product manufacturers wishing to supply information to current and future customers in the most cost-efficient way.

On the overall level, a wide and heterogeneous array of material and building aspects and impacts are evaluated together in the labeling schemes studied, resulting in a loss of detail. Therefore, readers with a focus on material performance are suggested to study EPDs including the use stage of the building for the relevant materials.

With respect to the importance of life cycle environmental information in building certification schemes, the UK-based BREEAM certification scheme clearly is the one giving most weight on the measurable environmental performance of materials and products. Six important building components are assessed, and their combined score will constitute up to 6% of the overall environmental score of a building. The German-based DGNB scheme includes an assessment of "all" building components, but because the results are combined with the results for life time operation of the building, the overall importance of the life cycle impacts of the materials is only about half of that calculated in BREEAM, about 3%. The study concludes that using the approach of DGNB, the materials and products gives a contribution to the overall scoring that matches their environmental impacts very precisely with respect to the global, regional and local environmental impacts addressed in the currently eleven criteria for ecological quality in DGNB.

The French HQE scheme requires that significant amounts of life cycle information in the form of Environmental Product Declarations be made available and used for calculation of the contribution of building products to the life cycle environmental impacts. If the information is used actively, e.g. to choose products with less environmental impacts, then the overall rating of the building may improve. The US-based LEED scheme does not use quantitative environmental information about materials in its assessment and certification of buildings, although a small fraction (about 1-2%) of the number of points are awarded if substantial amounts of EPD information is available. The C2C concept for certification is currently not aimed at buildings, only single products, and it does not use quantitative life cycle information at this level.

In all building certification schemes, the quantified environmental life cycle performance of the selected building materials and products appears to be less important than commonly thought, accounting at most for about 6% of the total score. The building materials and products may, however, also have a significant indirect influence on how the building performs in energy-related categories that are accounted for separately.

Although the life cycle environmental impacts of many insulation products are very similar, they may differ significantly with respect to product quality and fitness for use. Only the HQE scheme requires directly that the fitness for use is considered for each product. For insulation products, the fitness for use is an important feature over the whole life time of the building. If the insulation material settles – as is often the case for some types of loose-fill insulation, the building energy consumption will increase significantly. As will other quantified environmental impacts and – in the end – also the building environmental performance.

The upcoming European standards EN 15804 and EN 15978 are emerging as commonly accepted vehicles for exchange of environmental information for building products and whole buildings, respectively. If the information established by using the provisions in the standards also can be used for building certification in private schemes like those examined in the present study, this is a great advantage for all suppliers of building materials and products because they do not have to make more than one life cycle assessment (LCA), or - at worst - a basic LCA with small modifications related to national or technological differences.

The German-based DGNB scheme can use the information in an Environmental Product Declaration made according to EN 15804 as a direct input to its calculations. There is also a large product database available for DGNB certification in Germany, and the format of the data in this database corresponds very well to that of EPD's conforming to EN 15804. The data quality of the database is not known in detail, nor has it been assessed whether it is representative for building products from countries outside Germany. Allegedly, tailor-made software solutions can establish results that represent European average conditions, although 10% must added to the environmental impacts when generic product data are used.

The French HQE scheme primarily interacts with French national standards (NF P01-010 and XP P01-20-3), but with the new criteria published in autumn 2011, the HQE scheme accepts equivalent European standards (EN 15804 and EN 15978, respectively). In practice, the revised HQE scheme may therefore very well accept that EPDs made according to CEN standards are integrated in the calculations of life-time building performance which are part of the requirements in the scheme. Also for HQE certifications is a large EPD database available, conforming to the requirements in NF P01-010 and in the future also EN 15804 (www.inies.fr).

Currently, the UK-BREEAM scheme only accepts life cycle information established using the scheme's own methodology and it is very uncertain whether existing EPD's in the BREEAM database are established in a way which makes them suitable for use as substitutes for EN 15804-conforming EPD's in a total building assessment according to EN 15978. LEED and C2C neither require nor supply quantitative information that can be used in relation to the upcoming European standards, but it is mentioned that LEED gives credit to builders who collect EPD information for selected products and materials, even though there are no requirements regarding active use of this information..

The life cycle calculations made in both BREEAM, HQE and DGNB are fairly complex. The method used in the BREEAM UK for rating of products is very intransparent, combining traditional LCA elements with subjective weighting factors and dynamic changes in scoring. DGNB also apply a weighting step in the final step for scoring and rating of a building, but the weighting is done in a very transparent way, with all the preceding assessment steps being based on sound LCA methodology. The French HQE scheme compares the impacts from selected products and materials to the total life cycle impacts of the building, but does not require that specific quantitative targets be met.

In conclusion, the quantitative environmental product information used in the German-based DGNB scheme seems to be very similar to that produced in EPD's according to EN 15804, with respect to both general system boundaries and presentation format. The information formerly being required in the French HQE scheme is being aligned to meet the format used in EN 15804. ENEN

The report was commissioned by Eurima, the European Mineral Wool Manufacturers Association. It expresses, however, only the opinion of FORCE Technology, being based on years of experience with Life Cycle Assessment of building products.

1 INTRODUCTION TO THE REPORT

Environmental assessment of buildings, building components and building materials is becoming increasingly important for builders and entreENeurs all over the World. The ultimate goal is often to make a sustainable building and an integral element in this is to ensure that it is build of sustainable components and materials. There are, however, also many other relevant elements, and a number of building assessment schemes have emerged during the past decades, each addressing their selection of relevant elements. In Europe, BREEAM has been widely used for many years, but the German-based DGNB-scheme is becoming more and more popular. The French HQE scheme is increasingly used in France, and the US-based LEED scheme is also known in many European countries.

Having a life cycle perspective in building assessments is seen as crucial by most specialists, simply to prevent choosing sub-optimal solutions. Another important factor for a general approval of a scheme is that the assessment is made by a standardized method. In this context, the upcoming European standard EN 15804 (alone and in combination with EN 15978) may prove to be an important step towards a common framework for data collection and handling. Many national standards for product assessment are, however, still in demand, e.g. the British BRE, the Dutch MRPI and the French NF P01-010, and on the international level, certification schemes like Cradle-to-Cradle (C2C) are seen as a possible way of ensuring that products are sustainable.

The report analyses five commonly used approaches to environmental assessment of building products. Four of these approaches (BREEAM, LEED, HQE and DGNB) integrate some form of product assessment in an assessment of the whole building, including also social, cultural and economic aspects. The C2C concept primarily targets products alone, but is probably also applicable on the building level.

The analysis of the four schemes for whole building assessment focus on how the environmental performance of building materials and components is quantified in the context of the whole building. The analysis follows the steps from the initial data collection until the point in the process where a final score, e.g. a number of credits, is assigned to the chosen materials/components. For the C2C concept the analysis focus on what kind of environmental knowledge about building products and materials is made available by the basic steps in the certification process. It is also discussed how (and if) the information can help ensuring the sustainability of the whole building.

For each certification scheme, the report briefly discuss the problems that may emerge when a national scheme (e.g. German or UK-based) is adopted for use in another country or region. The focus for this discussion is on environmental criteria as well as databases, examining on a general level the relationship between the certification schemes and the upcoming European standards on Environmental Product Declarations (EN 15804) and Assessment of the environmental performance of buildings (EN 15978).

The report does not make any direct comparison between the examined schemes, nor does it discuss the quality of the final building assessment to any significant extent. It gives, however, an insight into some details that are believed to be of interest for the building community when discussing how the measured environmental performance of building products is used to assess building sustainability at a more general level. It also gives building product manufacturers information about the differences between data collection, handling and presentation in the examined schemes. The differences are often small, but it is nevertheless seldom possible to directly exchange information between schemes. Instead, a dedicated assessment must be made for each scheme.

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2 BRE ENVIRONMENTAL ASSESSMENT METHOD (BREEAM)

2.1 INTRODUCTION TO BREEAM

BREEAM is a voluntary measurement rating for green buildings that is operated in the UK by the Building Research Establishment (BRE), which describes itself as an independent and impartial, research-based consultancy, testing and training organisation.

The first version of BREEAM was introduced in the UK in 1990, and an international concept was presented in 2008. Today, at least 115,000 buildings have received a certificate[1], the main part being situated in England. After the international introduction, 176 projects have been registered in Europe, and 27 projects have been certified (Birgisdottir, 2010)[2]. Residential homes dominate in the UK, while commercial buildings, especially retail and office, dominate on the European level.

The BREEAM scheme distinguishes between at least 11 different building types, plus a “bespoke” category in case a suitable pre-defined category does not exist. The present report does, however, not examine the differences between criteria for different building types.

The present description is based on the document “BREEAM Offices 2008”, BREEAM Scheme Document SD 5055, version 4.0 of 01/05/2010. Please note that other building types than offices may have slightly different scoring systems, and the values and percentages presented in the report shall therefore primarily be seen as a representative example of how the BREEAM system works in general.

2.1.1 THE BASIC SCORING AND RATING SYSTEM

The very basic concept of the rating and scoring system is that the performance in ten “Sections” is assessed and the appropriate credits are awarded to each section according to the criteria. Subsequently, the importance of each section is given a weight where after the weighted section scores are calculated and aggregated into a single score, measured as percent of maximum achievable. This score is then compared to the scores defining “pass”, “good”, “very good”, “excellent” and “outstanding”, giving the overall rating of the building.

About 107 basic credits are available in total, but when they are weighted with their relative importance, the number of available “”Section points” amounts to about 130-135, depending on the building type.

2.1.2 WEIGHTING OF SECTIONS AND OVERALL SCORING

The relative importance of the BREEAM sections is determined not only by the number of credits available in each section, but also by a weighting factor applied to each section. The typical number of available credits can be seen in Table 1, together with the sections weightings currently applied in BREEAM assessments. It is noted that the same weightings also are used in the most recent manual from BREEAM[3].

[1] BREEAM Scheme Document SD 5055, version 4.0 of 01/05/2010.
[2] Birgisdottir H (2010). Sammenligning af certificeringsordninger for bæredygtig byggesektor. Presentation from the Danish Building Research Insitute.
[3] BREEAM (2011). New construction. Non-domestic buildings. Technical Manual SD5073. Version 1.0:2011.

BREEAM section	Credits available	Section Weighting	Weighted Section score
Management	10	0,12	12
Health & wellbeing	14	0,15	21
Energy	21	0,19	39,9
Transport	5	0,08	4
Water	6	0,06	3,6
Materials	12	0,125	15
Waste	7	0,075	5,25
Land use & ecology	10	0,1	10
Pollution	12	0,1	12
Innovation	10	0,1	10
Highest possible score	**107**		**132,75**

TABLE 1. WEIGHTING AND SCORING OF BREEAM SECTIONS. BASED ON BREEAM (2011)

For Materials, 12 credits out of a total of 107 are available, corresponding to 11.2% of the total. When considering that 6 out of 12 credits in the Materials section are awarded based on life cycle assessments it can be calculated that 5.6% of the total available score is based on actual life cycle considerations and calculations as they are made using the BRE Environmental Profiles Methodology. This method is presented and discussed in some detail in the following sections.

This picture does not change significantly when the section weightings are applied. In this case, Materials account for 15 out of a total of 132.75, corresponding to 11.3%. When applying the section weightings to the Energy section, the importance of this section increases significantly from about 20 to 30%.

2.2 Importance in BREEAM of LCA results for materials

Life cycle aspects are explicitly handled in the “Materials” category. Depending on the building type, 12-15 basic credits are available in the category, corresponding to 11-14% of the total amount of credits available for the building. It is noted in this context that the importance of the materials differs slightly from one building type to the other.

Criteria ID	Criteria	Number of credits available	Based on the Green Guide to Specification
Mat 1	Materials specification for major building elements, using Green Guide Ratings (see 2.3.2). The major building elements are specified below.	4-6 (4 for offices)	Yes
Mat 2	Use of A+ or A-rated materials for hard landscaping and boundary protection	1	Yes
Mat 3	Re-use of existing facade	1	No
Mat 4	Re-use of existing structures	1	No
Mat 5	Responsible sourcing of materials	3	No
Mat 6	Insulation (2 credits available (one for embodied impact, one for responsible sourcing))	2	Partly (one credit)
Mat 7	Designing for robustness (e.g. adequate protection of exposed parts of the building)	1	No

It is also noted that only 6-8 of the 12-15 credits in the “Materials” category are based on quantified environmental information obtained through the BRE Methodology for Environmental Profiles of Construction Products (see 2.3) and condensed in the Green Guide Ratings available from the BRE Green Guide to Specification (see 2.4). The credits are awarded in the Mat 1, Mat 2 and Mat 6 criteria, while seven credits are reserved for qualitative assessments regarding re-use of existing building elements, responsible sourcing and robust design. Each of these qualitative elements improves building sustainability, but is not suitable for a quantitative approach.

LCA results that are rated in the BRE Green Guide to Specification are thus used in BREEAM to assign maximum one credit to each of the following eight elements:

- External walls
- Windows
- Roof
- Upper floor slabs
- Internal walls
- Floor finishes/coverings
- Hard landscaping and boundary protection
- Insulation

Not all of the above elements are included in all building types, and their inclusion also depends on the building assessed being new or fit out.

The remaining 6 credits in the Materials section are not awarded based on quantitative LCA information but to the following very generally description of the criteria:

- "Mat 3": Re-use of facade, e.g. if 50% of the existing facade area is re-used, gives one credit
- "Mat 4": Re-use of structure, e.g. if at least 80% by volume of an existing primary structure is re-used, gives one credit
- "Mat 5": Responsible sourcing of materials, e.g. by choosing materials and products with appropriate 3rd party certification, can give 2 (fit out) or 3 (new builds/refurbs) credits
- Mat 6": Choice of responsible sourced insulation gives one credit
- "Mat 7": Design for robustness, recognizing and encouraging protection of the buildings and the landscape, gives one credit

These criteria are therefore not addressed further in the report.

2.2.1 The relative importance of material/product manufacturing and building operation

The BREEAM ratings are based on cradle-to-grave LCA's, using allocation rules and end-of-life scenarios defined with a specific view to UK environmental conditions. As such, the ratings can be seen as a crude assessment of the environmental impacts caused by selected building elements and the potential score of 5.5% of the total as an indication of the importance of materials in the overall picture.

Since the use stage of the building is not included in the LCA calculations, the interaction between the building elements, the whole building, and its external environment is not a part of the calculations. It is, however, obvious that operational impacts have a relatively high importance with the Energy section accounting for 30% of the total number of available credits. It is outside the scope of this report to investigate how easy it is to achieve the credits in the Materials and Energy sections, respectively. A crude indication of the relative importance is however possible, knowing that choosing materials with A or A+ rating is awarded the same amount of points as having a calculated energy/CO_2 performance that is 60% better than a building fulfilling the requirements in the 2006 Building Regulations.

2.2.2 Other product or material related criteria with relevance for health and environment

One credit is awarded in the Health and well-being section to products that have been tested and meet relevant standards for emissions of Volatile Organic Compounds (VOC). It is a requirement that a wide range of the building products (including wood panels, floorings, ceilings and wall coverings) used in the house be tested for their properties. One credit is available for compliance with the VOC criteria, i.e. less than one percent of the total amount of credits.

2.3 BRE Environmental Profiles Methodology

The "Methodology for Environmental Profiles of Construction Products"[4] is the core LCA method used to assess and rate the materials and products used in construction. The assessment can only be done by specially trained BRE consultants, and LCA's made by other consultants or in other schemes will most probably not be accepted, unless they are made in full accordance with the BRE requirements.

[4] BRE (2007). Methodology for Environmental Profiles of Construction Products. Draft August 2007. Downloaded March, 2011 from http://www.bre.co.uk/filelibrary/greenguide/PDF/Environmental_Profiles_Methodology_2007_-_Draft.pdf

The methodology paper allows for an examination of some of the most important elements in the concept, as outlined in the following sections.

Basically, the environmental profile and rating of a construction product is established through a number of steps, starting with the development of a conventional LCA profile as known from many other methodologies and in accordance with the requirements in ISO 14040:

- A life cycle inventory is calculated using a cradle-to-grave approach
    - End-of-life scenarios are defined in the methodology, based on current conditions with respect to recycling rates. The modeling of these scenarios in checked with manufacturers for appropriateness and tailored models are created where evidence is available for particular disposal practices. The publicly available datasets do not contain information at this level of detail and it is therefore not possible to judge whether the system boundaries are comparable to those now being specified for use in EN 15978.
    - The methodology uses the order of preference for allocation as recommended by ISO, i.e. with sub-division of processes being the preferred approach, followed by allocation based on physical properties. In practice, however, economic allocation is applied in most cases, most prominently in waste treatment and recycling processes.
- The in- and outputs of the inventory are classified and characterised with respect to 13 impact categories. The impact categories addressed by the Dutch CML-method are commonly used and internationally accepted as scientifically valid, whereas categories like "Waste disposal", "Water extraction" and "Freight transport" are unique for the BRE methodology and not necessarily recognized by the international LCA society.
- The characterised environmental impacts are normalized by dividing the impacts by the annual environmental impacts caused by one UK citizen, giving all impacts categories the units of "per year". The normalized results thus give a good indication of which impact categories are most affected by a product (i.e. the ones with the biggest contribution per year), but it is underlined that the biggest contribution as measured by this approach is not necessarily the most important. Determining this is to a large extent a subjective process called weighting. A weighting step is not allowed for product comparisons according to the ISO 14040 standard, but the BRE methodology nevertheless integrates an additional weighting step in its rating procedure, as outlined in the following section.

2.3.1 Weighting in the BRE methodology

While the first steps in the BRE methodology essentially are science-based, the final steps do not conform to the applicable ISO 14040 standard, stating in clause 4.3 k) that "there is no basis for reducing LCA results to a single overall score or number, since weighting requires value choices". In the BRE methodology, the normalized LCA results are subjected to a valuation scheme using weights developed in panels representing the perspectives of interest groups drawn from across the UK construction industry. The weights used in the scoring and rating process are presented in Table 2. The table includes both the weights used in a previous (2002) version of the Green Guide and the weights currently applied.

Environmental issue	Weighting (%) 2002-edition[5]	Weighting (%) 2007-edition
Climate change	38	21.6
Water extraction	5.4	11.7
Mineral resource depletion	3.5	9.8
Stratospheric ozone depletion	8.2	9.1
Human toxicity	7.0	8.6
Ecotoxicity to water	4.3	8.6
Nuclear waste	n.a.	8.2
Ecotoxicity to land	n.a.	8.0
Waste disposal	6.1	7.7
Fossil fuel depletion	12	3.3
Eutrophication	4.3	3.0
Photochemical ozone creation	3.8	0.2
Acidification	5.1	0.05

TABLE 2. WEIGHTINGS FOR ENVIRONMENTAL PROFILES

In the valuation step, the normalized results in the single impact categories are multiplied with the weight assigned to that specific category, thereby creating an "Ecopoint" score. Combined with the normalization step, 100 Ecopoints are equivalent to the impact of one Western European Citizen for one year.

It is outside the scope of this report to go into detail with respect to the weighting approach. Some critical (and to some extent also subjective) remarks are, however, believed to be in place:

- The concept for weighting and the first weights were developed in 1999 by interest groups from the UK industry. The weights have been revised since then (see Table 2), but seen in today's (2011) context - and applying a European perspective – the weights can at best be considered as arbitrary and at worst they give a wrong focus for environmental efforts to be done by the construction industry, broadly defined.
- The development is weightings shows that the focus may change significantly in just a few years
- It is noteworthy that the weight of impact categories included in the upcoming CEN standard EN 15804 constitutes less than 50% of the total weighting in the BRE Methodology
- The regional impacts categories acidification, eutrophication and photochemical ozone formation only account for 3.25% of the total weight. These impact categories are regarded as important in especially North European and Scandinavian countries.

[5] Anderson J, Shiers DE & Sinclair M (2002). The Green Guide to Specification. An environmental profiling system for building materials and components. Third edition. Blackwell Science.

2.3.2 Rating in the BRE methodology

Calculating the rating in the BRE Green Guide to Specification is the final step in the LCA process – and at the same time the first step in the overall assessment of materials in the context of whole buildings. Unfortunately, the rating system is only described very briefly in publicly available documents, and the following outline of the process may therefore not be 100% correct in all details.

The Green Guide ratings are obtained by calculating the environmental profile for all common construction specifications for a particular element, for example roofing. The range of impacts, from lowest to highest, is then divided into six categories, "A+" to "E". Ratings are given to performance in each environmental impact category and in an overall, summary category. In the 3rd. edition the of The Green Guide to Specification (Anderson *et al.,* 2002) each rating category was of the same numerical range, and this approach can very well have been continued in later updates.

2.4 The BRE Green Guide to Specification (BREGGS)

The BRE Green Guide to Specification (BREGGS) is a central tool in the process of awarding credits to materials, based on their measurable environmental performance in a life cycle perspective. BREGGS is a publicly available compilation[6] of the ratings achieved by a given product, with A+ being the best rating and E being the worst. As described above, ratings are given to individual impact categories as well as an overall, summary category. Also, the publicly available product profile gives a figure for CO_2-emissions, assumedly as calculated in the initial steps of the LCA. The calculated number of Ecopoints was available in earlier versions of the public profile, but this information cannot be found in the currently available versions.

The manufacturer of a product receives a certificate, showing the contribution to the environmental impacts (the characterised results) per functional unit as well as the normalized impacts. The certificate also informs about the Ecopoints score, but it does not give any information about the rating of the specific product. The reason for this can be that the rating system is dynamic. If a high-impact product is withdrawn from the market the full range of the remaining products changes, with accompanying consequences for each of the products. A hypothetical, but realistic example can be established, see Box 1.

> As of March 2011, the BREGGS product category "Insulation" contains 36 products. 17 of these are rated A+, 11 are rated A, 4 are rated B, 3 are rated C and one is rated E. If the E-rated product is withdrawn from the market, the range for the remaining products narrows considerably and the products currently being C-rated will now be E-rated. Likewise, B-rated products may change to C- or D-rating, and some of the A+ products will probably be rated A or maybe even B. Similar changes in existing rating will also occur if a product is introduced with much better environmental properties than other products in the same product group.

BOX 1. A HYPOTHETICAL EXAMPLE OF THE DYNAMICS OF BREGGS.

[6] BRE Green Guide to Specification. http://www.bre.co.uk/greenguide/podpage.jsp?id=2126

The BREGGS is used directly to assess the criteria regarding “Materials for hard landscaping and boundary protection” and “Insulation”. For both elements, one credit is awarded if the products/materials used are rated A+ or A in BREGGS.

For the 4-6 major building elements credits are awarded by combining their individual BREGGS ratings in a transparent scoring system, taking into consideration two relevant factors:

- More than one material can be used in a given building element. For example, floor finishing may be carpets in some rooms and linoleum in others. When this is the case, the individual materials are weighted based on the area they cover.
- The building elements are of different size/area, and they are therefore weighted accordingly. As an example, floor finishes constitute a much larger area than the roof in a multi-storey building.

The scoring system is, however, supplemented with a final adjustment with very little transparency. The BRE Manual explains the adjustment process in this way: “The final adjustment relates to the Ecopoints range for each assessed element. This adjustment ensures the environmental impact of the element in relation to the impacts of other assessed elements within the building is considered. For example; the external walls have a larger Ecopoints range than the internal walls, therefore, if both elements achieve the same Green Guide rating the rating of the external walls achieves a higher proportion of the overall points than the rating for the internal walls, thus recognising the relatively higher reduction possible in the environmental impact of the external walls, due to the larger Ecopoints range for that element”.

2.5 Overview of rating procedure for building materials and products

Figure 1 presents an overview of the complex procedure used to establish a BREEAM rating for relevant materials.

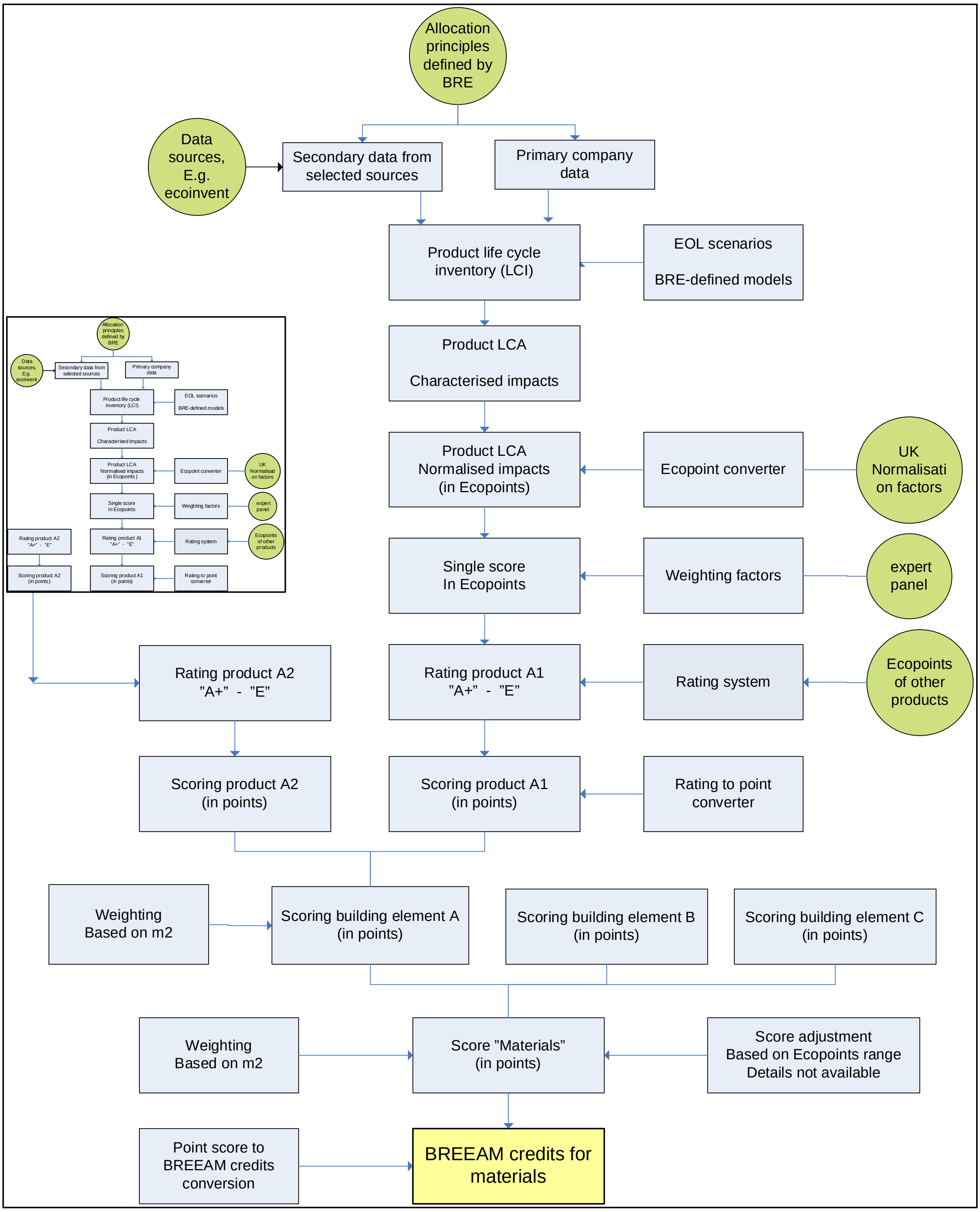


FIGURE 1. OVERVIEW OF ELEMENTS IN THE BREEAM RATING PROCEDURE. CIRCLES DENOTE DIFFERENT TYPES OF INPUT.

2.5.1 WEAK POINTS IN THE BREEAM RATING PROCEDURE

Seen in the perspective of using the BREEAM rating system on an international/EU level, the following elements are considered to be the major weak points:

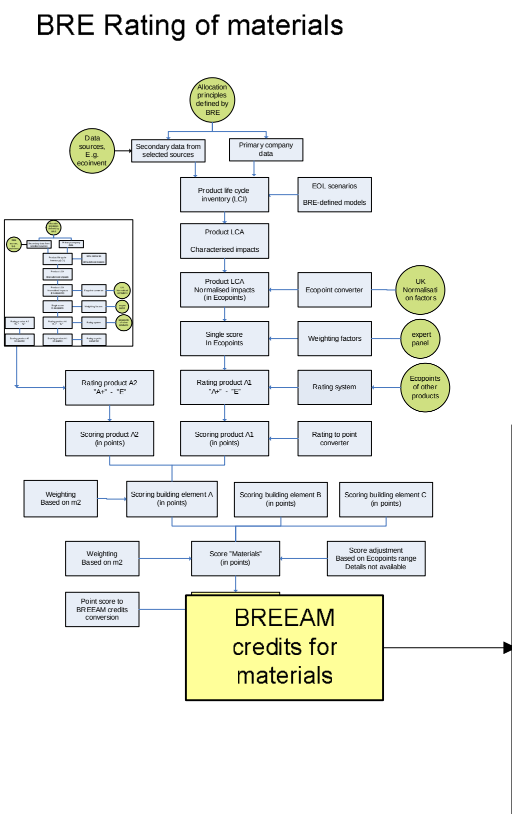
- The end-of-life scenarios used to calculate the life cycle inventory are based on UK conditions with respect to actual disposal routes. Other countries (and maybe even specific producers) may have very different distribution of treatment routes, leading potentially to large deviations in life cycle inventories.
- UK normalization factors are used for conversion of characterised LCA results to eco-points. Also here, other countries may deviate from average UK conditions.
- A UK expert panel is used to establish weighting factors, which in turn are used to calculate a single score for a material. This approach is not in accordance with ISO 14044. Being value-based, the approach can introduce a very large bias, even if a consensus-process is applied.
- The rating of a given product depends on how competing products perform in the UK. This can be seen as a dynamic feature, motivating product developers to improve their products, but for many stakeholders it may cause much confusion if ratings are subject to frequent changes following introduction of new products (or withdrawal of old) on the market.
- The score adjustment process is not transparent, so neither material producers nor BREEAM users have a chance to see the consequences.

The first four bullet points are closely related to the fact that the BREEAM system was developed to assess buildings in the UK and not international buildings in general. For an adoption of BREEAM in other countries to be meaningful, national figures should substitute UK-specific figures wherever relevant, or a different calculation method should be established and used as has been done in the Netherlands (see 2.8).

2.6 Overview of the BREEAM scoring system

As stated earlier, the life cycle based assessments of (selected) materials following the BRE methodology may account for up to 5.5% of the overall score for a building, and all elements in the Materials section may add up to about 11% of the total score. It is outside the scope of this study to discuss whether the importance assigned to materials in this way is too high, suitable or too low. There is, however, little doubt that the importance by most stakeholders will be regarded as significant, with the potential of changing the rating of the building.

Figure 2 shows how the BRE rating of materials is integrated in the overall BREEAM scoring through assignment of weights to the Materials section and the other nine sections.



Overall BREEAM scoring

BREEAM section	Credits available	Section Weighting	Section score
Management	10	0,12	12
Health & wellbeing	14	0,15	21
Energy	21	0,19	39,9
Transport	5	0,08	4
Water	6	0,06	3,6
Materials	12	0,125	15
Waste	7	0,075	5,25
Land use & ecology	10	0,1	10
Pollution	12	0,1	12
Innovation	10	0,1	10
Highest possible score	**107**		**132,75**

FIGURE 2. THE ROLE OF THE BRE RATING OF MATERIALS IN THE OVERALL BREEAM SCORING

2.7 RELATIONSHIP BETWEEN LCA IN BREEAM AND EPD'S AFTER EN 15804

The purpose of making LCA of materials in BREEAM is to make an evaluation of the sustainability of the materials used – and how they contribute to the overall sustainability of the building in a cradle-to-grave perspective. To do so, the basic, characterised, LCA results are subjected to further processing as described above.

In contrast, an EPD made according to EN 15804 only requires that characterised cradle-to-gate results are presented. Subsequently, data for each material/product can be aggregated according to the EN15978, together with data on other materials and using the same EN 15804 reporting format. Likewise, typical data for construction, use and disposal can be used to establish relevant optional information modules as described in the standard.

At the tangible level, neither BREEAM ratings nor the underlying LCA calculations conform to the basic requirements in EN 15804 in this stage, e.g. with respect to system boundaries, allocation rules, data quality and general comparability. The consequence of the very specific requirements in the BRE Environmental Profiles Methodology is therefore that neither full LCA's nor condensed EPD-results can be used in other building assessment schemes – or as input to EN 15978, equivalent to that obtained from a EN 15804 compatible LCA or EPD.

On the more detailed level, some of the basic inventory calculations in the BREEAM system and the underlying considerations may be usable for making an EPD according to EN 15804. However, given the fact that the BRE Methodology is almost ten years old and that both inventory considerations (e.g. system boundaries and allocation rules) have been developed continuously all over the World, it is not very likely that the existing information behind BREGGS can be translated into EN 15804-relevant information to any significant extent unless large resources are devoted to the task. As a final potential barrier to the use of BREEAM data on a general European level, it is seen as questionable whether they can fulfill the data quality requirements in EN 15978, e.g. clause 10.4 stating that "the scenarios and system boundaries of the data used should be consistent at the building level and shall be relevant to the building that is the object of the assessment". There is, however, not yet any practical experience with neither EN 15804 nor EN 15978, and the final acceptance of data from different sources will depend on how the standards are interpreted by certification and verification bodies.

A much more viable possibility is to open BREEAM for EPD's that are made according to other standards, primarily EN 15804, accepting in a transition period that existing and "new" LCA results are not necessarily fully comparable. Such an approach requires significantly fewer resources and all core elements in the rating procedure (except for allocation and EOL scenarios) can remain virtually unchanged.

BREEAM does not report the type of information which in an EPD made according to the requirements in EN 15804 is reported in Module D. The information typically considers the loads and benefits of recycling, looking beyond the system boundaries of the building. It is likely that much of the information can be found somewhere in the system, but it is not very likely that the format corresponds to the basic requirements in EN 15804, calculating the **flow** of secondary materials out of the system and the **impacts** of recycling these materials to a quality where they can substitute virgin materials in a new application.

2.8 Adoption of BREEAM in other countries

BREEAM is used in a number of countries other than the UK. It is outside the scope of this report to give details about the implementation of BREEAM in a given country since this undoubtedly will vary from one country to the other.

At the very general level BREEAM International promotes the use of local best practice codes and standards where such standards exist in a country or region. At the more practical level this may have large implications for the actual scoring and rating process on both the material level and the total building level.

A good example of this is the Dutch approach with respect to assessment and rating of Materials7. The same total number of credits is available in the Materials section as it is in the UK version, and equal amounts are awarded to re-use and recycling of facade and structure and to the life cycle based impacts of building materials. But the criteria for awarding the credits related to the life cycle impacts of materials are very different in the two systems.

In the UK BREEAM system, the Green Guide to Specification and its underlying methods is the central component. In the Dutch adoption of BREEAM, externalized shadow prices for environmental impacts must be calculated by using dedicated Dutch LCA calculation programs (e.g. GreenCalc+, EcoQuantum and GPR

[7] BREEAM – NL (2010). Keurmerk voor duurzame vastgoedobjecten. Beordelingsrichtlijn Nieuwbouw. Version 2.0, Spetember 2010.

Gebouw[8]) in combination with nationally derived unit prices, e.g. € 0.05 per kg CO2-equivalent (for climate change) and € 4 per kg SO2-equivalent (for acidification).

The shadow prices can be aggregated over both activities and impact categories, and the final result (measured in €) is compared to the shadow price for a reference building. One credit is awarded if the shadow price is 10% lower than for the reference building, and up to six credits can be awarded if the shadow price is 60% lower in the building being assessed.

The scope of building materials included in the Dutch calculation is much larger than in the UK system, including not only almost all building elements but also finishes and services (Pouwels *et al*, 2009[9]). In this respect, the BREEAM–NL approach is much more similar to DGNB and EN 15978 than the UK version of BREEAM.

The origin of the basic data stored and used in the calculation programs is a result from previous LCA developments in The Netherlands. It is a mix of data from public databases and producer's data which are supplied to one of several Dutch tools over time. This will change in the near future, since a 'national' LCA database is in development at the organization SBK (www.bouwkwaliteit.nl/milieu), which is supported by government, material suppliers and tool owners. It is the intention that all tools are going to use the same database, including BREEAM-NL. The database will consist of default data (extracted from EcoInvent) and producer-specific data.

Basis for the development of new LCA data is currently the Dutch NEN 8006 standard for establishing LCA data for building products[10] , but this standard and the SBK guidelines will be modified with the coming European standards EN 15804 and EN15978. The data developed by the two standards NEN 8006 and EN15804 are not fully comparable , e.g. with respect to allocation procedures, and updates will be necessary. This will also be the case for the building assessment tools. One of the issues will be the presentation of modular information, including Module D.

[8]The three programs have been developed over many years to meet the needs for environmental assessment of buildings in The Netherlands. More information is available from the web pages http://www.greencalc.com/ (in Dutch), http://www.except.nl/overig/yale/sem5/sustainabledesign/Eco-Quantum2.pdf and http://www.gprgebouw.nl/website/ (in Dutch)

[9]Pouwels I, Zegers F, Schipper F (2009). Comparison between international and Dutch assessment tools. Greenguide versus Dutch methodology. Ecofys, Utrecht.

[10] NEN 8006 (2004). Environmental data for building materials, building products and building elements for use in environmental product declarations - Assessment according to the Life Cycle Assessment (LCA) methodology. Translated on behalf of Stichting MRPI. Downloaded from http://ebookbrowse.com/english-nen-8006-november-2004-pdf-d120383811

3 GERMAN SUSTAINABLE BUILDING CERTIFICATE (DGNB)

3.1 INTRODUCTION TO DGNB

The German Sustainable Building Certificate was developed by the German Sustainable Building Council (DGNB, a private non-profit organisation) together with the Federal Ministry of Transport, Building, and Urban Affairs (BMVBS) to be used as a tool for the planning and evaluation of buildings in this comprehensive perspective on quality. On the more general level, the purpose of establishing DGNB was to create a second generation system for building certification, based on upcoming European standards for sustainable buildings and with focus on sustainability as an entity including ecology, economy, socio-cultural and functional topics, techniques, processes, and location.

The DGNB certification system was launched in 2009, followed shortly thereafter by the launch of its internationalization. By September 2010, more than 250 auditors were trained and more than 100 buildings certified or pre-certified. The main part of the certified buildings is office and administration buildings, but also retail and industrial buildings, new educational facilities, new residential buildings and new hotels are covered by DGNB criteria.

3.1.1 THE BASIC SCORING AND RATING SYSTEM

The very basic concept of the DGNB scoring and rating system is that the performance in five criteria groups with a fixed relative importance is assessed:

- Ecological quality (22.5%), subdivided into 11 criteria
- Economical quality (22.5%)
- Socio-cultural and functional quality (22.5%)
- Technical quality (22.5%)
- Quality of the process 10%)

The general DGNB scoring framework is illustrated in Figure 3.

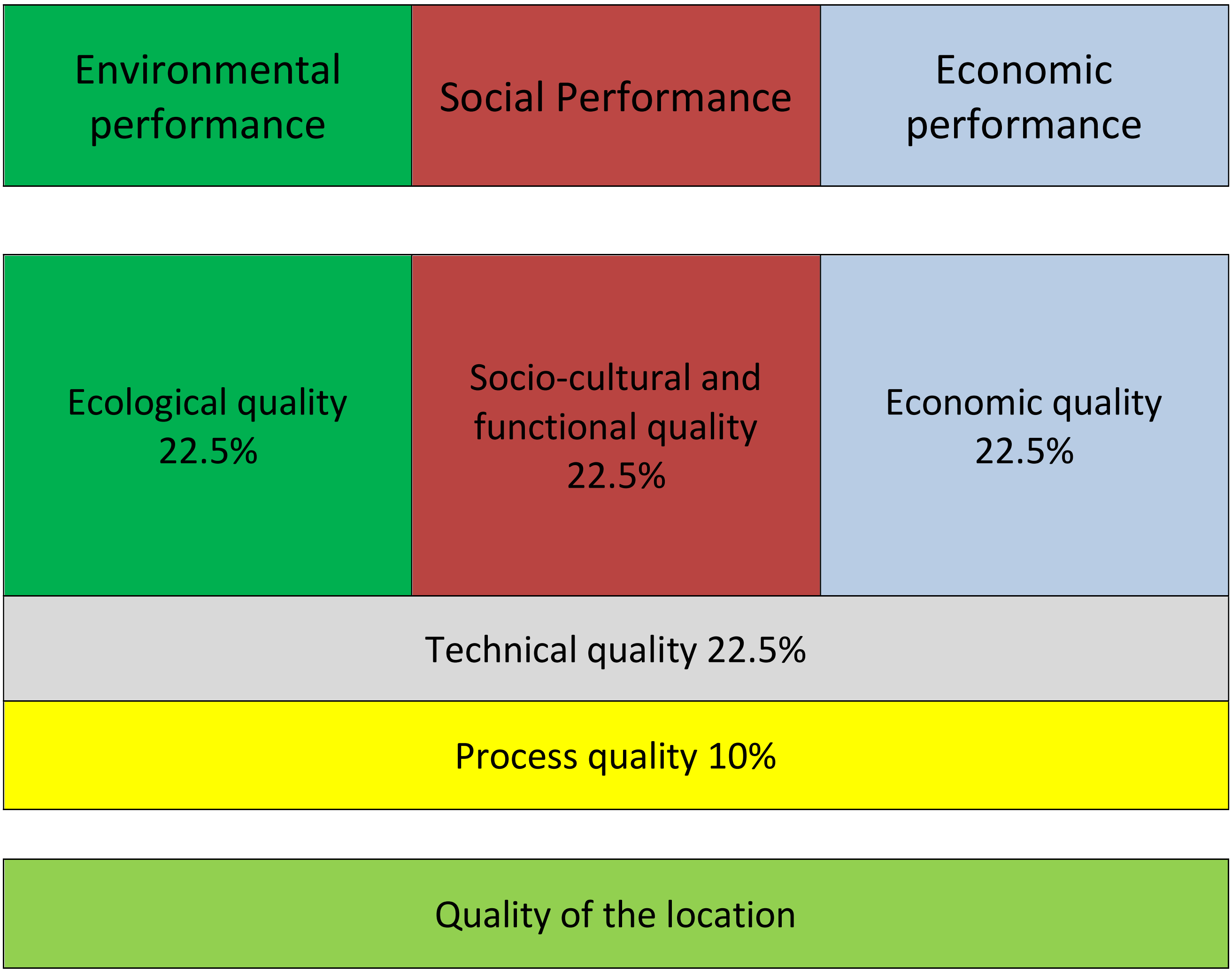


FIGURE 3. THE OVERALL FRAMEWORK FOR SCORING AND RATING IN THE DGNB SCHEME.

The scores of the individual criteria are weighted by a fixed weighting factor and a performance index in calculated for each criteria group, relative to a reference building. The five performance indices are subsequently weighted by the above factors (22.5% or 10%) and the total performance index, measured in %, is calculated. Finally, the calculated total performance index is compared to pre-set values for the award of a Bronze, Silver or Gold certificate.

In the present analysis of the DGNB scheme focus is alone on the scoring and rating of ecological quality, one of the five criteria groups that can be assessed independently of each other, but are integrated in the final score.

3.2 Importance in DGNB of LCA results for materials

In DGNB, the eleven ecological criteria accounts for 22.5% of the possible total amount of points available. The eleven criteria address the following impact categories:

1. Global Warming Potential (GWP)
2. Ozone Depletion Potential (ODP)
3. Photochemical Ozone Creation Potential (POCP)
4. Acidification Potential (AP)
5. Eutrophication Potential (EP)
6. Risks For The Local Environment (Qualitative)
7. Sustainable Use of Resources/Wood (Qualitative)
8. Non-Renewable Primary Energy Demand (PE_{nren})
9. Total Primary Energy Demand and Proportion of Renewable Primary Energy (PE_{ges})
10. Drinking Water Demand and Volume of Waste Water (W_{kw}) (Only use stage)
11. Space Demand (Qualitatively using indicators)

LCA results for building materials and products are an integral part of the assessment of the entire building. The environmental impacts of the building materials are not subjected to a rating on their own, but are added to other contributions from the building's construction, maintenance, dismantling and disposal in order to reach a value for the full life cycle, expressed in impacts/m^2 * year, using a reference period of fifty years. The impacts from the operation stage of a building are calculated separately by combining life cycle energy modeling with process or country specific information from the ESUCO database (see 3.3). The results of this calculation has the same format as the other calculations, and the two partial results are in the final aggregated to show the impact of the entire building per square meter and year.

It is thus not possible to pinpoint the importance in the DGNB assessment of a single material or product, unless the results are scrutinized at a very detailed level. The products are treated according to the methodology in EN15978, and In very plain words it can be said that the materials and products gives a contribution that matches their measurable environmental performance very precisely with respect to the global, regional and local environmental impacts addressed in the currently eleven criteria for ecological quality in DGNB.

It is obvious that Criteria 1-5 and 8-9 are central when quantifying the environmental impacts of the entire building in its full life cycle. Criterion 6 ensures that the risks for the local environment are minimized through a qualitative choice of materials without specified substances/preparations or unwanted properties as defined in the criterion. The qualitative choice is to some extent based on life cycle considerations, but there are no calculations attached to the criterion. Criterion 7 focuses on wood, ensuring at the lowest quality level that no tropic, sub-tropic or boreal wood is based. Criterion 10 and 11 are not assessed over the life cycle and they are not related to the choice of materials.

An estimate of the importance of material and component production in both the building life cycle perspective and in the DGNB rating is established in the next section (3.2.1).

3.2.1 Relative importance of material/product manufacturing and building operation

It is known from many studies that operational energy consumption and emissions in general play a more important role than energy consumption and emissions associated with production of the materials used in construction and maintenance of the building. There are large variations with respect to the relative importance of energy used for production of materials, construction, transport, etc. on the one hand and operational energy on the other. The differences are caused by factors such as building traditions, climatic conditions and choice of life cycle boundaries and assessment method. The following quotes shall therefore only be considered as indicative and in no way exhaustive:

Building type	Operating energy in % of total energy consumption	Source
Conventional building	93-95 %	Sartori & Hestnes (2007)[11]
Low-energy building	88-90 %	Sartori & Hestnes (2007)
Passive building, new	68 %	Sartori & Hestnes (2007)
Generic office building	80-90 %	Cole & Kernan, 1996[12]
Low density development	87 %	Norman *et al* (2006)[13]
High density development	85 %	Norman *et al* (2006)
Medium-sized, low energy commercial building	77-81 %	Fernandez (2008)[14]

TABLE 3. EXAMPLES OF OPERATING ENERGY IN PERCENT OF TOTAL ENERGY CONSUMPTION.

Using these indicative figures it can be assumed that the contribution from production of building products and materials to the quantified environmental impacts constitute about 20-25% of the total impacts.

As mentioned earlier, ecological quality can be awarded a maximum of 22.5% of the total score. The seven quantifiable building life cycle related criteria accounts for 120 out of 200 points available for ecological quality, and if 25% of these are related to impacts from production of materials and components, the maximum importance of these activities can be calculated to 22.5% * (120/200) points * 0.25 = 3.4% of the total performance index of a building. Energy-related activities are responsible for the main part of the remaining 75% of the impacts, or about 10%.

Given that a large number of building components, perhaps 50 or more, is included in the assessment it can be argued that each of these are without any practical importance in the overall assessment, contributing less than an estimated 0.1% of the total impact. This is significantly less than e.g. the BREEAM scheme, where six selected materials or components each contribute with up to one percent of the total number of credits. Even if the number of materials that are "important" in the life cycle context is lower in practice, amounting to perhaps 10-20, their individual importance is still significantly lower than in the BREEAM scheme.

On the other hand it can also be argued that choosing materials and products with a good measurable environmental performance can improve the overall results. As an example, choosing products with 20%

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[11] Sartori I, Hestnes AG (2007). Energy use in the life cycle of conventional and low-energy buildings: A review article. Energy and Buildings 39: 249-257.

[12] Cole RJ, Kernan PC (1996). Life-cycle energy use in office buildings. Building and Environment 31(4): 307-317.

[13] Norman J, macLean HL, Kennedy CA (2006). Comparing high and low residential density: Life cycle analysis of energy use and greenhouse gas emissions. Journal of Urban Planning and Development 132(1): 10-21.

[14] Fernandez NP (2008). The influence of construction materialson life-cycle energy use and carbondioxide emissions of medium size commercial buildings. Thesis submitted to the School of Architecture, Victoria University of Wellington.

less impacts can improve the overall environmental performance with up to almost 5% (20% of 22.5%), and this may in some cases be directly reflected in the scoring of ecological quality.

3.2.2 Other material-related criteria with relevance for health and environment

A number of other product or material related criteria address aspects that also are considered to be important in the building life cycle perspective:

- Indoor hygiene
- Safety and risk of failure
- Energetic and moisture proofing quality of the building's shell
- Ease of cleaning and maintenance of the structure
- Ease of deconstruction, recycling and dismantling
- Fire protection

Especially Indoor hygiene is an aspect related to the choice of materials, and the scoring for this criteria account for up to 2.5% of the total performance index or about 70% of the maximum contribution from "Materials" to the ecological criteria group. It is noted in this context that it is not the materials that are tested for indoor hygiene properties, but the indoor air quality in representative rooms in the finished buildings. It is also noted that it is relevant or requested to include information on most of the above issues in EPD's for many building products and materials. Such information could for example show specific compliance with the requirements in one or more systems like the German AgBB or the French Afsset – or concern the information requested for reporting of other modules in EN 15804.

3.3 The DGNB LCA methodology

The core element of the DGNB LCA methodology for building materials as well as operational impacts is the ESUCO database (European Sustainable Construction database), containing ecological data on almost 500 construction materials as well as country specific data on the use stage of building as HVAC, elevators, heating with electricity, etc.

The philosophy behind the ESUCO database is that it shall act as a European reference, allowing DGNB users all over Europe to make consistent calculations. This means that existing datasets (product specific or branch averages) can be used unless they can be regarded as a significant source of error. Examples of potential errors are if the available dataset is too old, if it reflects a different production technology and if there are inherent differences between countries, e.g. with respect to sourcing of electricity or end-of-life scenarios.

Having the ESUCO database as a core element means that the DGNB scheme operates in a way which is similar to the approach used in FEN 15978[15]. The standard prescribes in clause 10.2.1 that if a representative EPD made in accordance with EN 15804 is not available (or incomplete for the product used in the building), then a generic EPD or data set of a similar product may be used and adapted to create a new data set to reflect the actual situation as closely as possible.

[15] FEN 15978: 2011. Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method. Edited version from meeting held on 2011-02-02.

The hierarchy of data in the ESUCO database is that producer specific data are considered to be most appropriate, followed by national averages as second choice and European data as the third. This is in line with the recommendations in ISO 14044, but there are in practice no barriers against using average European data for specific buildings, unless data show relevance in the life cycle of buildings (PE International, 2010)[16].

Currently, the main part of the datasets in the ESUCO database has been developed by PE International based on German and European industry data, but it also contains data from the ELCD database (European Life Cycle Reference Database) for core materials and country specific data all EU member states for elements like electricity, heating, cooling and services. It has not been possible to find a precise description of the LCA methodology behind the ESUCO (e.g. with respect to system boundaries and allocation rules) used to establish the datasets, and it is not known if - or how - DGNB assesses the representativeness of a specific dataset in a given context. The scope of the database is, however, judged to be sufficiently broad to cover many of the data needs encountered when making building assessments on the national scale. It is, however, evident that both producer-specific data and country averages gives more precise information on building materials and components than the European averages found in the ESUCO database.

In the documentation of the datasets it is stated that they are established in accordance with ISO 14040 and 14044, using unit process data from the GaBi databases, but they may in practice equally well be based on the general GaBi methodology, the provisions in the ELCD database[17], the emerging EN 15804 or Product Category Rules developed by IBU (Institut Bauen und Umwelt[18]) in Germany.

Using the four methodologies will in general result in very similar assessments, but different allocation rules, e.g. with respect to use of primary and secondary raw materials, may lead to different results for selected materials, products and processes. The general impression of FORCE Technology is that differences between the four methodologies with respect to system boundaries and allocation rules do not lead to significantly different results in the cradle-to-gate LCA's. Other methodologies, e.g. the UK BRE methodology, LCA's according to the Dutch standard NEN 8086 and consequential LCA may, however, very well give somewhat different results especially for cradle-to-grave assessments because they for example apply different allocation rules.

Another important element of the DGNB scheme when used for assessment of German buildings is the *Ökobau.dat* database containing about 700 datasets for materials and products. Most of these are producer specific and apply to German conditions, while the rest are generic or branch specific. In all cases it can be assumed that the Product Category Rules from IBU has been used in the development of the datasets. It is therefore the impression of FORCE technology that the database is very useful for DGNB in Germany, but the representativeness for this database outside of Germany is unknown.

Figure 4 shows an overview of the life cycle activities included in the calculations, the main data sources used in the German version, and the impact categories addressed by conventional LCA methods. It is noted

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[16] Presentation by Johannes Kreissig, PE International, at Expo Real 2010.
http://www.dgnb.de/fileadmin/expo_real/Vortraege_2010/Moesle_Intern_DGNB_Zertifizierungssystem_04102010.pdf
[17] http://lct.jrc.ec.europa.eu/assessment/tools
[18] http://bau-umwelt.de/hp473/Produktgruppen-Regeln-PCR.htm

that the basic structure of the model corresponds closely to that used in EN 15978 (Figure 5, p. 22) for assessment of Environmental Performance at the building level, with a similar distinction between the same general life cycle activities.

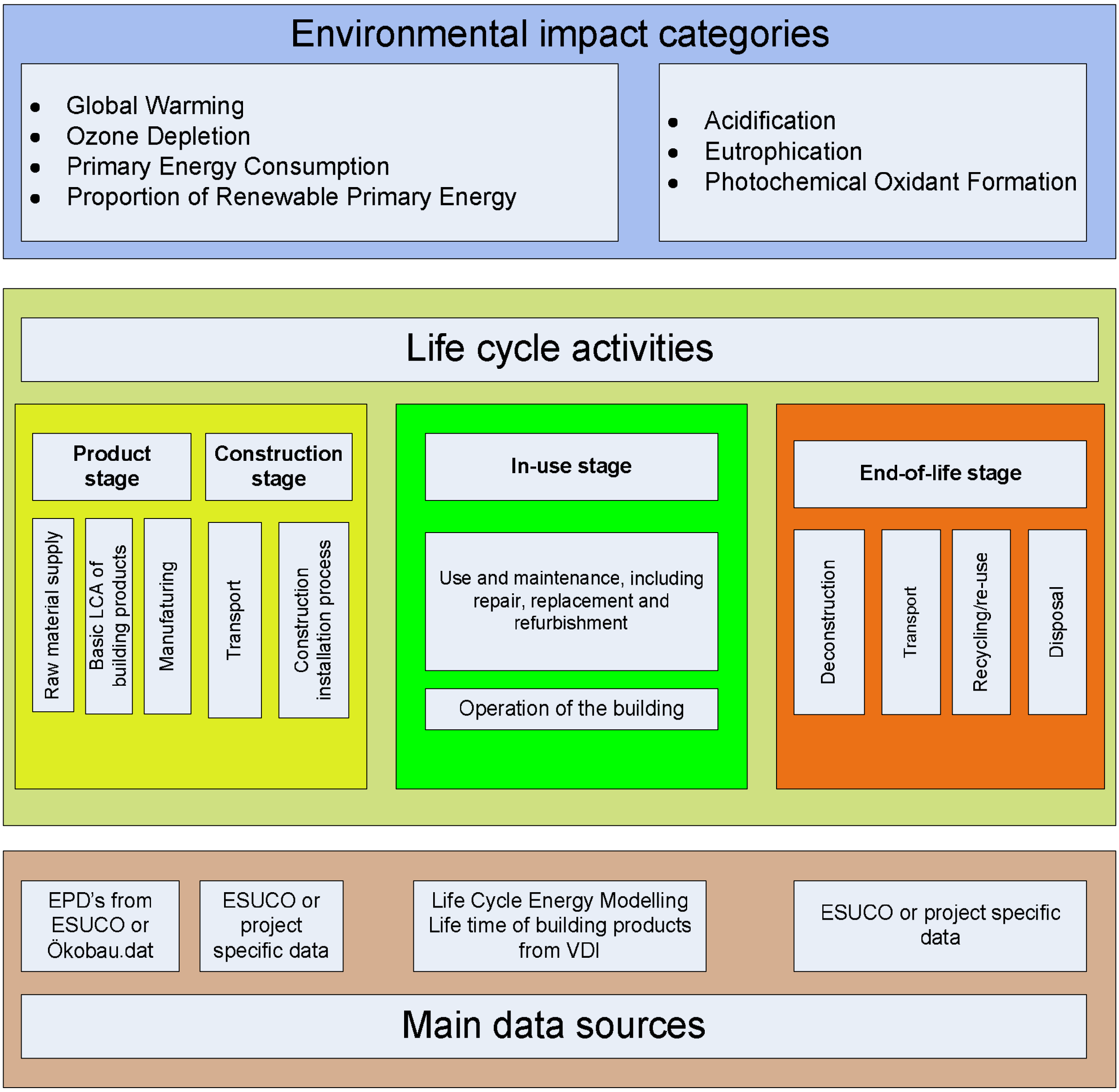

Figure 4. Life cycle activities included in the calculations, the main data sources used and the impact categories addressed quantitatively in DGNB.

It is noted that the supplementary information found in Module D in EN 15804 and EN 15978 about benefits and loads beyond the life cycle is stated to be included in the system boundaries for the DGNB assessment (Criterion 1-5, p. 6), but it is not clear whether the information is actually used in the calculations. It is thus possible that the loads from recycling/re-use of building materials and components are allocated to the building, whereas the benefits, e.g. from avoided production of energy materials, are not.

3.4 Building assessment and rating in DGNB

To make the DGNB certificate as informative and precise as possible, target values have been defined for each of the 11 impact categories (“criteria”) in the criteria group for Ecological Quality. Each of the criteria can receive a maximum of 10 points based on its documented or calculated quality.

At the same time, however, it is possible to increase the weighting of each criterion as much as threefold (or to disregard it entirely) based on its societal or political relevance and its importance for the specific use profile. In an example of the scoring in an assessment matrix, weighting factors between 1 and 3 were assigned to the criteria[19]:

Criteria	Criteria points		Weighting factor	Weighted points		Group points		Group performance index
	Maximum	Achieved		Maximum	Achieved	Maximum	Achieved	
Global Warming Potential (GWP)	10	10	3	30	30	200	178.5	89%
Ozone Depletion Potential (ODP)	10	10	1	10	10			
Photochemical Ozone Creation Potential (POCP)	10	10	1	10	10			
Acidification Potential (AP)	10	10	1	10	10			
Eutrophication Potential (EP)	10	7.1	1	10	7.1			
Risks For The Local Environment	10	8.2	3	30	24.6			
Sustainable Use of Resources/Wood	10	10	1	10	10			
Non-Renewable Primary Energy Demand	10	10	3	30	30			
Total Primary Energy Demand and Proportion of Renewable Primary Energy	10	8.4	2	20	16.8			
Drinking Water Demand and Volume of Waste Water	10	5	2	20	10			
Space Demand	10	10	2	20	20			

TABLE 4. EXAMPLE OF SCORING AND WEIGHTING OF THE ECOLOGICAL QUALITY CRITERIA GROUP IN DGNB, THE CRITERIA GROUP ACCOUNTS FOR 22.5% OF THE TOTAL AMOUNT OF AVAAILABLE POINTS IN THE DGNB SCHEME.

It has not been possible to find information relating to the development and use of weighting factors. In the example in Table 4 the weighting factors are without any practical importance for the Group Performance Index, which is 89% (178.5 out of 200) with the weightings and 90% (89.8 out of 110) without weights.

[19] DGNB (2010). Excellence defined. Sustainable buildings with a systems approach. Pamphlet from DGNB, September 2010.

Weightings will, however, be important in those cases where the building performs badly (scores low) in criteria with a high importance and weighting factor.

The weighting procedure is much more transparent than in BREEAM, but it can still be criticized from a strict LCA point of view as expressed in ISO 14040. As shown in the previous paragraph, the weighting may be of no importance, but it is under all circumstances seen as advantageous that the weights can be easily changed to accommodate requests from "pure" scientists (all weights are 1) or reflect national or regional environmental priorities.

3.5 Overview of the LCA process and the rating process for ecological performance

Figure 5 gives an overview of the rating process for ecological performance in DGNB, starting with calculation of EPD's for building products and ending with the Group Performance Score for ecological performance. In the overall building assessment, ecological quality has a weight of 22.5%. Economic quality, Socio-cultural and functional quality and Technical quality also have a weight of 22.5% each, while Process quality is given a weight of 10% in the Total Performance Index.

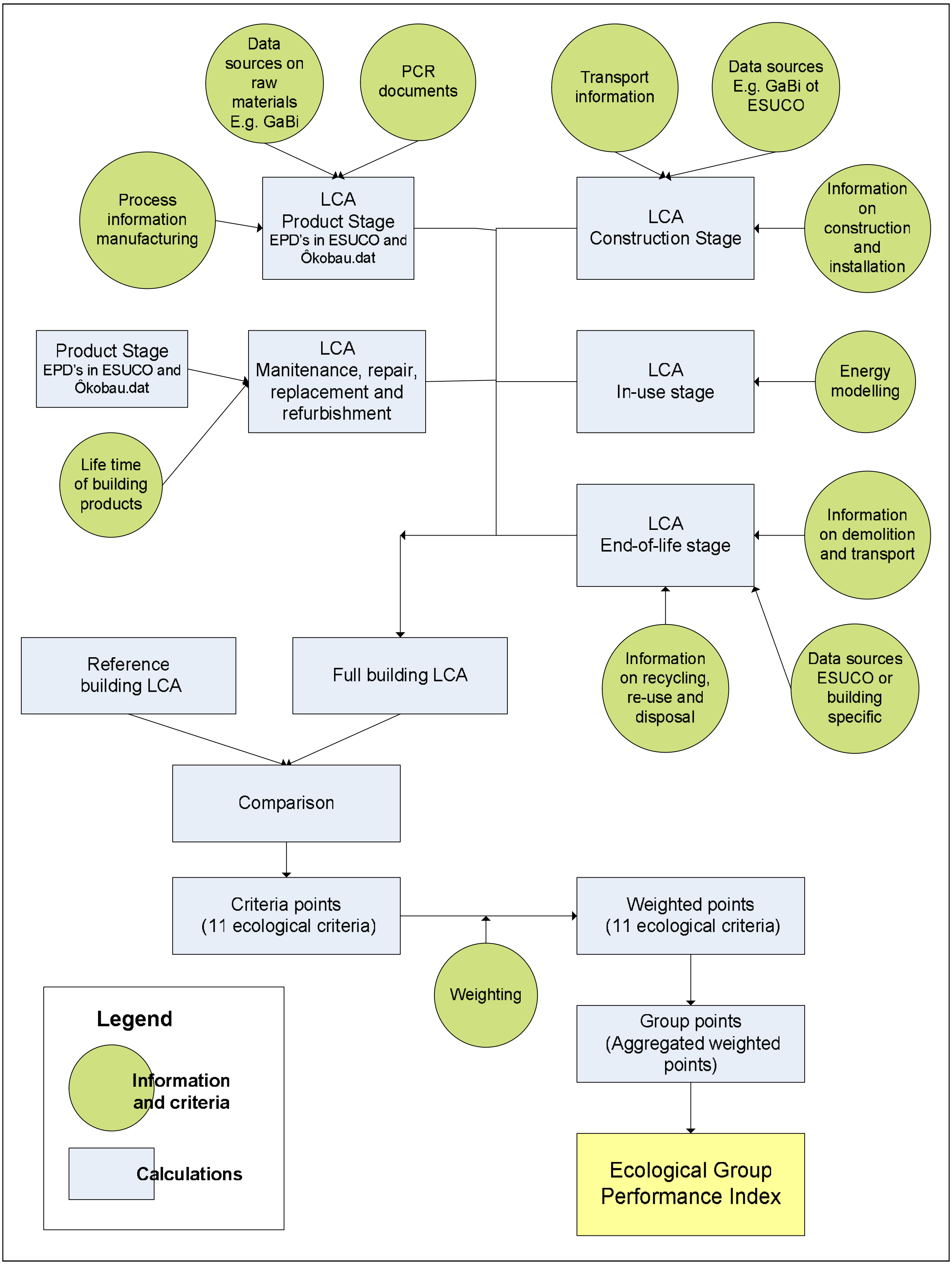

FIGURE 5. OVERVIEW OF ELEMENTS IN DGNB RATING OF ECOLOGICAL QUALITY

3.6 THE RELATIONSHIP OF DGNB TO EN 15804 AND EN 15978

The documentation for compliance with the ecological criteria in the DGNB scheme has been specified with a close view to the emerging CEN standard EN 15804. Being established ahead of the standard it has of course not been possible to ensure full conformity, but all major elements in DGNB appear to fit well into the framework of EN 15804. This is on the very general level evident when comparing Figure 4 in this report to Figure 1 in the draft standard.

The same activities from cradle to end-of-life are included in the building assessment and the format of the LCA results for building product performance used for calculation of the overall DGNB rating of the building corresponds well with the format prescribed in EN 15804. It is, however, also noticed that DGNB only considers selected impact categories and other types of quantified information. Impact categories such as “Depletion of abiotic resources-elements”, “Use of secondary renewable fuels” and “radioactive waste disposed” are thus not addressed in the DGNB assessment, whereas information about them (and several other categories) is required in EN 15804.

This is, however, not a “problem” since the ESUCO database contains the information necessary to calculate the requested parameters, e.g. when using GaBi and possibly also Build-It (see Box 2). Whether the information in the Ökobau.dat database (see Box 2) can be recalculated to fit into the EN 15804 format is not known, but it may very well be that the sufficient level of detailed information is available (at PE International) for further calculations in GaBi. Re-calculating the Ôkobau.dat database is thus probably more an economic issue than a practical problem. It is in this context worth noting that producers are expected to supply information on more products over time, most probably in a format compatible with EN 15804 in order to meet requirements of both the national and the European market.

It is concluded that there are some differences in the amount of data reported in DGNB assessments and in EN 15804. The differences are seen as a conscious choice, keeping the DGNB assessment process relatively simple. The basic data used for DGNB calculations can with great certainty be used to calculate all the information requested in EN 15804, at least with respect to information modules A1 – A3.

Databases and tools connected to the DGNB scheme

The Ökobau.dat database is available for free from the German Federal Ministry for Transport, Building and Urban Development (www.nachhaltigesbauen.de/baustoff-und-gebaeudedaten/oekobaudat.html).It contains about 650 datasets developed in a large research project with the German building industry as a partner. The datasets contain the core information requested by the DGNB, but they are much less detailed and transparent than EPD's made according to the basic provisions in ISO 14040/14044 and ISO 14025 and detailed in national EPD-schemes like the German scheme which is handled by Institut Bauen und Umwelt (www.bau-umwelt.de/hp2/Home.htm).

Build-IT is a commercial PC-tool from PE International in Germany used for calculating building life cycle environmental impacts as required in the DGNB. The user simply enters the amount of building materials and the energy demand of the building and GaBi Build-it calculates the environmental impact of the building in line with the requirements of the DGNB. Furthermore, Build-It contains data for the reference building used to assess the relative performance of the building under investigation. Build-It can thus assist planners and architects in the building planning stage as well as DGNB auditors in the assessment of the building when finished. More information from http://www.gabi-software.com/america/software/gabi-build-it/

The ESUCO database is described in section 3.3.

BOX 2. DATABASES AND TOOLS CONNECTED TO DGNB

3.7 ADOPTION OF DGNB IN OTHER COUNTRIES

DGNB is currently undergoing an internationalization process. The Austrian Green Building Council has adapted the system and awarded its first certificates, and as of May 2011 Bulgaria, Switzerland and Thailand have founded their organizations while partnerships exist with China, Brazil and Russia.

In the adoption process, the national Green Building Council will in general play an important role, irrespective of whicg scheme has been chosen. In relation to DGNB, two elements are, however, seen as central in the development of a scheme with adequate consideration of specific national conditions.

Firstly, a reference building must be specified. Based on Eurostat (2006)[20], Werner (2006)[21] found that the climate in border area between France and Germany (Strasbourg) was representative for the average EU-27 climate. Current German building stock may in a first, crude assessment be regarded as average of EU27-countries, but there are still considerable differences between how building environmental performance shall be measured in individual countries. As points are awarded based on a comparison with the reference building, the specifications for this building need to be adjusted to reflect national conditions. Otherwise, the rating of the building will be almost arbitrary.

Secondly, it must be assessed whether generic (EU or German) data for building products are representative for national production of the same goods. Differences may occur as a consequence of

[20] Eurostat (2006). Statistics in focus . ENVIRONMENT AND ENERGY 5/2006. Statistical aspects of the energy economy in 2004

[21] Werner S (2006). ECOHEATCOOL. Presentation at the NEP Conference, Helsinki, Jan 24, 2006

choice of technology, raw materials and energy sources, and the importance of this should be investigated in some detail. Likewise, the energy model used to address the operational stage must be assessed with respect to representativeness as requested in EN 15978.

There is no public information available about how this is or can be done in practice. It is, however, obvious that direct adaption of DGNB (or any other system) in a new country inevitably will lead to a skewed award of points. How large deviations that are acceptable cannot be determined objectively, but decision-makers should as a minimum be aware of the shortcomings of an adapted system.

4 LEED (Leadership in Energy and Environmental Design)

4.1 Introduction

The LEED green building certification scheme is managed by the US Green Building Council (USGBC), a US-based non-profit organization. The first LEED Pilot Project Program (LEED version 1.0) was launched at the US Green Building (USGBC) Membership Summit in August 1998. After extensive modifications, LEED Green Building Rating System was released in March 2000, with revisions in 2002 and 2005. Version 3.0 was released in 2009 and today, LEED consists of a suite of nine rating systems for the design, construction and operation of buildings, homes and neighborhoods. Five overarching categories correspond to the specialties available under the LEED Accredited Professional program:

- LEED for New Construction
- LEED for Core & Shell
- LEED for Schools
- LEED for Retail: New Construction and Major Renovations
- LEED for Healthcare

More than 7000 projects in the US and 30 other countries are encompassed by LEED, covering 99 km2 of development area.

The Green Building Certification Institute (GBCI) was established by USGBC to provide a series of exams to allow individuals to become accredited for their knowledge of the LEED rating system. This is recognized through either the LEED Accredited Professional (LEED AP) or LEED Green Associate (LEED Green Assoc.) designation. GBCI also provides third-party certification for projects pursuing LEED.

The chapter about LEED in this report is based on US Green Building Council, 2008[22]. An update is to be released in 2012, and the expected changes are addressed at the end of this chapter in section 4.5.

4.1.1 The basic scoring and rating system

The basic LEED rating system has a maximum of 100 points or credits available for a building. The rating system is organized into 5 environmental categories each with a maximum of possible points:

- Sustainable Sites (26 possible points)
- Water Efficiency (10 possible points)
- Energy and Atmosphere (35 possible points)
- Materials and Resources (14 possible points)
- Indoor Environmental Quality (15 possible points)

The allocation of points between credits is based on the potential environmental impacts and human benefits of each credit with respect to a set of impact categories. The impacts are defined as the environmental or human effect of the design, construction, operation, and maintenance of the building, such as greenhouse gas emissions, fossil fuel use, toxins and carcinogens, air and water pollutants, indoor

[22] USGBC (2008). LEED 2009 for New Construction and Major Renovations. USGBC Member Approved November 2008.

environmental conditions. A combination of approaches, including energy modeling, life-cycle assessment, and transportation analysis, is used to quantify each type of impact. The resulting allocation of points among credits is called credit weighting.

LEED 2009 uses the U.S. Environmental Protection Agency's TRACI environmental impact categories as the basis for weighting each credit (USEPA, 2002)[23]. TRACI was developed to assist with impact evaluation for life-cycle assessment, industrial ecology, process design, and pollution prevention. LEED 2009 also takes into consideration the weightings developed by the National Institute of Standards and Technology (NIST); these compare impact categories with one another and assign a relative weight to each. Together, the two approaches provide a solid – but US based - foundation for determining the point value of each credit in LEED 2009.

Each credit is allocated points based on the relative importance of the building-related impacts that it addresses. The weighting process involves three steps:

1. A reference building is used to estimate the environmental impacts in 13 categories associated with a typical building pursuing LEED certification
2. The relative importance of building impacts in each category are set to reflect values based on the NIST weightings
3. Data that quantify building impacts on environmental and human health are used to assign points to individual credits

Each credit is allocated points based on the relative importance of the building-related impacts that it addresses. The result is a weighted average that combines building impacts and the relative value of the impact categories. Credits that most directly address the most important impacts are given the greatest weight.

The description of the rating system in USGBC (2008) does not provide further details about the actual process for allocation of credits. As described below, quantitative life cycle information on building materials and products is not an integral part of the scoring and rating of buildings, while qualitative information on issues like building and material re-use, construction waste management, recycled content and regional sourcing is used in the scoring system.

4.2 Importance in LEED of LCA results for materials

As stated above, 14 of the 100 possible basic points can be awarded for environmental aspects relating to materials and resources, broadly defined. In practice, however, only 8 points are available for choices relating to specific material properties, while the remaining six points are credited for reuse of existing

[23] USEPA (2002). Tool for the reduction and assessment of chemical and other environmental impacts (TRACI): Users guide and system documentation. USEPA, Office of Research and Development, July 2002.http://www.epa.gov/nrmrl/std/sab/traci/.

exterior structural elements, reuse of interior non-structural elements like doors and floor coverings, and construction waste management.

An LCA is not requested in order to award one or more credits related to material properties. The criteria implicitly assume that reused materials, a high recycled content and regionally sourced materials are beneficial for the environment and it is thus not necessary to document through an LCA. This makes the award of credits a relatively simple procedure, comparing the cost of reused (recycled, regional) materials to the total cost of materials, Likewise, the use of regional materials, rapidly renewable materials and certified wood is also regarded *ceteris paribus* as beneficial for the environment, and simple cost calculations are also applied to these two criteria in the award process.

4.2.1 Other product or material related criteria with relevance for health and environment

In relation to indoor air quality, LEED awards four points to low-emitting materials, one in each of the following categories:

- Adhesives and sealants (criteria on VOC content)
- Paints and coatings (criteria on VOC content)
- Flooring systems (criteria for compliance with relevant certification schemes)
- Composite wood and agrifiber content (urea-formaldehyde resins must not be used)

It is noted that the criteria focuses on the <u>content</u> of unwanted substances in the materials as evidenced by e.g. Material Safety Data Sheets rather than the <u>emission</u> of certain substances as measured in different indoor air quality testing schemes. This means that the certification process is relatively easy, but also that it does not provide a science-based performance indicator, at least not in a strict sense.

4.3 Relationship between LCA in LEED and EPD's after EN 15804

There are no requirements in the existing LEED criteriawith respect to LCA results being available for LEED certification, and accordingly there is no relationship to EPD's as they are known from US-based (Green Seal) or other schemes in Europe (including EN 15804) or Worldwide. This is expected to change to some extent in a 2012 update, see section 4.5.

The only current relationship to a label appears with respect to certified wood, where the Forest Stewardship Council's principles and criteria must be met by a minimum of 50% of the wood-based materials and products.

4.4 Adoption of LEED in other countries

The LEED criteria are almost exclusively based on US referenced standards, and if the certification scheme should be adopted in an European country there is obviously a need to identify elements where national or regional requirements and standards differ from US standards, and subsequently modify the criteria so they fit in with standards and legal requirements that are applicable to the actual geographic area. This has to the best of our knowledge not been done hitherto.

With respect to the Materials category, the requirements regarding recycled content, rapidly renewable materials and certified wood are regarded as universal in nature, while the criterion on regional materials may need to be changed for use in other countries. In small countries like Belgium, The Netherlands and Denmark, the limit of 800 km for the distance between extraction/manufacturing site and project site will by many be regarded as a very loose limit, because it allows materials to be sourced from a wide range of countries. On the other hand is 800 km a very strict limit for some materials in a country like Denmark without extraction and manufacturing of basic raw materials like oil and gas (for plastics) and metals like iron, steel and aluminium.

4.5 Expected 2012 update of LEED

The US Green Building Council has in a press release dated September 13, 2011 announced that the next update to the LEED green building program, coined LEED 2012, will include updates to the Material and Resources (MR) credit category.

According to the press release, the credit category has been revised to include an increasedfocus on the application of Life Cycle Assessment (LCA). In practice, the draft revised criteria awards one or two credits (out of 10 in the new MR category) to buildings where productLife Cycle Assessment or third-party verified Environmental Product Declarations (EPDs) are available. For New Constructions for example, one credit is awarded if EPDs are available for more than 20% of the value of qualifying non-structural materials, and two credits are awarded if EPDs are available for 40% or more of the value of applicable materials (LEED, 2011)[24].

For material producers there are especially two issues that may be of importance. First, having EPDs of good or very good quality scores better than having manufacturer declared LCAs after ISO 14040 standard, and including an internal peer review. Good quality EPDs are Third-party Certified Type III Environmental Product Declaration (EPD) based on generic product family product category rules while EPDs of very good quality are based on product or brand specific product category rules instead of generic rules. In the building certification process, EPDs of very good quality are four times more valuable than conventional LCAs. As a very practical example of this weighting, two credits are awarded if the builder has EPDs of very good quality for 20% of non-structural materials as measured by their value. If “only” conventional LCA’s are available, the builder must have such documentation for 80% of the materials as measured by value.

The other important issue is that the actual environmental performance of the materials is not considered in the scoring process. The outcome of the calculations does not matter, only that the calculations are made according to best possible practice as determined by the quality criteria outlined above.

In conclusion. the 2012 update of LEED will thus not significantly change the relative importance of quantitative life cycle information of building materials. This is still low, amounting to 2% at most. The actual life cycle environmental performance does not play a role in the rating procedure, but material producers can possibly get a competitive edge by making EPDs according to the most stringent requirements in the country or region in question.

[24]LEED (2011). Building design and construction. LEED rating system. 2nd Public comment draft. July 2011.

5 HQE – HAUTE QUALITÉ ENVIRONMENTALE

5.1 INTRODUCTION TO HQE

HQE is a French certification scheme, administered by the HQE Association a publicly recognized non-profit organization (see www.assohqe.org). The three independent organizations CERTIVEA, CEQUAMI and CERQUAL have been mandated by the French standardization body AFNOR to develop certification reference documents and perform building certifications. The HQE association was founded in 1996 and the HQE scheme has until 2011 been used for about 400 building projects, the majority of which are found in France.The guiding principle in HQE corresponds to that of a conventional environmental management system as known from e.g. ISO 14001. The aim of HQE is to provide guidance to the builder and stakeholders in the building project as to how environmental issues can be addressed and assessed as an integral element during the whole project period. To fulfill that aim, the builder must in continuous process collect information on building performance and present it together with information about the building process.

HQE certifies both new and existing buildings, but since the scheme is process oriented existing buildings can probably only be certified in connection with a major renovation.

In practice, the environmental performance of the building is assessed three times during the project: After establishing the building program, at the end of the conception phase, and at the end of the construction of the project. Also the project management is assessed at the three phases. An assessor is appointed by the certifying body to follow the project from the start, and the role of the assessor is primarily to check that the requested information is available, not to provide guidance to the builder and his team.

The description of HQE is primarily based on technical documents from Certivéa/CSTB (2008)[25][26], and a report (in English) from a Danish test of several building certification schemes (Birgisdottir *et al*., 2010b)[27]. For the revised HQE criteria, a late draft[28] was used to identify significant changes, and for a description of the new "Sustainable Building Passport" concept, a presentation from Certivéa was used[29]

5.1.1 THE BASIC SCORING AND RATING SYSTEM

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[25] Certivéa/CSTB (2008). Technical scheme for the environmental quality of building. Offices/education. December 2008.

[26] Certivea/CSTB (2008b). Guide Pratique du Référentiel pour la Qualité Environnementale des Bâtiments – « Bureau/Enseignement ». Decembre 2008.

[27] Birgisdottir H *et al*. (2010b). Bæredygtigt byggeri. Afprøvning af certificeringsordninger til måling af bæredygtighed i byggeri. Byggeriets Evaluerings Center. Juni 2010. http://www.byggeevaluering.dk/media/5430/baeredygtighed_hr_inkl_uk.pdf

[28] Certivéa/CSTB (2011). Referentiel pour la qualite environmentale des bâtiments. Bâtiments Tertiaires. Juillet 2011. Version du 12 Julliet 2011. Version en cours de validation.

[29] Certivéa Sustainable Building Passport. A synthesis of the performance of commercial buildings. HQE certified (High Environmental Quality). Final version 2/9/11.

Basically, HQE operates with only one level of certification. In a recent update (September, 2011), the HQE system is further elaborated in order to be able to distinguish between four levels of rating of buildings with a HQE certificate. This development is described in section 5.1.3.

To achieve a certificate, it must be documented that the building meets specified targets for environmental quality within 14 different categories:

1. The building's relationship with its immediate environment
2. Integrated choices in construction products, systems, and processes
3. Low environmental impact worksite
4. Energy management
5. Water management
6. Management of activity-generated waste
7. Maintenance – permanence of environmental performance
8. Hygrothermic comfort
9. Acoustic comfort
10. Visual comfort
11. Olfactory comfort
12. Health quality of spaces
13. Health quality of air
14. Health quality of water

For each category, there are three target levels, i.e. “Basic”, “Performing” and High Performing”, and in order to achieve the certificate the building must be rated “High Performing” in at least 3 categories and “Basic” in maximally seven categories. Choosing the level of ambition for each of the categories is an important first step of the building certification process, and it is allegedly very difficult to change the decisions at a later point in the project.

Quantitative life cycle impacts of building products and materials are assessed in category No. 2, “Integrated choices in construction products, systems, and processes”. More precisely, the assessment is made in category 2.3, “Choosing construction products on order to limit the environmental impacts of the building”, consisting of two sub-categories addressing “Knowledge of environmental impacts of construction products” in sub-category 2.3.1 and “Choice of construction products to minimize environmental impacts of buildings” in sub-category 2.3.2. The criteria for the two sub-categories are described in some detail in section 5.2.

Category No. 2 includes three additional aspects, “Construction choices for the sustainability and adaptability of the building”, “Construction choices to facilitate the maintenance of the building”, and “Choosing construction products in order to limit health impact”. The requirements in all four sub-categories must be met in order for the building to be certified.

It is noted that qualitative impacts of materials and products are also assessed in several other categories, and it is the impression that HQE is relatively demanding in terms of ensuring the well-being of the users of the building as well as low impacts on human health in general.

5.1.2 Weighting of categories

The certification scheme does not address the relative importance of the categories, meaning in other words that they are equally important for the basic certification. Moreover, the approach also means that a bad performance in one category cannot be counterbalanced by a high performance in another. Please note, however, that the performance in the 14 categories can be aggregated in an overall rating of the building as outlined in the following section.

5.1.3 The Sustainable Building Passport

The basic HQE Certification system was in the autumn of 2011 extended with a new system for performance rating of certified buildings. The performance rating is based on the results obtained in the certification process, introducing a presentation format termed the "Sustainable Building Passport".

The Sustainable Building Passport is a one-page document, showing the overall rating of the building as well as the rating in each of the four categories addressed in the rating system, i.e. Energy, Environment, Health and Comfort. The Passport does not replace the certificate, but is a new display format in addition to the current profile display.

Four levels of overall rating are used to distinguish between building performance: Good, Very Good, Excellent and Exceptional. Both the overall rating and the rating in the four sub-categories are shown clearly in the passport.

The overall rating is calculated on the basis of the performance in the four categories, with four star symbols being available in each category. For the Environment, Health and Comfort categories, up to four stars can be awarded in each, depending on the performance as measured by the target levels (Basic, Performing and High Performing) met by the building. Box **3** shows an example calculation for the Environment category.

> *Example calculation – Environment category*
>
> For the "Environment" category, each of the targets 1, 2, 3 ,5, 6 and 7 (see section) are assigned two points if the building is rated "High Performing" and one point if the building is rated "Performing". The total number of points obtained this way is multiplied by four (the number of stars available) and divided with 12 (the maximum available number of points available in the category with six targets). Thus, if the building is rated "High Performing" in four of the targets, "Performing" in one and "Basic" in one target, the number of points obtained is (4*20) + 1 = 9. When multiplied by four and divided by 12, the result is 3, which is the number of stars being awarded in the Environment Category.

Box 3. Example calculation of the Environment category

The same calculation approach is used for the "Health" category, addressing targets 12, 13 and 14, and the "Comfort" category, addressing targets 8, 9, 10 and 11.

The "Energy" category addresses only one target (target 4), and a different approach is therefore used here. The carrying principle is that the performance of the building is compared to existing energy regulation and energy-labeling programs. In short, one star is awarded for each of the following levels being attained:

- HPE (Haute Performance Energétique (High Energy Performance)) with an energy consumption at least 10% lower than the conventional reference consumption as required in the French building regulation (Regulation Thermique, 2005)
- THPE (Tres Haute Performance Energétique (Very High Energy Performance)) with an energy consumption at least 20% lower than the conventional reference consumption as required in the French building regulation (Regulation Thermique, 2005)
- BBC (Batiment Basse Consumption (Low Energy Building)) with an energy consumption not exceeding in the baseline scenario 50 kWh primary energy per m2 and year.
- BEPOS (also called an Energy Plus building, producing more energy than it consumes)

The number of stars awarded in the four categories is aggregated and the total compared to the following overall rating criteria:

Number of stars	Overall rating	Comment
1-4 stats	Good	
5-8 stars	Very Good	
9-12 stars	Excellent	
12-16 stars	Exceptional	As a minimum the building must conform to BBC energy requirements

TABLE 5. RATING OF BUILDINGS FOR PRESENTATION IN THE HQE SUSTAINABLE BUILDING PASSPORT

5.2 Importance in HQE of LCA results for materials

Having quantitative LCA knowledge about construction products is an integral requirement in HQE. In the most recent version of HQE from September 2011, the quantitative information is used to investigate the contribution from construction materials to the overall environmental impacts of the building.

In order to get the "Basic" rating in sub-category No. 2.3.1 on "Knowledge of environmental impacts of construction products", an Environmental Product Declaration (EPD) must be available for at least 50% of the components in at least three categories of products (one from underlying structure, two from finishing). The EPDs must be established in accordance with the French standard NF P01-010 or an equivalent European standard.

To be rated "Performing" in sub-category No. 2.3.1, standardized life cycle information must be available for at least 50% of the components in at least six categories of products (two from underlying structure, four from finishing). To be rated "High performing" in sub-category No. 2.3.1,EPDs according to NF P01-010 or equivalent must be available for at least 80% of the products in at least six families of products (two from underlying structure, four from finishing).

Fulfilling this requirement also gives one so-called “High performing points” or HP points. Two HP points are awarded if the EPD information is available for 80% of the products in all product families in both underlying structure and finishing, and three HP points are awarded if the EPDs are available for 100% of the components in all product categories.

The information available from EPDs is utilized in sub-category 2.3.2. To be rated “Performing” in this sub-category, different scenarios for the contribution of products to the overall environmental impacts must be established for either the underlying structure or for the finishing.The scenarios must be calculated according to the requirements in the French Standard XP P01-020-3[30], and if adequate calculations are made for both underlying structure and finishing, the criteria for “High Performing” is fulfilled, and an additional four HP points are added.

The HP points obtained in sub-categories 2.3.1 and 2.3.2 are added to the HP points obtained in the other sub-categories in Category 2, and at least 35% of all points available (13 HP points out of 37) must be scored in order for Category 2 to be rated “High performing”. It is remarked that the HP points are awarded according to very different performance criteria, including e.g. easy access to components in facades, sun protection and rooftops is awarded with three HP points and knowing the emissions of VOC and formaldehyde for all products in direct contact with the indoor air is also awarded three HP points.

It is noted in this context that a justified choiceof products, systemsand processesrequiring little maintenance orlow maintenance is required to obtain a High Performing rating. The choice must be justified for at least 50% of the products in two of the following four product families:

- Windows, window frames and glazing
- Facades
- Sunscreens
- Roofs

The HQE scheme does not give information about how a justified choice can be documented, but the approach of HQE obviously gives a strong incentive for builders to start collecting and using structured life cycle data. It is important in this context that the organizing body for the certification scheme, CSTB, maintains a large database of reference on environmental and health characteristics of building products, established according to the requirements in NF P01-010. As of July, 2011, the FrenchINIÉS database contains 615 environmental product declarations, covering about 5000 commercial references. Many of the declarations are product specific, but some sectors have chosen to present average data for a number of producers. This seems to be in full accordance with HQE where the focus is on availability of good quality data rather than on choosing products with a good, measured, environmental performance.

5.2.1 Relative importance of material/product manufacturing and building operation

It is not possible or meaningful to assess the relative importance of the manufacturing stage and building operation, simply because HQE certification requires that all criteria are fulfilled satisfactory. It is, however,

[30] Afnor (2009). XP P01-020-3. Bâtiment – Qualité environnementale des produits de construction et des bâtiments – Partie 3 = évaluation des performances environnementales d’un batiment – Description de résultat de l’évaluation, de la méthode d’évaluation et de leurs déclinaisons à dif. Association Francaise de Normalisation. 09 Juillet 2009.

noted that the absolute value of the conventional primary energy consumption coefficient must be calculated and shown to be smaller than that for a reference building (Criteria 4.2.1).

5.2.2 Other material related criteria with relevance for health and environment

As mentioned, other parts of Criteria 2 address potential impacts on human health, e.g. Criteria 2.4 requiring knowledge of the VOC and formaldehyde emissions for at least 25% of the surfaces in contact with the indoor air of occupied rooms.

However, also several other of the 14 criteria address potential impacts on human health and environment – and as a special feature – also on human well being. Especially the criteria on "Health quality of air"is important in this context, looking at indoor climate as a function of the materials in contact with indoor air, but also the criteria on "Health quality of water" points to the use of materials.

5.3 The relationship of HQE to EN 15804 and EN 15978

The HQE scheme appears to have many elements in common with EN 15804 and EN 15978. There are, however, some differences with respect to both setting of system boundaries and calculation and reporting of environmental impacts. These differences are in turn related to the underlying standards for calculation of environmental impacts of building products and whole buildings. It is, however, important to know that the HQE scheme from autumn 2011 fully accepts information established using European standards that are equivalent to the French standards NF P01-010 and XP P01-020-3.

5.3.1 Comparison of EN 15804 and NF P01-010

On the building product level, HQE requires that life cycle information based on the French standard NF P01-010 is established. The NF P01-010 requires reporting of a detailed inventory of in- and outputs and an impact assessment of ten impact categories. In comparison, EN 15804 does not require the same level of detail with respect to inventory data, but it has on the other hand more detailed requirements with respect to reporting of aggregated values for e.g. resource consumption. With respect to impact assessment, EN 15804 only requires seven impact categories to be included, but some of the aggregated values for energy and resource consumption as well as waste generation must also be included.

More important are probably the differences with respect to setting of system boundaries. NF P01-010 requires that the EPD includes the full life cycle (cradle-to-grave) of the product whereas EN 15804 offers three possibilities for reporting, i.e. cradle-to-gate, cradle-to-gate (with options) and cradle-to-grave. In this context it is interesting to note that in NF P01-010 the default end-of-life scenario is defined as "landfilling" whereas EN 15804 at first considers the output from deconstruction, dismantling, etc as waste, but then requires a detailed examination of its fate until it reaches the end-of-waste state. If available, today's average can here be used for quantification of potential benefits or avoided loads, otherwise a conservative approach shall be used.

A third element that can be of importance is the rules for allocation. It is outside the scope of this report to go into significant detail, but it is mentioned that NF P01-010 appears to be relatively flexible, requiring in clause 4.5.3.a that when dealing with recycling or reuse "the main rule to be observed is to ensure that the choices made from one product to the next are consistent and transparent". Whether this rule is interpreted in the same way by different practitioners is an open question. EN 15804 provides more stringent rules in clause 6.4.3, requiring that the system is investigated in detail.

It is not possible to assess whether an EPD established in NF P01-010 formally is fully equivalent to one established using the provisions in EN 15804, and *vice versa*. As mentioned, the HQE scheme accepts information established using either standard, and there are therefore no practical problems with respect to data exchange. There may, however, prove to be some differences between the results for products with a high recycling potential or content of inherent energy when assessed by the two standards.

5.3.2 Comparison of EN 15978 and XP P01-020-3

The French standardisation organization, AFNOR, has published a standard (XP P 01-20-3) for how to calculate the environmental life cycle impacts of a building using the knowledge obtained from e.g. environmental product declarations according to NF P01-010. Likewise, CEN recently published the common European standard, EN 15978, also giving provisions for calculation of the life cycle impacts of whole buildings.

FORCE Technology has not had access to actual assessment of whole buildings, established according to the provisions in either scheme and it is therefore very difficult make a meaningful comparison of the two standards.

It is, however, evident that both standards have been established with the purpose of aggregating information available from environmental product declarations, calculations of energy consumption, etc. Since they both build as far as possible on the underlying product standards described in section 5.3.1, the results will have the same inherent differences, but now on a more aggregated level. Again, a conclusion is therefore that it cannot be ruled out that the results of a whole building assessment will be virtually the same, irrespective of the standard. It is, however, much more likely that they will be significantly differentat some points. Not so much because of differences in the calculated life cycle impacts of building products, but because the standards are not very similar with respect to their provisions and guidance for use stage scenarios.

On the more specific level, one of differences that emerge is that EN 15978 excludes reporting of land use as long as there is no scientifically agreed calculation method within the context of LCA, whereas the French standard requires reporting of land use, distinguishing in an informative annex between three types of land.

Another specific difference is that the French standard calls for a more detailed examination of the relative importance of a number of elements, including not only specific materials and components, but also water consumption, liquid wastes, energy consumption for elevators and automatic door, etc. These requirements are brought into play in section 2.3.2 in the HQE certification scheme.

5.4 Adoption of HQE in other countries

As mentioned in the introduction to HQE, most of the certified buildings are today situated in France, while the remaining buildings are found in French-speaking countries like Algiers, Belgium and Luxembourg.

This is not surprising, since much of the information available and most of the communication in the certification scheme is in French. This is for example the case for the environmental product declarations in the INIÉS database, that all are in French. This may appear to be a minor problem, but if a builder wants to use building products that are not already present in the French database, he may have to go through the process from scratch, establishing EPD's after NF P01-010 with French as the main language of communication.

This situation is significantly improved with the acceptance of EPDs made according to equivalent European standards. This means that a builder in principle can draw on EPDs made in other European countries than France. It is, however, still an open question if EPD information in the German Oekobau.dat database is of sufficient quality for use in the HQE scheme.

6 Cradle to Cradle Assessment

6.1 Introduction to the Cradle to Cradle concept

The Cradle to Cradle (C2C) concept was developed in the beginning of the millennium by two persons, William McDonough (USA) and Michael Braungart (Germany). Since then, the concept has been formalized and national offices in several countries (e.g. Switzerland, The Netherlands, Germany and Denmark in Europe) works on a commercial basis with implementation of C2C thinking in design and development as well as managing the certification process, which for many is important because it is the only visible proof on an on-going work.

The C2C concept has gained wide interest among especially designers over the past few years. The concept was originally aimed at developing sustainable products but is more and more becoming a new paradigm for a more sustainable World: "Imagine a world in which all the things we make, use, and consume provide nutrition for nature and industry—a world in which growth is good and human activity generates a delightful, restorative ecological footprint."[31]

The C2C concept rests on three pillars:

- **"Waste Equals Food"**, calling for the elimination of the very concept of waste and encouraging to be inspired by nature's endless nutrient cycles.Instead of the eco-efficient approach of trying to reduce the amount of waste, the focus should be to design systems with outputs that can be taken up as nutrient by other processes. Instead of addressing waste the approach thus distinguishes between biological and technical nutrients.
- **"Use Current Solar income"** dictates that the energy needed to sustain a closed loop C2C society must all come from what is termed "current solar income", i.e. photovoltaic, geothermal, wind, hydro and biomass. Due to the vision of being entirely supplied by energy from the sun, C2C design and product cycles are not constrained by the energy use during the life cycle of a product. As long as the energy quality meets the requirements (current solar income) the energy quantity is irrelevant.
- **"Celebrate Diversity",** taking into consideration that healthy ecosystems are complex communities of living things, each of which has developed a unique response to its surroundings that works in concert with other organisms to sustain the system.

It seems important for the C2C concept developers to distinguish itself from the Cradle-to-grave thinking that was the original idea when guidelines and standards for Life Cycle Assessment (LCA) were developed more than 10 years ago. Since then, LCA practitioners have changed the word "grave" to "end-of-life", indicating that in today's society, re-use, recycling and energy recovery marks the end-of-life of many products, not disposal in a landfill. Of course, many products still end up in landfills, also in highly industrialized countries, but LCA provides useful metrics for identifying the best solution from an environmental point of view, given the existing infrastructure.

[31] Quoted from McDonough W and Braungart M (2003). http://www.mcdonough.com/writings/cradle_to_cradle-alt.htm

6.2 Buildings in a C2C perspective

During the past few years, architects and constructors have become increasingly interested in the concept, with one of the founders, William McDonough, who himself is an architect, being a main source of inspiration. An example of how the C2C concept can be used in buildings is "The Treescraber", designed by McDonough[32]. Achieving full C2C status on the total building level is, however, not considered as feasible today by the C2C society, e.g. because there are only about 150 certified building products on the market, many of which only have a basic or silver certificate.

Instead, a more pragmatic approach has been suggested by both the Dutch and the Danish branch (www.vuggetilvugge.dk) of the C2C mother institution EPEA in Germany, in collaboration with McDonough and associates. As an example, in a project co-funded by the philanthropic Danish real estate investor RealDania, one of the intended goals is to develop a set of building instructions based on the C2C concept. The instructions are intended to pave the way for implementation of C2C in the building sector and it will be based on four principles, i.e.

- Design for circuits
- Use of green energy
- Use of healthy materials and
- Support of biodiversity

It is thus not the intention to establish a C2C certification scheme for buildings, but rather to give guidance as to innovative design and use of materials and energy systems. The goals for the project "Green solution house" are thus – within the general C2C principles - to

- Be an innovative platform for the highest level of sustainable development
- Be an example of continuous improvement
- Show solutions addressing biodiversity, materials, energy, water and waste
- Grow a network for knowledge sharing

6.3 Cradle to Cradle certification

As mentioned, the conceptual framework for design and production of C2C products presents to many people a paradigm shift addressing over-consumption and waste, and as such the concept shall not be limited by very stringent rules and definitions of good and bad. In practice, however, designers and producers need to have much more detailed guidelines for what to do and what not to do.

This need has been transformed into a commercial certification scheme for C2C products, aiming at establishing documentation of a continuous improvement in product performance. The continuous improvement is documented in four steps, starting with the Basic level and improving through Silver and Gold levels and ending with the ultimate C2C product with a Platinum certificate.

The certification scheme has been developed in a fairly closed and private process, with the founders McDonough and Braungart being the initiators. Not all details about the certification are known, but it is

[32] http://www.beautifycnmi.com/william-mcdonoughs-treescraper-tower-of-tomorrow/

noted that neither measurement methods nor classification of chemicals need to be in line with the requirements in European standards and policies such as REACH and the work of CEN TC 351. It is also noted that it is the mother organization EPEA that give accreditations to certifying bodies, ensuring full private control over the scheme.

A product certification starts with the basic level, where all product ingredients are identified and defined as biological or technical nutrients and assessed with respect to potential impacts on human health and ecosystems. Also at the basic level, energy use and sources are identified, and a strategy for optimizing the use of problematic ingredients and materials. The criteria for certification at the ultimate level, "Platinum", are much more comprehensive including e.g. that all problematic ingredients have been phased out, the re-utilisation rate for technical and biological nutrients are more than 80%, and that the entire product (including sourced raw materials) is using at least 50% current solar income. An overview of the criteria at the four levels (Basic, Silver, Gold and Platinum) is found in Figure 6.

6.3.1 BASIC LEVEL

Obviously and naturally the criteria are strengthened from the Basic to Platinum levels. Certification at the Basic level focuses all product ingredients are identified and defined as biological or technical nutrients and assessed with respect to potential impacts on human health and ecosystems, see Table 6. It is noted in this context that information about the criteria for obtaining "green", "yellow" and "red" scoring in this important element are not publicly available to any significant extent. It is known that the assessment is based on the information in Material Safety Data Sheets (MSDS), and it is therefore a natural assumption that the criteria to a large extent follow official legislation (most probably US based) regarding classification and labeling of chemicals and chemical products. All assessments are made by the certifying party, with the visible outcome being a certification report including the achievement level.

Also at the Basic level, energy use and sources are identified, and a strategy for optimizing the use of problematic ingredients and materials is established. The requirements for achieving a basic C2C certificate are thus very similar to the basic steps in implementing an environmental management system, e.g. conforming to ISO 14001. The first step here is to perform an environmental audit, mapping all relevant exchanges with the environment and the second is to formulate an action plan – or rather goals for improvement that not only concerns use and disposal of chemicals but all types of environmental impacts. However, environmental management systems will in general not consider the nature of the products being exported from the site, e.g. how their life and end-of-life will affect the environment.

About 5% of the products listed as certified (http://c2c.mbdc.com/c2c/list.php) have a Basic certification.

Score	Comment
Green	Little to no risk associated with this substance. Preferred for use in its intended application.
Yellow	Low to moderate risk associated with this substance. Acceptable for continued use unless a GREEN alternative is available.
Red	High hazard and risk associated with the use of this substance. Develop strategy for phase out.
Grey	Incomplete data. Cannot be characterized.

TABLE 6. CHARACTERISATION AND SCORING OF INGREDIENTS, SUBSTANCES AND MATERIALS

6.3.2 SILVER LEVEL

Certification at the Silver level adds a range of strategic considerations to the basic level requirements:

- Development of a strategy for using current solar income for product manufacture/assembly
- Creation or adaption of water stewardship principles/guidelines
- Adoption – across the entire company – of publicly available corporate ethics and fair labor statement(s)

Also at the Silver level the first technical exercise is to be conducted, i.e. documenting that the product has been designed/manufactured for the technical or biological cycle and has a so-called nutrient (re)utilization score >= 50. The nutrient (re)utilization score is a combination of the recyclability/compostability and recycled/renewable content of the product. Recycled content is only counted if it positively defined (e.g., recycled content of Red assessed materials will not count). In addition, a material must be easily separable to be considered recyclable. For example, if two different materials, each easily recyclable by itself, are irreversibly joined together neither one will be considered recyclable.

A certification at the Silver level can be compared to having defined a (narrowly) focused action plan in a certifiable environmental management system, adding elements from a Design for Recycling (DfR) product development strategy. A main difference at this level is that it is mandatory to consider the use of renewable energy for manufacturing and assembly processes, while a conventional management system would target energy reductions in general. Another difference is that the C2C certification requires documentation that the specified nutrient (re)utilization score (>= 50) can be reached. In a conventional DfR strategy, considerations are in general focused on improvements within the existing infrastructure (e.g. collection systems), whereas C2C certification encourages development of new infrastructural elements, especially when the demands for a high re(utilization) score becomes imminent at the Gold and Platinum levels.

About 90% of the products listed as certified (http://c2c.mbdc.com/c2c/list.php) have a Silver certification.

6.3.3 GOLD LEVEL

To achieve the Gold level certification the product (and the producer) must fulfill yet another set of criteria additional to those at the Silver level:

- The product formulation is optimized, i.e. all problematic inputs have been replaced or phased out
- No wood has been sourced from endangered forests

- C2C emission standards are met
- A well defined plan (including scope and budget) for developing the logistics and recovery systems for this class of products
- The nutrient (re)utilization score >= 65
- Use of 50% current solar income for product final manufacture/assembly
- Characterised water flows associated with product manufacture
- Identified third party social responsibility assessment system and begun to collect data for this

All of the Gold certificate criteria are relevant from a sustainable (building) product point of view, both on the technical side (C2C emission standards are defined) and on the more social side, where the work with corporate sustainability is a requirement. More notably perhaps, is the requirement that at this level the manufacturer must source 50% of the required manufacturing energy from renewable resources ("current solar income).

About 5% of the products listed as C2C certified (http://c2c.mbdc.com/c2c/list.php) have a Gold certificate.

6.3.4 Platinum level

In order to achieve the Platinum level certification, the product must comply with the requirements for the Gold label award as well as additional criteria:

- All wood is FSC certified
- The product contains at least 25% (or 50%?) components assessed as "Green". (Table 6 says 25%, but the report text say 50%, hence the uncertainty)
- Product can be recovered, remanufactured or recycled into a product of equal or higher value
- The nutrient (re)utilization score >= 80
- Use of 50% current solar income for the entire product
- Implementation of innovative measures to improve quality of water discharges
- The producer has an acceptable third party social responsibility assessment, accreditation or certification

The Platinum criteria present significant additional requirements at both product level, company and supply chain level. The requirement that "the product can be recovered, remanufactured or recycled into a product of equal or higher value" is related to basic principle that "Waste is food", but it is difficult to see how the requirement can be fulfilled in practice in a society with a market-based economy. As an example, mechanical recycling of plastic materials like nylon (e.g. used for carpets) will inevitably result in recycled fibres with reduced technical properties compared to virgin fibres. If a chemical feedstock recycling process is applied, there will invariably be losses. In a market economy, this will automatically lead to a reduced value.

At the supply chain level, the requirement that 50% of the energy for the entire product must come from current solar energy may necessitate that also some of the suppliers use renewable energy in their production of raw materials and components. Likewise, all suppliers are required to have publicly available corporate ethics and labor statements, similar to requirements at the Basic level.

No products have yet been awarded a Platinum certificate.

CRADLE TO CRADLE CERTIFICATION^{SM} CRITERIA	Basic	Silver	Gold	Platinum
1.0 Materials				
All material ingredients identified (down to the 100 ppm level)	•	•	•	•
Defined as biological or technical nutrient	•	•	•	•
All materials assessed based on their intended use and impact on Human/Environmental Health according to the following criteria: *Human Health:* Carcinogenicity, Endocrine Disruption, Mutagenicity, Reproductive Toxicity, Teratogenicity, Acute Toxicity, Chronic Toxicity, Irritation, Sensitization *Environmental Health:* Fish Toxicity, Algae Toxicity, Daphnia Toxicity, Persistence/Biodegradation, Bioaccumulation, Ozone Depletion/Climatic Relevance *Material Class Criteria:* Content of Organohalogens, Content of Heavy Metals	•	•	•	•
Strategy developed to optimize all remaining problematic ingredients/materials	•	•		
Product formulation optimized (i.e., all problematic inputs replaced/phased out)			•	•
No wood sourced from endangered forests			•	•
Meets Cradle to Cradle emission standards			•	•
All wood is FSC certified				•
Contains at least 25% GREEN assessed components				•
2.0 Material Reutilization/Design for Environment				
Defined the appropriate cycle (i.e., Technical or Biological) for the product and developing a plan for product recovery and reutilization	•	•	•	•
Well defined plan (including scope and budget) for developing the logistics and recovery systems for this class of product			•	•
Recovering, remanufacturing or recycling the product into new product of equal or higher value				•
Product has been designed/manufactured for the technical or biological cycle and has a nutrient (re)utilization score >= 50		•	•	•
Product has been designed/manufactured for the technical or biological cycle and has a nutrient (re)utilization score >= 65			•	•
Product has been designed/manufactured for the technical or biological cycle and has a nutrient (re)utilization score >= 80				•
3.0 Energy				
Characterized energy use and source(s) for product manufacture/assembly	•	•	•	•
Developed strategy for using current solar income for product manufacture/assembly		•	•	•
Using 50% current solar income for product final manufacture/assembly			•	•
Using 50% current solar income for entire product				•
4.0 Water				
Created or adopted water stewardship principles/guidelines		•	•	•
Characterized water flows associated with product manufacture			•	•
Implemented water conservation measures				•
Implemented innovative measures to improve quality of water discharges				•
5.0 Social Responsibility				
Publicly available corporate ethics and fair labor statement(s), adopted across entire company		•	•	•
Identified third party assessment system and begun to collect data for that system			•	•
Acceptable third party social responsibility assessment, accreditation, or certification				•

FIGURE 6. CRADLE TO CRADLE CERTIFICATION CRITERIA. FROM MBDC (2008)[33]

6.4 C2C CERTIFICATION CRITERIA IN A PRODUCT LIFE CYCLE PERSPECTIVE

A renewed life cycle paradigm, i.e. Cradle to Cradle rather than Cradle to Grave, is the carrying idea behind the concept C2C. Two of the criteria elements are judged to be of special importance n the C2C perspective, namely the required use of current solar income and the (re)utilisation of materials and components as

[33] MBDC (2008). Cradle to Cradle^{SM} CertificationProgram. Version 2.1.1. (http://mbdc.com/images/Outline_CertificationV2_1_1.pdf)

nutrients in other cycles. It is, however, obvious from the description of the certification levels that the content of chemical substances in the product has a key focus throughout the certification process.

The criteria regarding use of current solar income as the main energy source is one the one hand a very straightforward choice with large potential benefits for environment: Given the choice, most people will choose clean and renewable energy without risks rather than polluting or hazardous energy sources. On the other hand, the C2C concept is to a large extent based on the expectation that renewable energy sources are or will be plentiful in a foreseeable future and we therefore do not need to consider how much energy we use as long as it is based on current solar income. This scenario is very optimistic, and although it is very inspiring for many designers and product developers, it will probably lead to sub-optimal products in most cases as long as the C2C universe must function within current societal infrastructure. Using the example of nylon recycling, the large amounts of (renewable) energy needed for chemical feedstock recycling could perhaps be used better in other places, e.g. substituting coal for power production or just used for food. This finding would most probably be supported by a conventional life cycle assessment with appropriately expanded system boundaries.

The criteria regarding (re)utilization of materials and components as technical or biological nutrients for other cycles represents a slightly different approach to re-use and recycling than conventional concepts within the area life cycle thinking and life cycle management. The main difference is that waste does not occur in the life cycle of C2C products, only nutrients. In order to achieve this goal, strict requirements regarding dismantling, separation and recovery are included in the criteria for Gold and Platinum certification. In principle, specail circuits must be designed and implemented for each product. They need not be dedicated product take-back programs but may equally well be utilization of design for disassembly (DfD) strategies in collaboration with third party regional recyclers.

The C2C concept does not include any form of quantification of environmental impacts as is known from LCA. It is, however, obvious that Gold and Platinum certified products will have a relatively low environmental impact in most LCA impact categories, simply because they in the “ideal C2C world” are produced using a large share of renewable energy (without significant impacts) and because they at the end of their useful life are fully recycled into usable materials and components that can substitute other technical or biological nutrients, also without impacts from energy production. Whether the “ideal C2C world” can be realized in practice is still a very open question.

It is concluded that outside the ideal C2C world can C2C products with Basic or Silver certificates be regarded as similar to products from suppliers with an on-going ISO 14001 certification scheme and a focus on the recyclability of products and materials found in the value chain. The products aim at having better environmental properties than conventional products, but the improvements have not necessarily been implemented yet.

For products with a Gold or Platinum certificate specific improvement options have to be implemented. Especially use of current solar income will have a positive effect on the environmental profile as calculated by both attributional and accounting LCA. In practice, however, the picture may be different. If the energy from current solar income is sourced externally, e.g. through acquisition of Renewable Energy Certificates (REC), there is no guarantee that the increased demand will result in an increased production. As long as the supply of renewable energy is limited (and this will be the case for many years to come) the main result is that customers buying average electricity will receive less green electricity. Accordingly, no changes are induced in the global climate account. If, on the other hand, the energy from current solar income is sourced through investments in new renewable energy (e.g. from wind mills, solar panels or photovoltaic elements installed on-site) then the benefits for the environment are real.

6.5 C2C PRODUCTS IN A BUILDING LIFE CYCLE PERSPECTIVE

Irrespective of the level of the certificate, C2C products will only make a minor difference in a building life cycle perspective – if any. On the Basic and Silver level, C2C products do not affect the building life cycle performance in neither a positive nor a negative way. On the Gold and Platinum levels, C2C products may themselves perform slightly better than conventional products, but they do not reduce the life cycle impacts of the building in general, e.g. with respect to energy consumption, global warming potential, etc. The only exception from this picture is, if the (re)utilization scheme for the product works in practice when the building is demolished. If so, the amounts of waste being landfilled will be less than for conventional products and – depending on the actual product and the recycling scheme – the recycling benefits can be demonstrated by a LCA.

6.6 RELATIONSHIP BETWEEN THE C2C CERTIFIED PRODUCTS, EN 15804 AND EN 15978

Basically, there is no relationship between the documentation needed for C2C product certification and the documentation requested in EN 15804. This is especially the case for quantitative information used to aggregate the life cycle impacts on the total building level as described in EN 15978. The C2C certification will thus not be useful for any purpose stemming from the CEN TC 350 framework.

There may, however, be small exemptions from this general rule, e.g. with respect to information about the release of dangerous substances to indoor air, soil and water during the use stage (Module B1-B7), the content of toxic and ecotoxic substances in the products and possibly also properties of building products and/or their constituents (Module D). “Other loads and benefits” (e.g. relating to dedicated reuse and recycling circuits) can also be included in Module D, but only after calculation of the actual flows of substances out of the system.

6.7 ADOPTION OF C2C IN OTHER COUNTRIES

The Cradle-to-Cradle framework has been developed as global from the beginning, without any formal ties to national or regional regulations. As such, both the certification criteria and the process is the same in all countries. Accordingly, a C2C certificate on a product is valid all over the World. If new production facilities are installed, using a different infrastructure or different suppliers, products coming out from these facilities need to have their own certificate.

The report at a glance

The study examines four international building certification schemes (BREEAM (UK), LEED (US), DGNB (DE) and HQE (FR)) as well as the so-called Cradle-to-Cradle concept.

On the overall level, a wide and heterogeneous array of material and building aspects and impacts are evaluated together In the labeling schemes studied, resulting in a loss of detail. Therefore, readers with a focus on material performance are suggested to study Environmental Product Declarations (EPDs) including the use stage of the building for the relevant materials.

The most important findings are:

- In all building certification schemes, the direct environmental life cycle performance of the selected building materials and products appears to be less important for the final rating than commonly thought, accounting at most for about 5% of the total score. The building materials and products may, however, also have a significant indirect influence on how the building performs in energy-related categories that are accounted for separately.
- The DGNB and the HQE schemes seem to follow the provisions in the upcoming European standards EN 15804 and EN 15978 as close as possible and they are therefore well suited to describe the material and building impacts during building lifetime.
- The US-based LEED scheme and the Cradle-to-Cradle concept do not use any kind of quantitative information about the life cycle environmental performance of materials and products. LEED, however, gives a small credit if EPDs are available.
- The HQE and DGNB schemes require that life cycle assessments (LCA) of building products are available. In DGNB, the LCAs are an integral part of calculating and rating the building performance, while HQE rewards the calculation of the contribution from building products, but not necessarily the results. However, if the life cycle results are used actively, e.g. in the choice of products, the overall rating of the building may improve.
- The UK-based BREEAM scheme appears to use an LCA approach which is not in full accordance with international standards and practice.
- In a building lifetime perspective it should be remembered that differences with respect to “fitness for use” of building materials often are much more important than the differences measured by assessments in which their function is not considered. This information should be available from good quality Environmental Product Declarations, and it is obligatory to consider these aspects in the HQE scheme

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