Environmental and health related criteria for buildings

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2. EXECUTIVE SUMMARY

2.1. Scope and Objective

The objective of the study is to provide ANEC with a background paper on environmental and health-related criteria for buildings. The background paper shall be the basis for developing a European set of environmental and health-related indicators.
The study shall support ANEC in position finding processes and enable to shape upcoming discussion on these issues. Key criteria were selected from a consumer's perspective account by focussing on familiar information (e.g. NO_x emission rather than acidification indicator for central heating burner). However, the potential readers of the study are expected to be experienced in the topics of assessing the environmental performance of buildings.

In order to do so the study at hand presents an analysis of the problem of the Commission's numerous initiatives, reveals new perspectives, and principle solutions.

It was not the aim of the study to elaborate a detailed complete criteria and indicator catalogue for an assessment method to be used in CEN/TC 350 or in EU Ecolabel for buildings as such.

The first approach was a consideration of several existing building assessment systems with special attention to the communalities. The following technical guides and references to building assessment systems were considered:

EU Eco-Label	EU Eco-Label Award Scheme for Buildings: Supporting document to third draft criteria (ed. ISPRA, May 2010)
SBTool	Reference: "An Overview of SBTool, September 2007 Release" (ed. iisbe, Nils Larsson)
CSH	Code for Sustainable Homes: Technical Guide May 2009, Version 2; ed. Department for Communities and Local Government, 2009
BREEAM MR	BREEAM Multi-residential 2008 Assessor Manual (BREEAM BRE Environmental & Sustainability Standard BES 5064: Issue 1.0; ed. © BRE Global, 2008, http://www.breeam.org)
LEED HRS	LEED® for Homes Rating System, Version 2008 including corrections, clarifications and new exemplary performance rulings (ed. U.S. Green Building Council, January 2010)
LEED NC	LEED Reference Guide for Green Building Design and Construction (for the Design, Construction and Major Renovations of Commercial and Institutional Buildings Including Core & Shell and K-12 School Projects (ed. US. Green Building Council, Washington, 2009)
DGNB	DGNB – residential buildings. Steckbriefe (Draft, May 2010)
TQB	TQB-Kriterienkatalog (TQB catalogue of criteria), status 22.07.2010

Building assessment systems may use similar indicators but conceptually handle them differently. These different approaches should be described with their advantages and disadvantages and conclusions drawn about which concept would be useful for consumers.

Next step was the choice of indicators that had to be exemplified. It led to the following categories for which an in-depth analysis was carried out:

- Life cycle assessment (LCA) with focus on building material
- Energy demand and CO_2-emissions with focus on operation phase
- Daylighting
- Emissions on construction site
- Chemicals in building materials / indoor air

2.2. Energy and CO_2 Emissions

Operation phase

Highly aggregated results such as CO_2 emissions or primary energy demand – especially when summarized over the whole life cycle may lead to losses of important interim results and optimisation steps which are more relevant to target groups of building rating systems. End-consumers for example need comprehensible and sufficiently accurate information of the energy efficiency of both, building envelope and HVAC systems, and guidance which energy carriers are environmentally-friendly, secure and available at affordable costs.

Therefore, the following bottom-up approach is recommended:

a) Heating or – if more applicable for southern latitudes – cooling and heating energy demand (assessment of the building envelope, solar passive gains and passive cooling measures)

b) Delivered energy (assessment of the energy-efficiency of both envelope and HVAC systems)

c) Primary energy (restricted to the operational phase)

d) CO_2 Emissions (restricted to the operational phase)

e) NO_x Emissions, Particulate Matter (restricted to the operational phase)

a) Heating or – if more applicable for southern latitudes – cooling and heating energy demand

Apart from local climate conditions, heating energy demand is influenced by parameters that describe the thermal specifications of a building: average U-value, compactness, air-tightness of the building, avoidance of thermal bridges, ventilation losses, and passive solar gains, cooling energy demand by size of windows and passive cooling measures (like shading devices, thermal capacity of the building mass, night venting, etc.).

Individual measures (like reduction of heat loss parameters) are awarded in almost all sustainable building assessment systems[1] in order to focus on important optimisation strategies and to ensure that besides the efficiency of HVAC systems (see next section) the building itself meets defined quality requirements.
The authors try to avoid the rating of individual measures due to the complexity of regional and local specifics and market availability of components but recommend the assessment of the heating and cooling energy demand in addition to more comprehensive energy indicators like delivered or primary energy demand which are based on these basic figures (see sections b-e).
Because of the variety of calculation methods within the EU member states and the various main indicators used for energy performance certificates, a more consistent method is required for an EU Eco-label of buildings. Two options are possible:

- referring either to EN ISO 13790[2] (in this case uniform calculation parameters have to be defined where national adaptations are allowed in principle[3] to guarantee the comparability of calculated figures for an EU-wide labelling of buildings)
- or the reference is the PHPP calculation method (Passive House Planning Package 2007) following the guidelines of the Passive House Institute Darmstadt.

Defining benchmarks for rating, an EU-wide Eco-label must not neglect regional climate conditions (heating/cooling degree days, solar radiation, etc.). A differentiation into at least three zones (cold, moderate and warm climate zones[4]) within Europe is recommended.

b) Delivered energy (including efficiency of HVAC systems)

The delivered energy for each energy carrier should be part of any consumer-oriented assessment system (rated in both absolute figures and in comparison to similar building services to be able to assess the energy efficiency of the system(s) installed). The delivered energy (defined as the final energy demand lowered by the gains of (solar) plants on the building site) is of significant relevance for the prospective buyer or tenant of a building or building unit. Energy costs are based on the delivered energy (to the building or building unit) including losses and gains of all HVAC systems installed (calculation is based on standardised conditions for user behaviour and climate and usually includes all energy services).
Power consumption for domestic appliances is not always included in the calculation methods of the final or delivered energy demand or, if taken into account, it is calculated only by default values as electrical appliances are usually not provided by the builders. However,

[1] (apart from DGNB which uses highly aggregated indicators such as primary energy non-renewable or CO2-emissions over the whole life-cycle).
[2] EN ISO 13790: 2008 Energy performance of buildings - Calculation of energy use for space heating and cooling
[3] E.g. method of calculation (monthly balance/ heating (cooling) period balance, simplified or detailed hour-based simulation). internal gains from electrical appliances, etc. Climate data (heating degree days, solar radiation) and corresponding parameters (e.g. length of heating period) have to be defined regionally as consequence of methodology.
[4] Cold: above 4200 heating degree days, moderate: between 2200 and 4200 heating degree days and warm: below 2200 heating degree days per year (according to the study Boyano, A.; Wolf, O.; "Analysis and evaluation of 3rd draft criteria for Buildings and next steps: The application of the Ecolabel Regulation (EC66/2010) to Buildings: Draft Preleminary Study Task 1: Product Group Definition and Priorization Analysis of Previous Draft Criteria Studies (ed. JRC Institute for Prospective Technological Studies, October 2010)

home owners or tenants should at least be informed about the savings potential through energy-efficient domestic appliances (e.g. via energylabel, user guides, web links etc.).

c) Primary energy demand (restricted to the operational phase)

Delivered energy is an appropriate informative parameter for consumers but not sufficient as ecological key indicator for the whole energy consumption of the building sector. Important relevant energy generation processes are excluded from consideration. Energy scarcity and the upstream processes to generate energy delivered to the final consumer cannot be neglected. Therefore, it is necessary to include primary energy into a comprehensive building assessment method. Additionally, the authors recommend to rate renewable and non-renewable energy consumption separately, since availability and renewability of resources is an important ecological aspect. This can be done by rating the primary energy demand of non-renewable resources or by assessing both the total primary energy demand and the share of renewable resources.

Primary energy factors for different energy carriers (especially electricity and district heating) must be consistent and based on the same datasource when assessing buildings within one rating system. Ranges of production mix (e.g. >70%, > 50%, >35% Combined Heat and Power) have to be specified.

The highest level to achieve (zero energy/plus energy buildings) need clear distinction and a stringent definition of the balance boundaries (whether zero energy level will be achieved within a period of one year or at any time and renewable energy sources on-site/off-site are taken into account).

d) CO_2 Emissions (restricted to the operational phase)

Apart from causing emissions of pollutants such as SOx, NOx and particulate matter, energy generation and supply is one of the main sources of carbon-dioxide emissions thus contributing to man-induced greenhouse effect. Apart from industry production processes and transport, buildings are the main consumers of energy.
CO_2 based assessments of buildings will be inevitable in future taking into consideration the European environmental policy.

Not all member states have already implemented a CO_2 calculation method.
In this case the primary energy demand is acceptable as key indicator in order not to cause extra calculation expense. Where CO_2 indicators are already implemented it is recommended to add a rating for the CO_2 emissions for assessing the efficiency of climate protection measures in the building sector. [5]

e) NO_x emissions, Particulate Matter (restricted to the operational phase)

Minimum requirements for the NO_x and Particulate Matter emissions of the heating systems in regular operation shall be given in an EU-wide Eco-label for buildings.

[5] Advantages and disadvantages of using CO_2 as key indicator for product rating (e.g. Product Carbon Footprint) are broadly discussed in the study "Quack, D.; Grießhammer, R.; Teufel, J.; Requirements on Consumer Information about Product Carbon Footprint (ed. Öko-Institut e.V. commissioned by ANEC, Freiburg, 2010)"

Embodied Energy in Building Materials

The embodied energy in building materials shall be considered as a proxy indicator to assess the environmental performance of the building. For more details to lifecycle considerations see the following chapter “Life cycle assessment”.

Traffic-related Energy Consumption

Transports to and from sites (for construction, refurbishment, and removal of buildings) are required in an overall LCA. They contribute to only 4% of the total embodied non-renewable primary energy over the whole lifecycle. An overall assessment of primary energy does not allow differentiation. Therefore, it is more effective to optimise the traffic-related energy consumption to and from site by indicators requiring the use of (low-emitting) vehicles with efficient diesel consumption than to limit the overall primary energy demand over the lifecycle.

2.3. Life Cycle Assessment

Introduction

ANEC has commissioned several studies and already formed its opinion about LCA as well as its application in building assessment. Hence, the following chapter concentrates on the compilation of the main findings in the relevant studies and on recommendations concerning the use of LCA in building assessment systems.
A detailed analysis of the use of LCA in the existing building assessment systems is not carried out since LCA-methodology is clearly defined in ISO 14040 and 14044. The various building assessment systems differ concerning the used indicators, the considered life cycle stages and the weighting and benchmarking of the indicators.
The conclusions and recommendations concerning the use of LCA in building assessment systems rely on own experience with and knowledge of life cycle assessment of buildings and the following meta-studies (see also chapter “3.2 Background”):

- European Commission / Joint Research Centre: Environmental improvement potential of residential buildings (IMPRO-Building, 2008)
- European Commission / Joint Research Centre: Environmental Impact of Products (EIPRO). Analysis of the life cycle environmental impacts related to the final consumption of the EU-25 (EIPRO, 2006)
- ANEC / Öko-Institut, Ökopol: Environmental product indicators and benchmarks in the context of environmental labels and declarations (PRAKASH, REINTJES, 2008).

Recommendations for the use of LCA in building assessment systems

LCA is an excellent tool for orientation purposes in the initial phase of environmental product labelling (or criteria setting) and for comparing system alternatives. Therefore, it will not be necessary to carry out complete LCAs by any means (as pursued by CEN/TC 350)

- since orientation studies like IMPRO show that the use phase (dominated by the energy demand for heating) is the most important for new buildings, while the end-of-life phase and the construction process are of much lower importance.

- since it can be shown that most LCA-indicators correlate strongly with energy (IMPRO, 2008).
- since the POCP-indicator of a building mainly results from the VOC-emissions of solvent-based building materials. In this case the criteria shall be based on the avoidance of the use of these products instead of an elaborate LCA-indicator (LIPP, 2010).

Based on this fundamental statement, we recommend the following implementation of LCA in building assessment tools:

Primary energy use and greenhouse gas (GHG) emissions are good proxy indicators to assess the environmental performance of the buildings (IMPRO, 2008). The gain in information by taking other LCA-indicators in account is questionable, whereas leaving them out saves oneself the question of weighting the indicators.

The compactness of the building could also be a good first proxy indicator for the environmental performance of the building.

We recommend considering the use phase (for more details see chapter “Energy and CO_2-emissions”) and the manufacturing of the construction materials (cradle to gate) within a proxy LCA. The construction operation can be neglected and the improvement options for disposal processes could be expressed much better with the help of qualitative indicators (MÖTZL, 2009). All considered **life-cycle stages** of the building should be regarded separately.
The renovation cycles should be taken into account – in principle, unless the service life of the building is limited with as short periods of service life as in IMPRO-study (40 years) or DGNB (50 years). Reference values for renovation cycles were proposed in ZELGER et al (2009) for instance.

According to IMPRO (2008) the impacts caused by the construction phase of new building primarily stem from the construction of the exterior walls, the basement, and floors/ceilings. Interior walls, roof and windows only play a minor role. Our own LCA-calculations however show that the roof (in single-family houses) and the windows play must not be underestimated. Hence, we recommend taking all listed constructions into account. Interior and exterior doors, paintings, adhesives, screws and other auxiliary materials can be neglected or roughly estimated.

Calculations can be made on the basis of (agreed) **generic data**. Methodological conventions (e.g. which energy mix to be used) must be established at the regulatory level in Europe. Standardisation should not be considered as sufficient to this end.

It is strongly recommended to focus on **different instruments**, such as environmental impact assessment, chemical risk assessment etc. for measuring the non-LCA-indicators. There is no need to restrict the environmental assessment to mathematical operationalisation of environmental mechanism as it is practised by CEN/TC 350 at the moment. As has been shown in building assessment systems and product labelling for many years, the characterisation models of non-LCA-indicators could be formalised operations based on measurements or qualitative inventory information.

It is recommended to use the same functional unit as for the energy performance assessment (e.g. per “conditioned gross floor area and year” in Austria).

Benchmarks could be set on national level e.g. based on a range of assessed buildings or on political targets.

2.4. Daylighting

Daylighting and lighting related issues are recognized as relevant comfort and health topics in most of the analysed building assessment systems for residential buildings (see chapter 9.9 Summary and Conclusions Daylighting, Table 17).

Daylight factor is the only indicator common to almost all systems, although definition, calculation methods and benchmarks may vary. Daylight factor requirements can be defined either as point or average daylight factor(s) (for relevant rooms of dwellings) or averaged over the whole (or a defined percentage of the) net floor area of a building. Optimisation strategies are more effective if rooms / dwelling units are considered separately and the overall rating is based on an arithmetical mean value of single scores of all dwelling units. Net floor area based ratings consider all rooms independently of their functions and daylight requirements ignoring the fact that darker zones are acceptable for retreat areas, corridors, bathrooms, etc.

Daylight has to be complemented by an indicator assessing the **daylight availability** on site considering latitude, orientation and access to direct sunlight. Sun-drenched rooms are one of the most important purchasing criteria for consumers. Access to direct sunlight in dwelling units can be evaluated by parameters such as sun hours per day especially in wintertime (at low positions of the sun). By this means, criteria like “views out” and “direct sky light” are automatically fulfilled.
As for northern latitudes the optimization potential for winter sun is limited, it is recommended to define regional benchmarks adapted to country-specific conditions.

Glare control (for balanced luminance distribution in the visual field) is of greater significance for office buildings, rooms with workstations, schools, etc. and need not generally to be integrated in an indicator-catalogue tailored for residential buildings (apart from mixed use or southern European countries with higher solar radiation).

Lighting control is not considered to be an important indicator for residential buildings.

The authors recommend to assess the geometric prerequisites of the building (by defining a minimum **point daylight factor** in living rooms in order to ease verification) as well as **direct sunlight** in the dwelling units **(by using sun hours in winter-time)** for the rating of the visual quality of residential buildings. These indicators can be complemented by glare control measures in southern European countries.

2.5. Construction Site Management

Construction site activities are responsible for environmental impacts especially at a local level (e.g. soil erosion, soil contamination, loss of biodiversity, air pollution, waste) and nuisances such as dust and noise (caused by traffic from and to the building site, construction machines, etc.).
The analysed building assessment systems refer to similar impacts caused by building site activities (construction waste, noise, dust, environmental impacts to soil, water), but use different indicators for rating them (see chapter 10.7 Conclusions and Summary – Construction Site Management, Table 21). Ratings differ in scope and subject of assessment, extent of impact and groups affected by the considered impact.

CSH, the Code for Sustainable Homes offers the most comprehensive evaluation for construction sites using an established **third-party certification** scheme of the construction industry (“Considerate Constructors”) to detect and assess all relevant impacts of construction site activities including operational safety and health protection measures and cleanliness of site as well as information policy and a code of behaviour for operatives. Besides this certification scheme, CSH additionally awards the ecological value of site and its conservation, monitoring of energy and water consumption of building site activities and responsibly resourcing of construction timber.

The analysis of different building assessment systems shows two different approaches in defining criteria to minimise these effects:

- **Process-oriented ratings** (i. e. existence of Quality Management Systems, experience of designers in waste reduction, implementation of Environmental Management Systems or other certification schemes by constructors). These criteria aim at a continuous improvement of processes on the construction site, but do not guarantee the fulfilment of definite objectives.
- **Target-oriented ratings**: require specific measures to be set on construction site and provide detailed information to achieve defined target values or levels of quality.

The authors recommend preferring target values which allow clear benchmarks and comparison of rating results achieved in different projects.

The main issues of concern as defined in most of the analysed environmental building assessment systems are the following:

- avoidance of traffic related emissions and noise attenuation through building logistic management:
  - lowering the truck traffic volume to and from the site,
  - using alternative means of transports,
  - claiming obligatory documentation of all transports to and from site),
  - use of low-emitting and low-noise trucks and construction machinery complying with ecolabel criteria (e. g. blue angel[6])
- dust attenuation
  - wetting of the waste groups during reloading,

[6] Low-Noise Construction Machinery (RAL-UZ 53): Basic Criteria for Award of the Environmental Label “Der blaue Engel” (ed. RAL German Institute for Quality Assurance and Certification, Febr. 2007)

  - interdiction of free storage of sand and debris,
  - pavement of site roads,
  - cleaning of tires in a tire washing plant,
  - installation of dust shield nets during renovation, etc.
- appropriate information policy for neighbours and public in general
  - contact point for complaints (on site),
  - appointment of a responsible person
- appropriate waste management
  - detailed waste sorting and instruction of workers
  - reuse of excavation material on site – if possible
- erosion control and protection of the ecological biodiversity on site – where relevant

Energy and water consumption at the construction site is considered to be negligible in comparison to the operation phase of the building and need not to be monitored as well as material flows for construction activities (e.g. building site timber and its responsible sourcing)

LCA-based approaches (using main indicators such as primary energy, GWP, ODP, POCP, AP, NP, etc.) underemphasize construction site relevant impacts (on human health and local environment). The effects of this phase disappear in comparison to long-lasting phases such as operational or renovation phases.

Therefore, indicators (in form of detailed measures as defined above) are recommended to detect the weaknesses of construction site activities and to optimise all relevant processes.

2.6. Chemicals in Building Materials and Indoor Air

Summary

Neither REACH nor the Construction Products Directive nor any other European Legislation or Standardisation are sufficient instruments to guarantee the absence of hazardous ingredients in or emissions from building materials into indoor air.

The existing building assessment systems go beyond legislation but cover the use of chemicals in a very different manner[7]: in a range from the ban of certain chemicals or categories of chemicals to strict limits for VOC-emissions of building materials.

The current harmonisation work on testing methods concerning the VOC-emissions from building materials (CEN TC 351, ECA-IAQ) and the mandatory labelling in Germany (AgBB) and France (AFFSET) will have a positive effect on the availability of tested products. While it is still cumbersome to prescribe low-emitting products because of missing data, it will become much easier in some years.

In order to allow different target values set e.g. in mandatory versus voluntary labelling systems, a shared data handling and reporting tool as suggested by ECA-IAQ (2010) is of importance.

[7] as one can see in chapter 11.3, Table 31

Recommendations for the assessment of chemicals in building materials

Parameters

The following table shows an outline of the authors' and contractors' recommendations concerning chemicals in building materials:

Table 1: Recommendations of the authors concerning chemicals in building materials and emissions from building material

Parameter		Minimum	Excellence
Hazardous ingredients / Problematic materials			
HFC (insulation materials, polyurethane foam, heat pump, ...)		banned	banned
CMR cat I & II in chemicals (varnishes, lacquer, glue,…)		banned	banned
CMR cat I & II in finished goods		avoided (e.g. scores)	banned
other substances of very high concern (vPvBs und PBTs)		banned as far as technically possible	banned
specified other toxic substances e.g. APEOs, heavy metals, halogenated organic solvents, isothiazolinone, endocrine disrupters such as phthalates		-	catalogue of banned / avoided substances e.g. Austrian GPP-standard, ecolabels
Plasticised PVC containing phthalates		banned	banned
Rigid PVC	containing cadmium or lead	banned	banned
	chlor-alkali production based on mercury or diaphragm cell	avoided (e.g. scores)	banned
	others	-	avoided (e.g. scores)
VOC / SVOC		avoided in adhesives for floors (e.g. EMICODE EC1 products)	catalogue of VOC-content-limits for different products e.g. Austrian GPP-standard, ecolabels, can be replaced by forced measurements in test chambers

Products relevant for indoor air quality

Products have to be considered, if they are

- building chemicals applied to the room covering (exterior and interior)
- building materials which are applied inside of the rooms (airtight layer and all building materials inside of it)

The following list is derived from a compilation of BREEAM Multiresidential and the Austrian Standard for Green Public Procurement (or klima:aktiv for commercial buildings respectively)

- Wood Panels (particleboard, fibreboard including MDF, OSB, cement-bonded particleboard, plywood, solid wood panel and acoustic board)
- Timber Structures (glued laminated timber)
- Resilient, textile and laminated floor coverings (vinyl / linoleum, cork / rubber, Carpet)

- Wood flooring (e.g. parquet flooring, laminated wood flooring)
- Flooring adhesives
- Decorative paints and varnishes
- Wall-coverings (finished wallpapers, wall vinyls and plastic wallcoverings, wallpapers for subsequent decoration, heavy duty wall-coverings, textile wall-coverings)
- Adhesive for hanging flexible wall-coverings
- Sealings (e.g. polysiloxane sealing, liquid foil)
- Bitumen coatings and adhesives (also for outdoor use due to VOC migration)

Emissions to indoor air from building products

Harmonised horizontal testing methods which still have to be defined by CEN/TC 351 "Construction Products - Assessment of release of dangerous substances" will not be available in the near future. Hardly any mandatory requirements on VOC-emissions from building materials to indoor air exist in Europe, except for Germany or France.
In this situation the ECA-EAQ scheme could be used as a basis for assessment.

Table 2: Evaluation scheme for the emissions from building materials

Requirements / Parameter	Minimum (modeled on ECA-EAQ)	Excellence (based on natureplus)
Measuring method / Chamber Measuring points (days)	Harmonised CEN Standard (based on ISO 16000 series) 3 and 28	Harmonised CEN Standard (based on ISO 16000 series) 3 and 28
Harmonised list of EU carcinogens classes 1 and 2 compounds	not measureable	not measureable
Single VOCs evaluated ($R = \Sigma\ Ci/LCI < 1$))	R < 1 Harmonised list of LCIs	benchmarks oriented on toxicology-cally derived values where possible
Compounds without LCI assessment	Sum < 100 μg/m^3	benchmarks for sum of impact categories
TVOC measured	1000 μg/m^3 (upper value)	300 μg/m^3
TSVOC measured	100 μg/m^3 (3)	100 μg/m^3
Formaldehyde measured	E1 (≤ 0.12 mg/m^3) (1)	E1 (≤ 0.024 - 0.048 mg/m^3) (2)
Sensory evaluation	Await ISO 16000-28	Await ISO 16000-28

(1) acc. to formaldehyde regulation in various European countries, ECA-EAQ has no value fixed yet

(2) varies between different products

(3) acc. to AGBB, ECA-EAQ has no value fixed yet

While it is still cumbersome to prescribe low-emissions products because of missing data, it can be expected to become much easier in the coming years. Current harmonisation work on testing methods concerning VOC-emissions from building materials (CEN TC 351, ECA-IAQ) and mandatory labelling in Germany (AgBB) and France (AFFSET) will increase availability of tested products.
A remaining problem is that standards set by different initiatives (e.g. mandatory versus voluntary labelling systems) may differ. Additionally, declared values could be indicated as "fulfilling the legal requirements" (e.g. < 0.12 mg/m^3 formaldehyde concentration measured in

a test chamber) rather than indicating the actual value. Then one could not use the declaration for a voluntary scheme requiring a lower emission value (e.g. requiring a threshold of e.g. 0.048 mg/m³ formaldehyde). A shared data handling and reporting tool as suggested by ECA-IAQ (2010) can afford relief to that problem.

Miscellaneous

Measurements on building sites could be done on a random basis in order to keep costs low. Craftsmen should be aware that their work might be assessed. In addition, preliminary test procedures, to be used before harmonised European standards are available, should be identified.

Requirements concerning dangerous substances in, and emissions from, building materials should go as far as possible. In Austria good experiences have been made with the combination of building assessment with product assessment (ecolabels, green public procurement). Detailed criteria for building products can be left to a “product manager” who is in charge of tendering and ordering proper materials. Building assessment systems are limited to requirements for indoor air quality and/or to assessing the “products’ management” or the ecolabelling process itself.

Another important step forward would be recording **information** about installed materials. The EU Eco-Label draft suggests that a list has to be set up with detailed information on the installed materials. If this list also contained information about the ingredients of materials it would be of high importance that bidders were forced to provide this information that is hard to obtain for planners or contracted co-workers in most cases.

3. INTRODUCTION

3.1. Terms and Abbreviations

AP	Acidification Potential
BREEAM	Building Research Establishment's Environmental Assessment Method
BREEAM MR	BREEAM Multi-residential, considered building assessment system, quoted in list of literature
CEN/TC	Technical Committee of the European Committee for Standardization (CEN)
CEN/TC 350	CEN/TC "Sustainability of Construction Works"
CEN/TC 351	CEN/TC "Construction Products - Assessment of release of dangerous substances"
CMR	substances which are classified as cancerogen, mutagen or toxic for reproduction according to 67/548/EWG or Regulation (EC) 1272/2008 respectively
CSH	Code for Sustainable Homes (British standard for new homes), considered building assessment system, quoted in list of literature
CSR	Corporate Social Responsibility
DGNB	German Sustainable Building Council (Deutsche Gesellschaft für Nachhaltiges Bauen) / German building label (Deutsches Gütesiegel für Nachhaltiges Bauen), considered building assessment system, quoted in list of literature
EEE	Electrical and Electronical Equipment
EMAS	Eco-Management and Audit Scheme
EMS	Environmental Management Systems
EU Eco-Label	EU Eco-Label award scheme for buildings (third draft), considered building assessment system, quoted in list of literature
GPP	Green Public Procurement
GPP(A)	Green Public Procurement, Austrian Standard – harmonized criteria catalogue of "ÖkoKauf Wien" and "baubook oeg"
GWP	Global Warming Potential
HQE	Haute Qualité Environnementale (French building assessment system)
LCA	Life cycle assessment
LEED	Leadership in Energy and Environmental Design (US building assessment system)

LEED® HRS	The Leadership in Energy and Environmental Design for Homes Rating (US), considered building assessment system, quoted in list of literature
LEED® NC	The Leadership in Energy and Environmental Design for Homes Rating (LEED) Reference Guide for Green Building Design and Construction, considered building assessment system, quoted in list of literature
LEnSE	Methodology Development towards a Label for Environmental, Social and Economic Buildings
natureplus	European ecolabel for building products
NP	Nutrification Potential
ODP	Ozone Depletion Potential
ÖGNB	Austrian Sustainable Building Council (Österreichische Gesellschaft für Nachhaltiges Bauen)
POCP	Photochemical Ozone Creation Potential
QMS	Quality Management System
ROHS	Restriction Of the use of certain Hazardous Substances (ROHS) Directive Directive 2002/95/EC of 27 January, 2003
SBTool	Sustainable Building Tool (considered building assessment framework), quoted in list of literature
TQB	Total Quality Building (Austrian building assessment system), considered building assessment system, quoted in list of literature

3.2. Motivation

Based on a mandate of the European Commission, CEN/TC 350 “Sustainability of buildings” develops standards for sustainability assessment of building products and buildings. At the same time, European ecolabel criteria for buildings (“EU ecolabel”) are being prepared under the lead of the Italian Competent Body (ISPRA – Italian Institute for Environmental Protection and Research)[8].

Another set of criteria for buildings was developed in the context of the European Green Public Procurement (GPP) initiative. In addition, several other regulatory activities relate to green buildings or building products such as the revision of the Energy Performance of Buildings Directive (EPBD), the revision of the Construction Products Directive (CPD), the revised Energy Related Products Directive (ERP, formerly EuP). Next to many other initiatives and research projects addressing this subject, also the Commission Lead Market Initiative (LMI) deals among other issues with sustainable construction. However, there is no accepted EU policy concept or ‘master plan’.

[8] EU Eco-Label Award Scheme for Buildings: Supporting document to Third draft criteria (ed. ISPRA, May 2010)

ANEC has therefore called for a broad European discussion involving all stakeholders, and including all relevant Commission departments.

ANEC has commissioned several research projects in the past which addressed some of the major consumer concerns with respect to environmental product information (comprehensibility, comparability, reliability, precision, transparency, completeness, benchmarking and enforcement) and provided some model declarations. It became more and more clear that indicators based on life cycle assessment (LCA) methodology may not be the best option to suitably characterise and declare the environmental performance of a product (ÖKO-INSTITUT 2008). Serious limitations include omissions of relevant environmental aspects (e.g. site-specific emissions like noise or non-quantifiable impacts like biodiversity) and low accuracy and reliability of data.

Hence, in many cases significant production or use phase indicators (e.g. energy efficiency, indoor emissions) derived from a variety of tools (e.g. chemical risk assessment) will be a better choice for product labelling and differentiation of similar products compared to LCA indicators." (ANEC, 2009)

"ANEC's goal is to establish a harmonised and coordinated EU policy in this area which leads to a significant reduction of all environmental burdens associated with buildings and which takes into account not only interests of business but also the wishes of other stakeholders. The future EU scheme should be cost efficient and avoid including criteria that are common practise but have limited value for consumers." (ANEC, 2009)

3.3. Objective of the Study

The objective of the study is to provide ANEC with a background paper on environmental and health-related criteria for buildings. The background paper shall be the basis for developing a European set of environmental and health-related indicators.
The study shall support ANEC in position finding processes and enable to shape the upcoming discussion on these issues. This frame was set from a consumer's perspective account by focussing on familiar information (e.g. NO_x emission rather than acidification indicator for central heating burner). However, the potential readers of the study are expected to be experienced in the topics of assessing the environmental performance of buildings.

In order to do so the study at hand presents an analysis of the problem of the numerous evidently uncoordinated initiatives of the Commission, reveals new perspectives, and principle solutions.

It is not the aim of the study to elaborate a detailed complete criteria and indicator catalogue for an assessment method to be used in CEN/TC 350 or the EU Ecolabel for buildings as such.

3.4. Scope

The assessment methodology focuses on new-built projects for residential purposes. Existing buildings, buildings with major refurbishments as well as other building types (commercial buildings, education, health-care, etc.) are excluded from this report, although they are very important for sustainable development. The intention of the restriction is to prove the feasibility of the approach chosen. Nevertheless, the results of the study are expected to be applicable to all kinds of buildings in principle.
The existing building assessment systems were screened with respect to small buildings, complex building assets were not be taken into account.
The construction site was included in the assessment (but not the surroundings/infrastructure of the site).
The scope of the study is restricted to environmental and health-related indicators. Except health-related indicators, other social indicators such as social and equal rights, accessibility or employee attitude were not taken into account.

Definition of "indicator" in the context of this study

Indicators are objectively verifiable and repeatable measures of a particular criterion. They tell us whether (or how far) the objectives have been achieved. One can distinguish between quantifiable and qualitative indicators.

- **a) Quantitative indicators** measure numerical values, e.g. primary energy.
- **b) Qualitative indicators** measure information which is not easily measured through numerical values such as process-related improvements, and quality of services, policies or capacity. Qualitative indicators usually need additional criteria. For example, if an intended result is to provide "high-value urban open space", and the indicator on building level is the "quality of the green space planning", partners will have to agree beforehand on the criteria for determining a quality process. These criteria will often be country-specific, and once agreed, they can be used in a simple monitoring checklist (UNDG, 2006 presumably).
  Side note: Qualitative indicators are sometimes defined in a broader sense as indicators that "cannot be counted but must be described, analysed and perceived. This can be done through, for example, interviews, role plays, art and drama[9]". To the authors' point of view these non-measurable indicators are criteria rather than indicators.

On contrary to the harmonisation activities of CEN/TC 350 "Sustainability of Construction Works", which limits its scope to quantifiable environmental information (mainly LCA-indicators), the study at hand considers also measureable qualitative indicators (e.g. measurements to reduce dust from construction work, quality of green space, compliance with product eco-label criteria, etc.) since this is the well-established praxis in building assessment systems. To the authors' and commissioners' point of view, in many cases the qualitative indicators are the more relevant indicators for describing the environmental performance of buildings.

[9] e.g. http://www.sais-jhu.edu/cmtoolkit/issues-in-practice/evaluation/evaluating-change.htm, DL 15.02.2011

Definition of "environmental" and "health related" in the context of this study

Building assessment indicators are based on the challenge to meet demands for new and renovated facilities that are affordable, accessible, secure, while minimizing their impact on the environment and health, well-being and productivity of the users.
Beyond these building assessment indicators the weakest common denominator is achieved in regard to environmental and health related aspects. What are the most import impacts of building construction and operation on environment and health? Which indicators can be used to describe these impacts? Which benchmarks can be set in order to reach sustainable development?
In order to give answers to these questions the study is limited to environmental and health related aspects of building construction and operation – being aware that only a comprehensive view can represent the complexity of buildings and built environment which is out of the scope of this study

Building construction and operation have extensive direct and indirect impacts on the environment. Buildings use resources such as energy, water, land, and raw materials, generate waste (occupant, construction and demolition). They contribute to climate change and emit potentially harmful emissions to water, air and soil (WBDG, 2011). These impacts are measured by environmental indicators. In doing so the aspect of the life cycle of buildings is very important.

The health related indicators considered in the study at hand are restricted to the operation phase and construction site. The most relevant building related aspects of health during operation phase are indoor air, comfort and noise.

3.5. Procedure

The first step of approach shall be a consideration of different existing building assessment systems with special attention to the communalities. The building assessment systems may use similar indicators but conceptually handle them differently. These different approaches should be described with their advantages and disadvantages and conclusions drawn which concept would be useful for consumers.

The next level will be the choice of indicators that will have to be exemplified. This step led to the following categories for which an in-depth analysis should be carried out:

- Life cycle assessment (LCA) with focus on building material
- Energy demand and CO_2-emissions with focus on operation phase
- Daylighting
- Emissions on construction site
- Chemicals in building materials / indoor air

The following background papers and systems will be screened in regard to the purpose of the study

- ANEC studies and position papers on EPDs and LCA
- CEN and ISO documents considering sustainability of construction work (particularly CEN TC 350, CEN TC 351, ISO TC 59/ SC 17)

- European directives (particularly Energy Performance of Buildings Directive (EPBD), Construction Products Directive (CPD), Energy Related Products Directive (ERP, formerly EuP), Globally Harmonized System of Classification and Labelling of Chemicals (GHS))
- Building assessment systems (particularly draft EU Eco-Label, BREEAM/Code for Sustainable Homes, LEED, DGNB, SB Tool, TQB)
- Green public procurement tools (particularly EU GPP, ÖkoKauf Wien, public building in the region of lake constance, criteria of the sustainable construction and innovation (SCI-network) and criteria for eco labels (particularly EU Eco-label, natureplus)

4. BUILDING ASSESSMENT SYSTEMS AND RELATED INITIATIVES

Existing marketable environmental building assessment methods differ in structure, extent, scope and range of assessment. The following chapters give a short overview of widely used comprehensive building assessment methods in Europe, national as well as cross-national systems and new developments. It starts with an introduction to the structure of building assessment methods and an historical overview.

4.1. Structure of Building Assessment Methods

Building assessment methods usually comprise

- the explanation of overall objectives and target groups
- the definition of categories (sub-categories), criteria and indicators
- the definition of the rating system and range of assessment (passed, highest level)
- schedule of evidence (to demonstrate compliance with the criteria defined above)
- assessment result(s) of the building (in detail for all indicators and aggregated to overall result)

The main target of building assessment methods may be e.g. social, economic and ecological sustainability, cost-efficiency within the life cycle, reduction of CO_2 emissions, improvement of working and living environment, stability of value of the property, etc. Detailed objectives can be explained for each criterion assessed.
The overall aim conditions focus and scope of the building assessment, total sum and weighting of indicators.

A building assessment system comprises analytical elements and valuation elements including value ratings. The following table briefly explains the basic elements of an assessment method:

Elements	Description	Examples
Analytical elements		
Criteria	Criteria define general characteristics of buildings.	Reduction of CO_2 Emissions, Accessibility of Public Transport, Avoidance of VOC Emissions
Categories / Subcategories	Similar criteria may be summarized to categories and sub-categories.	Category: Health and Wellbeing Subcategory: Indoor Air Quality Criterion: Avoidance of VOC Emissions
Indicators	Indicators specify criteria. They transform the information about buildings into figures or standardized descriptions making the evidence comparable.	Quantitative indicators use of potable water: l/(Person,a) transport: total sum of ton-km (from production place to construction site) via trucks Qualitative indicators Green space planning

Elements	Description	Examples
Schedule of evidence	The evidence required and measuring methods have to be defined for each (sub)-criterion to be able to assess a specific development.	Calculations of the daylight factor, Energy Performance Certificate, design drawings, etc.
Valuation elements		
Objectives	Objectives give an overview of the intent of the assessment method, may vary depending on the target group and ease the choice for a specific assessment method. Objectives may be defined in general or for each criterion assessed in form of measurable target values.	Quantitative objectives: Primary energy demand <= 120 kWh/(m²a); average daylight factor > 3%, etc. Qualitative objectives: conservation of biodiversity on site, avoidance of natural risks, etc.
Valuation	A degree of achievement can be defined for each indicator in relation to the objectives and the corresponding results can be reviewed in a rating of the building.	For each criterion, a rating scale or benchmarks may be defined (e.g. best assessment – average – passed).
Weighting	The weighting defines the relevance of the criterion assessed within the whole criteria catalogue.	The definition of weighting factors may vary depending on the assessment system (e.g. % of total score)
Aggregation	The results of the detailed assessment of indicators are aggregated to one descriptive or quantitative result.	75 of 100 credits, passed, excellent, bronze/silver/gold

Table 3: Basic elements of assessment methods for buildings

4.2. Historical review

First Systems

The beginning of environmental building assessment systems dates back to the late 1980s. The objectives were raising the demand for environmentally friendly buildings, finding innovative solutions that minimize the environmental impact and enhancing best practice examples. The first comprehensive assessment system was launched by BRE (Building Research Establishment) in the United Kingdoms in 1990 (http://www.breeam.org). It was called BREEAM (BRE Environmental Assessment Method) and revised several times. Today it is the most widely used environmental label for buildings, with over 110,000 buildings certified and over half a million registered for certification. BREEAM is used all around the world and can be readily adapted to local regulation and conditions. BREEAM gave substantial impetus for the development of international and transnational systems (including the GBTool, see paragraph below). In the UK, the standard is well established: all government buildings have to achieve the assessment level "excellent". In May 2008, the Code for Sustainable Homes based on the BREEAM scheme “Ecohomes” became mandatory for new housing in England.

The second world-widely-used system is LEED (Leadership in Energy and Environmental Design). It was launched in 1998 by the U.S. Green Building Council (USGBC http://www.usgbc.org). In 2009, the Green Building Certification Institute (http://www.gbci.org) assumed responsibility for administering the LEED certification program under which more than 17,000 commercial projects now await certification. GBCI coordinates the work of global certification bodies with expertise in validating international standards (ISO-compliance) and ensures that the third-party certification and verification of buildings under the LEED Rating System is of high quality. LEED is used in many countries - including Canada, Brazil, Mexico and India.
LEED and BREEAM offer benefits for international companies, as these systems enable to assess whole building portfolios in different countries using the same rating system. The disadvantage is that a high translation effort is required to apply international systems (raising the costs of consulting for a successful certification).

GBC (Green Building Challenge)

The following initiatives pay more attention to regional conditions, but do not offer marketable certification schemes, but frameworks to adapt.
In 1996, an international working group called "Green Building Challenge (GBC)" was founded by the Canadian architects Nils Larsson and Ray Cole. The aim was to define a common framework for environmental building assessment, to test the criteria on projects in different countries and to provide a platform for developing national systems.
The so-called “GBTool” was launched as a master tool by the members of the working group and adapted to region-specific context. This process of optimization and testing was accompanied by conferences held every three years (the first conference took place in 1998

in Vancouver) and resulted in different national building assessment systems based on the key indicators of the GBTool and tailored to the needs of the regional market. The GBTool which is now called SBTool (Sustainable Building Tool) is a flexible framework operating on Excel that can be configured to suit almost any local condition or building type. It may also be thought of as a toolkit that assists local organizations to develop regional SBTool rating systems (e.g. ITACA, the Federal Association of the Italian Regions, adopted the GBC respectively SB methodology as basis to develop an institutional assessment system for residential buildings: Protocollo ITACA. It is now the reference rating system of the regional authorities in Italy combined with specific funding incentives for sustainable buildings). SB Method is set to allow easy insertion of local criteria, weights can be switched off or reduced.

iiSBE (International Initiative for a Sustainable Built Environment)

The loose network "Green Building Challenge" was transformed into the international association **iiSBE** (International Initiative for a Sustainable Built Environment http://www.iisbe.org), which is today responsible for the organization of the "World Sustainable Building" conferences. It is a non-profit organization with 400 members and 23 Board Members from 20 countries. The most important activity is networking; helping specialists and generalists to get to know each others' abilities and to present best practice examples. The next conference will take place in Helsinki in October 2011. Further activities are

- development of the SBTool rating framework,
- operation of SBIS (http://www.sbis.info), a web-based database providing objective information about sustainable building practices around the world
- operation of working groups on survey of rating systems, indicators suitable in micro-urban areas, zero built environment (focusing on zero operating energy, GHG and water), synergy grids and sustainable infrastructure

SB Alliance (Sustainable Building Alliance)

In April 2008, the **Sustainable Building Alliance (SB Alliance)** was founded in Paris – an organization with the aim to concentrate the activities in the field of environmental building assessment (http://www.sballiance.org). SB Alliance is a grouping of primarily *European assessment and certification-oriented organizations*. Its goal is to delevop common metrics that can be used to compare the sustainable performance of buildings or built environment through the different voluntary rating schemes. SB Alliance works to develop a greater level of communality between the different assessment systems to improve understanding, comparibility and take-up. The members will refer to a core set of common metrics for key issues. SB Alliance is not a certification body and will not develop a new assessment system. Existing certification systems will not be replaced. Members are e.g. BRE, USGBC, DGNB, HQE, effinergie, etc.

The first board of directors of the SB Alliance is composed of representatives from one of the following organizations:

- Building research establishment (UK)

- Centre scientifique et technique du bâtiment (France)
- Deutsche Gesellschaft für nachhaltiges Bauen (Germany)
- Fundaçao Carlos Alberto Vanzolini (Brazil)
- Instituto per le technologie della construzione del Consiglio Nazionale delle Ricerche. (Italy)
- Valtion Teknillinen Tutkimuskeskus (Finland)

Ecolabel (European Community)

In 2008, the European Ecolabelling scheme started an Ad-hoc Working Group on a European Ecolabel for buildings. The first drafts have been prepared under the lead of the Italian Competent Body (ISPRA). In 2010, the leadership was handed over to Joint Research Centre's Institute for Prospective Technological Studies (JRC-IPTS) whose first report was drafted in October 2010 starting with the analysis of the previous draft criteria studies and the product group definition and priorisation (BOYANO&WOLF, 2010). The progress of the work can be followed through the website: http://susproc.jrc.ec.europa.eu/buildings.

The latest draft considered in the study at hand is ISPRA's third draft in May 2010 (EU ECO-LABEL, 2010).

The following requirements have to be met:
Ecolabels may only be awarded to a product possessing characteristics which enable it to contribute significantly to improvements in relation to key environmental aspects. For buildings, the ecological criteria should be divided into mandatory and optional criteria. These criteria aim to set limits on the main environmental impacts from the three phases of the life cycle of buildings (project, construction, use and maintenance, refurbishment, end of life). In particular they aim to:

- limit energy, water and materials consumption,
- limit waste production and enhance recycling,
- favour the use of materials with high environmental performances
- favour the use of renewable resources and of substances which are less hazardous to the environment,
- favour indoor well-being,
- promote information and education on a correct management of the building

The product group "buildings" shall comprise "buildings considered in their entirety, as well as small houses, new or existing, public or private, used for residential purpose and for use as offices". Individual apartments and flats in a building are excluded; new buildings include also major refurbishments; existing buildings include also renovations.
For details see 13.1 Appendix: EU Ecolabel for new buildings (Draft) – EC

Standardisation

Since 2005, a technical committee of CEN (Comité Européen de Normalisation) numbered CEN/TC 350 has been working on a framework for "Sustainability of construction works". CEN TC 350 is responsible for

- the development of voluntary horizontal standardized methods for the assessment of the sustainability aspects of new and existing construction works and
- for standards for the environmental product declaration of construction products.

The standards shall be relevant for the assessment of integrated performance of buildings over its life cycle. The goal is a harmonized methodology for assessment of environmental performance of buildings and life cycle cost performance of buildings as well as the quantifiable performance aspects of health and comfort of buildings. On contrary to the existing building assessment systems, CEN/TC 350 focuses on life cycle assessment (LCA) in order to assess the environmental performance of buildings.
Since 2009 CEN/TC 350 published Technical Reports and European Standards, many of them under development, are expected to be published in 2013 the latest.

Besides: Parallel to CEN/TC 350 the International Standard Organisation (ISO/TC 59, SC 17) is developing a series of standards in the field of "Sustainability in construction works". Even for members of CEN/TC 350 it seems very difficult to keep the subtile distinctions between the scopes of CEN and ISO standards apart.

4.3. BREEAM – UK

Residential buildings

BRE developed a scheme for the assessment of housing called “EcoHomes” which can assess new homes, apartments/flats, and houses, apartments and flats undergoing major refurbishment at the design stage and post construction. The scheme EcoHomes became a national code in an adapted form in April 2007 and is mandatory from 1st May 2008 for all new self contained dwellings in England to include a Code for Sustainable Homes (CSH) certificate in the Home Information Pack (HIP). The Code has been drafted by the BREEAM Centre at the Building Research Establishment (BRE) under contract to the Department for Communities and Local Government.

The Code for Sustainable Homes (CSH) is a national standard for use in the design and construction of new homes with a view to encouraging continuous improvement in sustainable home building. CSH was based on BREEAM Ecohomes but differs to the common BREEAM schemes in main categories, rating levels (level 1 to 6 where 6 is the highest), weightings and targets to achieve.

CSH has been selected for comparison as it is the assessment which all new build homes in England have to undergo since May 2008. CSH assesses individual dwellings (instead of group of dwellings) and establishes minimum mandatory standards for CO_2 emission rates, indoor water use, materials, waste and surface water run-off, for achieving even the lowest level of the Code. For dwellings which do not achieve the minimum Code rating, a certificate is issued which shows a summary of the performance achieved, but does not show a rating from 1 to 6. For dwellings which are not assessed, a nil-rated certificate is issued. In addition to the mandatory standards, each design category scores a number of percentage points. The total number of percentage points establishes the Level or Rating for the dwelling. The certificate illustrates the rating achieved with a row of stars. A blue star is awarded for each level achieved. Where an assessment has taken place by where no rating is achieved, the certificate states that zero stars have been awarded.

From the 1st of May 2008, a minimum of Code Level 3 is required for all new housing promoted or supported by the Welsh Assembly Government or their sponsored bodies and from 2nd June 2008, Code Level 3 is required for all new self-contained social housing in Northern Ireland. The Code does not apply in Scotland.

The code contains mandatory performance levels in 6 key areas (see 13.2 Appendix: Code for Sustainable Homes (CSH)) which are the following

- Energy and CO_2 Emissions
- Water Efficiency
- Water Surface Run-off
- Site Waste Management
- Household Waste Management
- Materials
- Lifetime Homes (only Level 6)

Additional credits are available in the following categories: Energy and CO2 Emissions, Water, Materials, Surface Water Run-off, Pollution, Health and Wellbeing, Management, Ecology.

Code assessments are normally carried out in two stages:

- Design Stage leading to an Interim Certificate
- Post-Construction Stage leading to a Final Certificate

The scheme "**BREEAM Multi-residential**" is intended for use on multi-occupancy residential buildings which are not suitable for assessment under the Code for Sustainable Homes (CSH) or EcoHomes, e.g. student halls of residence, key worker accommodation, care homes that do not consist of extensive medical facilities, sheltered housing and other multi-residential buildings which contain residential accommodation with communal areas, of which make up more than 10% of the total Net Internal Floor area.

As the market for residential buildings is primarily regional and many indicators reflect local conditions, there is still no international BREEAM scheme available to assess buildings in the European Community or world-wide although development is ongoing. Today, residential buildings in Europe are assessed under the scheme "Bespoke" which means that the set of indicators is specially tailored to each building undergoing assessment. For Spain, a national BREEAM scheme for residential buildings as well as for commercial purposes and communities has been developed by the Instituto Tecnológico de Galicia (ITG). The core principles and issues, as held within all BREEAM schemes, will remain consistent to maintain the quality of BREEAM assessed buildings.

Categories

Credits are awarded in ten categories according to performance. The total sum of credits can vary within the categories assessed for different building types and schemes.

BREEAM 2008 Environmental weightings (valid for e.g. multiresidential buildings in UK)

MAN Management	12%
HEA Health and Well-being	15%
ENE Energy	19%
TRA Transport	8 %
WAT Water	6 %
MAT Materials	12.5 %
WST Waste	7.5%
LE Land Use and Ecology	10%
POL Pollution	10%
INN Innovation	10%

Innovation credits provide additional recognition for a building that innovates in the field of sustainable performance, above and beyond the level that is currently recognised and rewarded within standard BREEAM issues. *Innovation credits* therefore enable clients and design teams to boost their building's performance and in addition, help support the market for new innovative technologies and practices. An additional 1% score can be added to a building's final BREEAM score for each *Innovation credit* achieved. The maximum number of

Innovation credits that can be awarded for any one building assessed is 10; therefore the maximum available score achieved for 'innovation' is 10%.

The credits are added together to produce an overall score on a scale of Pass, Good, Very Good, Excellent and Outstanding.
< 30% = Unclassified
≥ 30% = Pass
≥ 45% = Good
≥ 55% = Very Good
≥ 70% = Excellent
≥ 85% = Outstanding (besides >= 85% percentage score, there are additional requirements for achieving a BREEAM *Outstanding* rating)

To achieve a BREEAM rating, the minimum percentage score (>=30%) must be achieved and the minimum standards (i.e. number of credits achieved for specific sub-categories) applicable to that rating level complied with (see Table 4).

Table 4: Minimum BREEAM standards

BREEAM issue	PASS	GOOD	VERY GOOD	EXCEL-LENT	OUT-STANDING
Man 1 - Commissioning	1	1	1	1	2
Man 2 - Considerate Constructors				1	2
Man 4 - Building user guide				1	1
Hea 4 - High frequency lighting	1	1	1	1	1
Hea 12 - Microbial contamination	1	1	1	1	1
Ene 1 - Reduction of CO2 emissions				6	10
Ene 2 - Sub-metering of substantial energy uses			1	1	1
Ene 5 - Low or zero carbon technologies				1	1
Wat 1 - Water consumption		1	1	1	2
Wat 2 - Water meter		1	1	1	1
Wst 3 - Storage of recyclable waste				1	1
LE 4 - Mitigating ecological impact			1	1	1

More details to BREEAM schemes see http://www.breeam.org

The issues of the Code CSH are summarized in 13.2 Appendix: Code for Sustainable Homes (CSH) .

4.4. LEED (The Leadership in Energy and Environmental Design) - USA

The LEED rating system has been developed since 1998 by the U.S. Green Building Council (USGBC) through an open, consensus-based process led by LEED committees. Each committee is composed of a diverse group of practitioners and experts representing a cross-section of the building and construction industry. The assessment method was adapted to different building types (New construction and major renovation, existing buildings, commercial interiors, core & shell, schools, retail, healthcare, homes, neighborhood development,…) and regional specifics (such as LEED Canada, LEED Emirate). The objectives mainly refer to environmental and economic aspects.

(Small) residential buildings (< 4 storeys) are assessed under the scheme “LEED for Homes”[10], large-volume buildings for residential purposes under “New Construction and Major Refurbishment”.

“LEED for Homes”[11] is a national rating system and measures the environmental and overall performance of a home across eight categories (total achievable points: 136):

Innovation and Design Process (ID) – the category that includes several types if innovative measures including: special design methods, unique regionally credits, measures not currently adressed in the rating system and/ or exemplary performance levels (11 points)

1. **Location and Linkages (LL)** – the placement of homes in socially and environmentally responsible ways in relation to the larger community (10 points)
2. **Sustainable Sites (SS)** – the use of the entire property so as to minimize the project´s impact on the site (22 points)
3. **Water efficiency (WE)** – the water conservation measures (both indoor and outdoor) (15 points)
4. **Energy and Atmosphere (EA)** – improvement of the energy efficiency particulary of the building envelope and heating and cooling design (38 points)
5. **Materials and Resources (MR)** – the efficient utilisation of materials, selection of the environmentally preferable materials and minimization of waste during construction (16 points)
6. **Indoor Environmental Quality (IEQ)** – the improvement of indoor air quality by reducing possible air pollution (21 points)
7. **Awareness and Education (AE)** – the education of homeowners, tenants and building managers about the operations and maintenance of the green features of their Leed Homes (3 points)

LEED for Homes has a **different scale as other LEED green building certification systems**, due to rating system being developed at a different point in time than the other rating systems.

[10] More details see 13.3 Appendix: LEED for Homes

[11] LEED® for Homes Rating System, Version 2008 including corrections, clarifications and new exemplary performance rulings (ed. U.S. Green Building Council, January 2010)

LEED v3 is the new version of the LEED green building certification system. Till date, LEED v3 does only apply for commercial and institutional building applications and high-rise residential buildings of all sizes (LEED for New Construction & Major Renovations, existing buildings: Operations & Maintenance, Commercial Interiors, Schools and Core & Shell) and does not include LEED for Homes, due out in 2012, following the new ENERGY STAR for Homes Version 3 changes phase in January 2011.

Launched on April 2009, LEED v3 builds on the fundamental structure and familiarity of the existing rating system, but provides a new structure for making sure the rating system incorporates new technology and addresses priorities like energy use and CO_2 emissions.

Notable technical advancements include:

- LEED prerequisite/credit alignment and harmonization
- Transparent environmental/human impact credit weighting
- Regionalization

LEED v.3. (2009) comprises the following main categories (the achievable points refer to the criteria catalogue of “New Construction and Major Renovations”)

- Sustainable Sites (26 points)
- Water Efficiency (10 points)
- Energy and Atmosphere (35 points)
- Material and Resources (14 points)
- Indoor Environmental Quality (15 points)
- Innovation and Design Process (6 points)
- Regional Priority Credits (4 points)

Assessment results: 40 – 49 points – Certified
50 – 59 points – Silver
60 – 79 points – Gold
80 – 110 points – Platinum

Rating System Structure – LEED for Homes

The LEED for Homes rating system works by awarding credit for different aspects of environmental design in each of the above categories. Within each category are credits and/ or prerequisites.

Prerequisites do not earn the project any points because they are required for the project to be considererd. The term “prerequisite” refers to a mandatory project characteristic, measurement, quality and value or function. Prerequisites represent the key criteria that definde green building performance. Each project must satisfy all specified prerequisites outlines in the LEED rating system under which is registered. Failure to meet any prerequisite will render a project ineligible for certification.

The term “credit” means a non-mandatory project characteristic, measurement, quality and value or function. Credits represent particular facets of sustainable design. No single credit is mandatory: they are selected and pursued at the option of a project team.

There is no additional weighting of credits. The total sum of credits achieved forms the overall result (e.g. LEED for Homes):

- 45 – 59 points – Certified
- 60 – 74 points – Silver
- 75 – 89 points – Gold
- 90 – 136 points – Platin

4.5. HQE (Haute Qualité Environnementale) - France

HQE (Haute Qualité Environnementale) is the French environmental building assessment system launched by CSTB (Centre Scientifique et Technique du Bâtiment) and continuously revised by “L’Association HQE” which is responsible for the further development of the system, but not for certification of buildings. The aim was to enhance sustainability of buildings over the whole life cycle, minimize environmental loadings by construction work and provide healthy and comfortable buildings.

The labels vary depending on the building type assessed:
Since 2005, Certivéa, a subsidiary company of CSTB is responsible for the certification of office, commercial buildings, hotels, healthcare, hospitals, logistics centers, etc. The certification is called “NF Bâtiments Tertiaires – Démarche HQE®”. The assessment of single family houses is managed by CEQUAMI, the certification is called “NF Maison Individuelle – Démarche HQE®”. Multi-Residential buildings are certified under “NF Logement – Démarche HQE®” by CERQAL.

	Detached Houses	Multi-unit Residential Buildings	Non-Residential Buildings
Certification Name	NF Maison Individuelle – Démarche HQE®	NF Logement – Démarche HQE®	NF Bâtiments Tertiaires – Démarche HQE®”.
Certifying Body	CEQUAMI (CSTB-Qualitel)	Cerqual (Qualitel)	Certivéa (CSTB)

Table 5: Certification schemes HQE®

The system comprises both management items (**Système de Management de l'Opération SMO**) and quality assurance of the building (**Qualité Environnementale du Bâtiment QEB**).

SMO supports management during all design and construction stages in the following way:
– Engagement: definition of design goals corresponding to location study, concept for utilization of the building and analysis of profitability
– Construction work: definition of time schedule, responsibilities and proof of qualification
– Supervision of design and construction stage
– Post-Occupancy Evaluation: customer satisfaction,..

The assessment of the building QEB (Qualité Environnementale du Bâtiment) is based on 14 unweighted issue areas:
1. Managing the impacts on the outdoor environment
2. Selection of Materials / Building Elements
3. Sustainable Construction Site

4. Energy
5. Water demand
6. Waste Management
7. Adaptability and durability of the building

8. Hygrothermal Comfort
9. Sound insulation
10. Optimization of natural and artificial light comfort
11. Reduction in sources of unpleasant odours / air pollutants

12. Hygienic Aspects
13. Indoor Air Quality
14. Drinking Water Quality

Three classifications form the range of assessment within one subcategory:
- B Base (basic: regulation level or normal practice)
- P Performant (good practice, better than basic)
- TP Très performant (best practice, comparable to the best projects in the country)

The results of the subcategories are not aggregated to an overall result.
To achieve a HQE certificate the following requirements ("minimum profile") must be met:
– TP in at least three sub-categories
– P in at least four sub-categories
– B in 7 sub-categories (at most)
– P or TP in subcategory 4 „Energy "

In 2009, CSTB *(Centre scientifique et technique du bâtiment)* and its subsidiary Certivéa had signed a Memorandum of Understanding to work together with BRE (The British Research Establishment) to develop a pan-European building environmental assessment method.

4.6. GB (Green Building) Tool / SB (Sustainable Building) Tool

The Green Building (GB) Tool was developed within the international working group "Green Building Challenge (GBC)" which was launched by the Canadian architects Nils Larsson and Ray Cole in 1996 with the aim to improve the environmental performance of buildings and to provide a mastertool for assessment which can easily be adapted to regional conditions.

The assessment method was tested and developed by a group of more than a dozen teams. In 2002, responsibility was handed over to the International Initiative for a Sustainable Built Environment (iiSBE), the GB Tool transformed to the Sustainable Building Tool (SBTool). SBTool is a generic framework for rating the sustainable performance of buildings and built environment. It may also be thought of as a toolkit that assists local organizations to develop rating systems. The system covers a wide range of sustainable building issues, not just green building concerns, but the scope of the system can be modified to be as narrow or as broad as desired, ranging from 125 criteria to half a dozen.

The main topics are the following:

A) Site Selection, Project Planning and Development
B) Energy and Resource Consumption
C) Environmental Loadings
D) Indoor Environmental Quality
E) Service Quality
F) Social and Economic Aspects
G) Cultural and Perceptual Aspects

These main topics comprise 29 categories sub-divided into 125 indicators (depending on the scope of assessment, see 13.5 Appendix SBTool 07 for new apartments).
The weighting factors may vary depending on regional specifics of a country. The range of assessment goes from 0 to 5

- 0 - Acceptable Practice
- 3 - Good Practice
- 5 - Best Practice

Detailed information is available on http://www.iisbe.org/iisbe/sbc2k8/sbc2k8-dwn.htm

The system allows third parties to establish parameter weights that reflect the varying importance of issues in the region, and to establish relevant benchmarks by occupancy type, in local languages. Thus, many rating systems can be developed in different regions that look quite different, but share a common methodology and set of terms. The main advantage, however, is that a SBTool version developed with local knowledge is likely to be much more relevant to local needs and values than other systems.
The system handles large projects or single buildings, residential or commercial, new and existing construction, or a mix of the two.

4.7. LEnSE (Label for Environmental, Social and Economic Buildings)

LEnSE (abbreviation for Methodology Development towards a **L**abel for **En**vironmental, **S**ocial and **E**conomic Buildings) was a project co-funded by the European Commission within the Sixth Framework Programme and coordinated by BBRI - Belgian Building Research Institute. It was carried out 2006/2007 with the main target to develop a building assessment system for the European market which is applicable in different countries taking into account regional specifications. It was the first system considering the three pillars of sustainability: economic, environmental and social.

The LEnSE methodology encompasses a set of 57 sustainability issues, grouped into 11 categories in the 3 pillars of sustainable construction. Following European wide testing of the method on a series of case study buildings, a number of issues were consolidated. This has led to a final set of 30 developed issues (see 13.4 Appendix: LEnSE)

The assessment is based on a 1000-point-scheme (800 points are achievable for the assessment of indicators common to all countries, 200 points for country-specific subcategories).
LEnSE is not a fully developed assessment tool rather than based on existing methods. Due to the time limit, it has been decided by the LEnSE partners that only a limited but representative number of issues will be fully developed and included in the tool for the purpose of testing the LEnSE methodology. Therefore, 30 sub issues have been integrated in the prototype. Other sub issues have not been developed, but most of them are covered within other building assessment methods. The tool has been tested on eleven different projects (residential, office and mixed use buildings) in nine different European countries, i.e. Netherlands, Belgium, United Kingdom, Germany, Switzerland, Czech Republic, Greece, Austria and Italy).

Detailed information is available under http://www.lensebuildings.com.

THEME	**Category**	**Points**
ENVIRONMENTAL		**400**
	Climate Change	150
	Biodiversity	100
	Resource use and Waste	100
	Environmental Management and Geophysical Risk	50
SOCIAL		**240**
	Occupants' Well Being	75
	Accessibility	70
	Security	30
	Social and Cultural Value	65
ECONOMIC		**160**
	Financing and Management	50
	Whole Life Value	60
	Externalities	50
Common Indicators	***Cross-national***	***800***
Regional Sub-categories	***Country-specific***	***200***
Total Sum	**Overall result**	**1000**

Table 6: Main Categories - LEnSE

The LEnSE rating is presented as an A to G scale (where A is the best possible result and G the worst following the widely-used classification of the Energy Performance Certificate of buildings) and furthermore a rating of the total achieved points and the total available points. A level below the overall performance three separate ratings are given for the total environmental, social and economic performance.

4.8. DGNB Certification System (DGNB - German Sustainable Building Council)

One of the youngest building assessment systems is the method of the German Sustainable Building Council called DGNB (Deutsches Gütesiegel für nachhaltiges Bauen) which was developed by the German Sustainable Building Council (DGNB) together with the Federal Ministry of Transport, Building, and Urban Affairs (BMVBS) in 2008. The overall objective is to point out and advance paths and solutions for sustainable building. This includes the planning of buildings, but also their construction and operation. The basis for the system was developed on the building type “New Construction of Office and Administration buildings”, the first Sustainable Building Certifications took place in 2009. The adaptation of the assessment system to different building types is ongoing. The main features for residential buildings, hotels and hospitals were presented on the Consense, the international congress and trade fair for sustainable building in Stuttgart which took place in June 2010 (http://www.dgnb.de). The basis of the evaluation, which was developed with a wide consensus, is a list of topics and the criteria for sustainable construction that are included within that list. These criteria are weighted differently, depending on the building type to be evaluated. Thus, each variation of the system, or each building type, has its own evaluation matrix.

The following 3 main issues are considered for certification (Ecological, Economic and Socio-Economic und Functional Quality), with Technical and Process Quality as cross-cutting elements. The site quality is not included in the final grade but is presented separately.

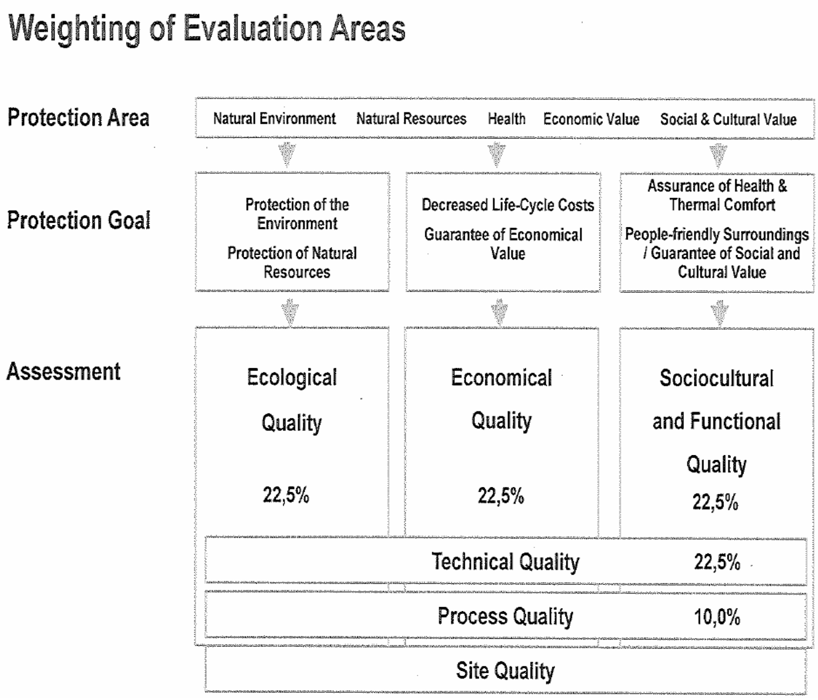

Table 7: Weighting of Evaluation Areas – DGNB (Source: German Sustainable Building Certificate: Structure – Application – Criteria. Ed. DGNB, Stuttgart, 2nd English Edition, March 2009)

Outstanding buildings are awarded the categories bronze (50%), silver (65%), or gold (80%).

The weighting factors refer to scheme “New Construction Office and Administration, Version 2008”. See Appendix 13.6 Appendix: DGNB (German Sustainable Building Certificate) New Construction Office and Administration (NBV09)

In the meantime, schemes for the following building types have been developed (February 2011, source: http://www.dgnb.de):

- New office and administration buildings (NBV09)
- New retail buildings (NHA09)
- New industrial buildings (NIN09)
- New educational buildings (NBI09)
- Modernized office and administration buildings (MBV10)
- New residential buildings (NWO11)
- New hotels (NHO10)
- City Districts (NSQ10)
- Existing Office and Administrative Buildings (BBV10)

4.9. “klima:aktiv haus” - Austria

“klima:aktiv haus” is the Austrian climate protection initiative launched by the “Federal Ministry of Agriculture, Forestry, Environment and Water Management”, embedded in the Austrian federal climate strategy. The primary objective of “klima:aktiv haus” is to introduce and promote climate friendly technologies and services. This assessment method is a self-declaration system (not a third-party-certification). The criteria aim primarily at a reduction of the total energy consumption and CO_2 emissions of buildings both for operation and construction as well as at environmentally compatible construction methods and healthy living.
The assessment is carried out on the basis of a 1000-credits scheme and comprises the following main categories:

- **Design Quality and Quality Assurance during Construction**
  a maximum of 120 credits is achievable for
  accessibility of amenities and public transport, barrier-free buildings, avoidance of thermal bridges, air tightness
- **Energy**
  a maximum of 600 credits is achievable for
  low energy demand, passive house standard, utilization of renewable energies
- **Building Materials**
  a maximum of 160 credits is achievable for
  avoidance of critical building materials, use of ecologically optimized products
- **Indoor Air Quality**
  a maximum of 120 credits is achievable for
  ventilation systems, thermal comfort, avoidance of air pollutants

There are three classes of awards:

- *klima:aktiv haus Gold*: the building has awarded the certificate “quality-tested passive house” according to the guidelines of Dr. Wolfgang Feist (Passivhouse Institute Darmstadt) and achieves at least 900 credits
- *klima:aktiv haus Silver* (at least 900 credits achieved without passivehouse certification)
- *klima:aktiv haus Platin* (at least 700 credits achieved)

Detailed information in German is available under http://www.klimaaktiv.at („Bauen und Sanieren“).

4.10. TQ (Total Quality) and revised version TQB (Total Quality Building) - Austria

The Total Quality (TQ) System for Building Design, Building Assessment, and Building Certification has been developed in Austria since 1998 in close contact with the international initiative “Green Building Challenge” (GBC) in order to stimulate the construction of user friendly, environmentally friendly and cost efficient buildings on the Austrian market. Development of the TQ assessment method was funded by the ministry for agriculture, forestry, environment and water management, the ministry of economy and labour and the ministry for transport, innovation and technology. Since 2001 the assessment system has been continuously improved and adapted to different building types.

In 2010, the building assessment method TQ has been modified: Total Quality Building (TQB) Assessment – revised version is now defined by a set of indicators that refer to the three dimensions of sustainability: society, ecology, and economy. The prime and secondary categories have been adapted and new indicators defined in accordance with the requirements of recently published standards. The scope of the assessment method was extended to non-residential buildings. Furthermore, the system is now compatible with approved national building assessment systems such as klima:aktiv house and IBO ÖKOPASS. The development was promoted by ZIT, the technology agency of the city of Vienna. TQB has been developed with the clear target to be widely spread and applied in the building sector in Austria. Therefore, the Austrian Council for Sustainable Buildings (ÖGNB – Österreichische Gesellschaft für Nachhaltiges Bauen) has been founded in 2009.
TQB is a means of quality management for building design and construction: the system provides the information necessary for designing a high performance building at the pre-design stage (“high quality” in terms of improved comfort as well as decrease in negative environmental impact, at affordable costs), and assesses the performance achieved in two steps; (1) prior to construction and (2) prior to handing over. It is the main target to use the TQB system already in pre-design stage. Clients and their design team will go through the assessment criteria; it will remind them of important aspects to consider. In addition, TQB-certified buildings gain of an advantage in marketing compared with average buildings. The certificate consists of briefcase responding all relevant information in short form (4 pages)

with approximately 30 pages computer printout attached containing detailed information: all input data used for assessment are presented, completed with additional information that might be relevant for potential users of the building. Since 2001 a number of national and international office and residential projects has been "TQ-assessed". All certified projects are listed under http://www.argetq.at/tqobjekte.htm.

The TQB system is available through internet and linked with a database to administrate and evaluate certified buildings (http://www.oegnb.net). The assessment system consists of the TQB guideline and a web-based tool which allows the registration, documentation, assessment and evaluation of projects. The TQB guideline contains information about all assessment criteria, gives advice for improvement of buildings during pre-design, design and construction stage, presents the assessment scales and describes the requirements for the submission of supporting documents as the condition for certification. TQB tool and TQB guideline are regularly revised according to latest scientific findings and findings derived from practical application.

The following criteria have to be considered (here we only display an overview, for details in terms of indicators see Appendix "TQB Criteria in Detail and TQB Certificate" or http://www.oegnb.net) :

Table 8: TQB Criteria - Overview

A	**Site and Facilities**
A.1	Infrastructure
A.2	Safety and Sustainability of Site
A.3	Facilities
A.4	Barrier-free Building
B	**Economic and Technical Performance**
B.1	Economic Efficiency (incl. LCC)
B.2	Construction Site Management
B.3	Durability and Adaptability
B.4	Fire Protection
C	**Energy and Water**
C.1	Energy demand
C.2	Energy supply (primary energy / use of renewable energies / CO_2 emissions)
C.3	Water
D	**Health and Comfort**
D.1	Thermal Comfort
D.2	Indoor Air Quality
D.3	Sound Insulation
D.4	Daylighting
E	**Resource Efficiency**
E.1	Avoidance of critical substances
E.2	Use of recycled, re-used and regional materials
E.3	Eco-Efficiency - life cycle view (PE non-renewable, GWP, AP)
E.4	Waste Disposal (at the end of life-time)

4.11. IBO ÖKOPASS - Austria

The „IBO Ökopass“ is an assessment system specially developed for residential buildings in urban context by IBO (Austrian Institute for Healthy and Ecological Buildings) in cooperation with a developer in 2001. Indicators with high importance for the future leaser or owner of the flats are assessed by means of calculations and measurements in a two-step assessment (preliminary and final assessment). The highly user-oriented indicators focus on the one hand on well-being (thermal comfort, indoor air quality, noise, daylighting/winter sun, electromagnetic fields) and on the other hand on ecology (environmental quality of building materials, total energy and water demand). The classification of the indicators assessed ranges in a four-part scale from “passed” (this award confirms compliance with the IBO ÖKOPASS requirements which exceed building regulation requirements) to “excellent” (in this case, ambitious solutions promise excellent comfort and low operating cost to the future residents). Unlike other systems, there is no aggregation to an overall result (e.g. total score). If a building fails in one category the documentation is nevertheless published via internet thus encouraging developers or contractors to improve the performance of the building. Transparent information available to consumers takes top priority within the IBO ÖKOPASS.

The largest IBO ÖKOPASS project (more than 800 flats on one construction site) was completed in April 2008 in one of the largest urban development zones of Vienna called “Kabelwerk”. Because of the special target group and the high user orientation of the IBO ÖKOPASS the set of criteria could be limited to a minimum. As compact as possible it is the assessment system with the highest market penetration in Austria (about 8,000 units assessed). More than 20 developers all over Austria have already successfully certified projects.

The primary objective of development was an instrument for marketing and quality assurance for the funded and privately financed housing sector. Key figures from audit reports are also translated into a non-technical language understandable by the end-users who obtain a quick overview of the most important key data of their future apartment.
All assessment results are available under http://www.ibo.at/de/oekopass

4.12. La Casa Clima più (ClimateHouse plus) - Italy

“Casa Clima” (ClimateHouse) is the Italian climate protection initiative for buildings to improve the energetic and environmental performance of buildings. The principles of a ClimateHouse are compact construction, highly insulated building envelope, low-e glass, air-tightness, avoidance of thermal bridges, use of solar energy and optimized construction methods.

There are three classes of ClimateHouse depending on the heating energy demand: ClimateHouse Gold, ClimateHouse A and ClimateHouse B.

- ClimateHouse Gold: heating energy demand <10 kWh/m²a (requiring practically no active heating system), is also called “one-litre” building, as it requires one litre of oil (or a single cubic metre of gas) per square metre each year.
- ClimateHouse: heating energy demand < 30 kWh/m²a (“three-litres” building)

- ClimateHouse B: heating energy demand < 50 kWh/m²a ("five-litres" building)

The highest KlimaHaus certification is **La CasaClima più (ClimateHouse plus)**. Awarded to residential buildings distinguished not only by energy-saving construction, but also by ecological construction methods and use of renewable energy for heat production. To qualify for KlimaHausplus certification, a building must fulfil the following criteria:.

- Heating energy consumption < 50 kWh/m²a
- Heating fuelled by renewable energy sources
- Use of environmentally-friendly, non-health-damaging building materials
- Inclusion of at least one of the following measures: A photovoltaic system, solar panels for water heating and/or integrated with heating system, rainwater usage, green roof.

More than 2000 buildings have achieved the certification "ClimateHouse" in Italy and abroad. In 2009 the new label for "ClimateHotel" was presented.

http://www.klimahausagentur.it

4.13. CEN TC 350

i. Documents

FprEN 15643-1 (2010-04): Sustainability of construction works – Sustainability assessment of buildings – Part 1: General framework (Final Draft)
prEN 15643-2 (2009-04-01): Sustainability of construction works – Assessment of buildings – Part 2: Framework for the assessment of environmental performance (Draft)
prEN 15643-3 (2010-05-15): Sustainability of construction works – Assessment of buildings – Part 3: Framework for the assessment of social performance (Draft)
prEN 15643-4 (2010-04): Sustainability of construction works – Assessment of buildings – Part 4: Framework for the assessment of economic performance (Draft)
prEN 15978 (2010-07-15): Sustainability of construction works – Assessment of environmental performance of buildings – Calculation Method (Draft)

ii. Environmental indicators

Following the proposals of CEN/TC 350, environmental indicators are derived from quantifiable impacts based on the result of the Life Cycle Assessment over the life cycle of a building. "The following environmental indicators have been chosen on the basis that there is agreed calculation method. In this first generation of CEN/TC350 standards other indicators, for which there is no scientifically agreed calculation method within the context of LCA, e.g. human toxicity, eco-toxicity, depletion of resources, biodiversity, land use, are not included" (prEN 15643-2: 2009).
The indicators are varying from draft to draft. Environmental indicators under current discussion are (FprEN 15804, 2011-02 and FprEN 15978, 2011-01):

Parameters describing environmental impacts

- Global warming potential, GWP (kg CO_2 equiv)
- Depletion potential of the stratospheric ozone layer, ODP (kg CFC 11 equiv)
- Acidification potential of soil and water, AP (kg SO_2 equiv)

- Eutrophication potential, EP (kg $(PO_4)_{3-}$ equiv)
- Formation potential of tropospheric ozone, POCP (kg Ethene equiv)
- Abiotic depletion potential (ADP-elements) for non fossil resources (kg Sb equiv)
- Abiotic depletion potential (ADP-fossil fuels) for fossil resources (MJ, net calorific value)

Parameters describing resource use

- Use of renewable primary energy excluding renewable primary energy resources used as raw materials (MJ, net calorific value)
- Use of renewable primary energy resources used as raw materials (MJ, net calorific value)
- Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials) (MJ, net calorific value)
- Use of non renewable primary energy excluding non renewable primary energy resources used as raw materials (MJ, net calorific value)
- Use of non renewable primary energy resources used as raw materials (MJ, net calorific value)
- Total use of non renewable primary energy resources (primary energy and primary energy resources used as raw materials) (MJ, net calorific value)
- Use of secondary material (kg)
- Use of renewable secondary fuels (MJ, net calorific value)
- Use of non renewable secondary fuels (MJ, net calorific value)
- Use of net fresh water (m^3)

Other environmental information describing waste categories

- Non-hazardous waste disposed (kg)
- Hazardous waste disposed (kg)
- radioactive waste disposed (kg)

Other environmental information describing output flows

- Components for re-use (kg)
- Materials for recycling (kg)
- Materials for energy recovery (kg)
- Exported energy (MJ per energy carrier)

iii. Social Indicators

Quotation “The social dimension of sustainability concentrates, in this first generation of standards, on the assessment of impacts of a building related to its occupants and other users expressed with the quantifiable indicators. The social performance measures will be represented through indicators for:

- Health and Comfort;
- Accessibility;
- Maintenance;
- Safety / Security;
- Loadings on the neighbourhood.

Construction and deconstruction stages of the building life cycle including health and safety aspects related to construction workers are not part of the first generation of standards.” (prEN 15643-3: 2010).

Social indicators of the current draft of prEN 15643-3 (2010-05-15) are:

<table>
<tr><th colspan="2">Use Stage</th></tr>
<tr><td>Building-related data for the fabric during use stage including, maintenance, repair, refurbishment and replacement</td><td>User- and control system-related data for operation of the building and its elements during use stage</td></tr>
<tr><td>a) Health and comfort
1) Thermal performance
2) Humidity
3) Quality of water for use in buildings
4) Indoor air quality
5) Acoustic performance
6) Visual comfort
b) Safety and security
1) Resistance to climate change
2) Fire safety
3) Security against intruders and vandalism
4) Security against interruptions of utility supply (e.g. electricity, water, district heating, etc.)
c) Accessibility
1) Accessibility for people with specific needs (prams, children, etc.)
d) Maintenance
1) Maintenance Requirement
e) Loadings on neighbourhood
1) Noise
2) Emissions
3) Glare
4) Shocks/vibrations</td><td>a) Health and comfort
1) Thermal performance
2) Humidity
3) Indoor air quality
4) Visual comfort
b) Safety and security
1) Security against intruders and vandalism
c) Maintenance
1) Maintenance Requirement
d) Loadings on neighbourhood
1) Noise
2) Emissions</td></tr>
</table>

Table 9: Social indicators of the current draft of prEN 15643-3 (2010-05-15)

The system boundary (time scale) of social indicators within the first generation of EN 15643 is restricted to the use stage.

5. SELECTION OF CATEGORIES FOR IN-DEPTH ANALYSIS

Ordering party of this study and authors jointly selected categories to be submitted to an in-depth analysis. Selection was based on the generic category framework of SBTool 07. In a next step, missing subcategories in the framework were added.
Selected categories were finally divided into the following chapters:

- Energy demand and CO_2-emissions with focus on operation phase
- Life cycle assessment (LCA) with focus on building material
- Daylighting
- Construction site management
- Chemicals in building materials / indoor air

Table 10 shows the results of the discussion.

Table 10: Selection of categories for in-depth analysis based on the generic category framework of SBTool 07. The brackets after the term “selected” indicate the chapter of the in-depth analysis. The categories added by the project team are marked by italic red type.

n°	Category	Results of discussion
A	**Site Selection, Project Planning and Development**	
A1	Site Selection	important categories concerning local impacts on the environment; not selected for in-depth analysis, because not in the focus of current European standardization work on buildings
A2	Project Planning	
A3	Urban Design and Site Development	
B	**Energy and Resource Consumption**	
B1	Total Life Cycle Non-Renewable Energy	**selected** (“Energy and CO_2-emission”)
B2	Electrical peak demand for facility operations	**selected** (“Energy and CO_2-emission”)
B3	Renewable Energy	**selected** (“Energy and CO_2-emission”)
B4	Materials *(remark: resource-oriented indicators)*	**selected** (“Life Cycle Ass.”)
B5	Potable Water	important category concerning local impacts on the environment; not selected for in-depth analysis, because not in major discussion
C	**Environmental Loadings *and Risks***	
C1	Greenhouse Gas Emissions	**selected** (“Energy and CO_2-emission” and “Life Cycle Ass.”)
C2	Other Atmospheric Emissions	**selected** (“Life Cycle Ass.”)
C3	Solid Wastes (construction, demolition, operation)	**partly selected** (“Construction site management”)
C4	Rainwater, Stormwater and Wastewater	important category concerning local impacts on the environment; not selected for in-depth analysis, because not in major discussion
C5	Impacts on Site	**partly selected** (“Construction site management”)

n°	Category	Results of discussion
C6	Other Local and Regional Impacts	important category concerning local impacts on the environment; not selected for in-depth analysis, because not in major discussion
C7	*Hazardous ingredients in building materials*	**selected** ("Chemicals and indoor air")
D	**Indoor Environmental Quality**	
D1	Indoor Air Quality	**selected** ("Chemicals and indoor air")
D2	Ventilation	not selected for in-depth analysis, because category is dealt with in building codes
D3	Air Temperature and Relative Humidity	not selected for in-depth analysis, because category is dealt with in building codes
D4	Daylighting and Illumination	**selected** ("Daylighting")
D5	Noise and Acoustics	important category concerning health and comfort of inhabitant; not selected for in-depth analysis, because category is dealt with in building codes and because of the cultural and technical differences throughout Europe
E	**Service Quality**	
E1	Safety and Security During Operations	neither environmental nor health related categories
E2	Functionality and efficiency	
E3	Controllability	
E4	Flexibility and Adaptability	has an impact on the environmental performance of buildings but originates from the technical sphere
E5	Commissioning of facility systems	neither environmental nor health related category
E6	Maintenance of Operating Performance	Use of durable materials etc. has an impact on the environmental performance of buildings but originates from the technical sphere
F	**Social and Economic aspects**	
F1	Social Aspects	F.1.3 Access to direct sunlight from living areas of dwelling units
F1.x	*Loadings on neighbourhood*	**selected** ("Construction site management")
F2	Cost and Economics	neither environmental nor health related category
G	**Cultural and Perceptual Aspects**	neither environmental nor health related category

PART II: IN-DEPTH ANALYSIS OF SELECTED TOPICS

6. INTRODUCTION

The following technical guides and references to building assessment systems were submitted to an in-depth analysis

EU Eco-Label	EU Eco-Label Award Scheme for Buildings: Supporting document to third draft criteria (ed. ISPRA, May 2010)
SBTool	Reference: "An Overview of SBTool, September 2007 Release" (ed. iisbe, Nils Larsson)
CSH	Code for Sustainable Homes: Technical Guide May 2009, Version 2; ed. Department for Communities and Local Government, 2009
BREEAM MR	BREEAM Multi-residential 2008 Assessor Manual (BREEAM BRE Environmental & Sustainability Standard BES 5064: Issue 1.0; ed. © BRE Global, 2008, http://www.breeam.org)
LEED HRS	LEED® for Homes Rating System, Version 2008 including corrections, clarifications and new exemplary performance rulings (ed. U.S. Green Building Council, January 2010)
LEED NC	LEED Reference Guide for Green Building Design and Construction (for the Design, Construction and Major Renovations of Commercial and Institutional Buildings Including Core & Shell and K-12 School Projects (ed. US. Green Building Council, Washington, 2009)
DGNB	DGNB – residential buildings. Steckbriefe (Draft, May 2010)
TQB	TQB-Kriterienkatalog (TQB catalogue of criteria), status 22.07.2010

in regard to the following topics:
- energy and CO_2 emissions
- life cycle analysis
- daylighting
- construction site management
- chemicals in building materials and emissions from building materials to indoor air

If illustrative, also European legislation and initiatives were investigated.

The in-depth analysis shall lead to a recommendation concerning preferable indicators within the investigated topic.

7. ENERGY AND CO_2-EMISSIONS

7.1. Operational energy and relevant energy indicators

Energy effectiveness is defined as relation between energy input and output in form of energy services (electricity, thermal energy, mechanical energy). Output achieved with lowest consumption of resources is characterised as energy efficiency.
Losses occur in converting or transforming primary energy (energy found in nature, e.g. coal, crude oil, biomass, wind energy, etc.) into secondary energy (e.g. heating oil, petrol, electricity, rapeseed oil, etc.). Both secondary energy and in some cases also primary energy carriers are delivered to final consumers. Losses of distribution, transformation as well as non-energetic consumption occur until the final energy carriers reach the consumers in form of heating oil, wood chips, gas or electricity.
The final energy carriers are transformed by building services or electrical appliances into useful energy to satisfy specific needs (e.g. space heating, hot water preparation, cooking, data transfer).

Primary Energy
(e.g. crude oil)
⇒ Secondary Energy
(e.g. heating oil - raffinery)
⇒ Final Energy
(e.g. heating oil – oil tank)
⇒ Useful Energy
(space heating,..)

Useful Energy (Heating energy demand)

Building-related energy indicators were first developed to minimise the useful energy demand (and focused on the main energy service "space heating"). Minimum requirements for the thermal envelope (U-values) were defined. The next step was to balance internal as well as solar gains against transmission and ventilation losses thus determining the heating energy demand. This figure is characterised as useful energy in order to maintain a defined temperature inside the building. Losses of heat generation, distribution and dissipation within the building are not taken into account. The efficiency of furnaces or other energy generation systems were excluded as well as energy demand for hot water preparation, mechanical ventilation systems, cooling, lighting or electrical appliances.
More recently, heating energy demand as core indicator to characterise operational energy of buildings has been gradually replaced (or supplemented) by indicators like final energy demand, primary energy demand, use of renewable/non-renew-able energies or/and CO_2 emissions as the analysis of the main energy indicator(s) of wide-spread environmental assessment systems as well as the diverse implementation of energy performance certificates in EU member states clearly reveals (see Table 13, p. 54 and Table 15, p. 78).

Delivered Energy – Final Energy – Energy Costs

From a consumer's point of view total energy costs are most relevant. They are based on the energy delivered to the building (m^3 natural gas, kWh electricity, m^3 wood, etc.) comprising all energy needed (for electrical appliances, lighting, domestic hot water, cooling, auxiliary electricity for ventilation, pumps, etc.). Delivered energy is usually identical with final energy consumption of the building. In case of building- or site-related energy generation plants (photovoltaics, solar collectors, wind turbines, etc.) which produce electrical or thermal energy for the building itself the energy which must be delivered to the building is lowered by these gains in comparison to the final energy demand.

Energy costs are usually based on metered consumption data. A clear distinction has to be made between metered consumption and calculated energy need. Actual consumption may deviate considerably from calculations of the final energy need of a building which take into account standardized user behaviour and climate conditions as well as default values for the performance of the building services installed.

Costs are built upon final energy consumption of a building but are influenced by other variables. Costs may vary depending on the mix of energy carriers needed, their availability, actual market demand, distance of transport, calorific value of energy carriers, investment costs and maintenance of related building services and constructional expenditures (storage facilities, geothermal boreholes).

Consumers' decisions may be facilitated by recommendations for preferable heating systems summarizing pro's and con's but the choice itself shall depend also on local resources and market supplies as well as building specifications. Decentralised biomass heating systems are useful in rural wooded regions, but are not recommendable in densely populated urban and suburban areas because of increasing NOx emissions and particulate air pollution. Utilisation of geothermal energy may be facilitated by geological chasms. General recommendations (even EU wide) are not regarded as useful instruments for optimisation.

Ratings of the final energy demand are often bound to reference buildings with comparable technical equipment (e.g. oil condensing furnaces are compared with conventional oil furnaces, pellet heating with wood log heating, etc.) thus aggravating the definition of absolute benchmarks.

Different calculation methods for different types of heating systems do not allow or at least complicate direct comparisons. As annual efficiency rates and optimisation potentials vary considerably between different systems. Different operating modes need distinct consideration and assessment. Potential of gas furnaces can be increased up to 98% using the waste heat of exhaust gases whereas the efficiency of biomass-based boilers are limited to 80-85%.
To be able to rate the final energy demand, the percentage improvement to a reference building with similar building services is calculated taking into account the specifications of similar systems[12]. Special calculation methods are needed in case of heat pumps where the relevant energy efficiency indicator is defined as annual coefficient of performance taking into

[12] e.g. CSH

account the output of thermal energy in relation to the electricity input over the whole year (1 kWh electricity supplies 3 to 4 kWh thermal energy). The final or delivered energy demand may be up to 75% lower than the useful energy[13].

Final energy demand or consumption considers the efficiency of building services on site but not the efficiency of energy generated off-site (e.g. production mix of electricity, of local or district heating, combined heat and power, regional small hydro or wind power plants,…). Building-related losses for electricity are 0%, but may rise up to 65% considering electricity generation and distribution. The next step is to include the losses outside the building and the building site with all difficulties of elaboration and evaluation of primary energy factors for electricity, local district heating, etc. with respect to different providers and remarkable country-specific and regional differences in the production-mix.

Approximately the same final energy demand is needed if water is heated by gas condensing boilers or electricity (supplied by the grid) whereas the primary energy efficiency differs considerably: Natural gas production and distribution to final consumers result in 10 % losses, the average German electricity production mix, however, causes 65 % conversion and distribution losses resulting 35 % primary energy efficiency for electricity versus 90 % energy efficiency for natural gas.[14]

The different calorific values of energy carriers are not yet considered in the indicator “final energy demand”, but influence the amount of fuels and storage capacity needed.

Primary energy demand (total / renewable / non renewable)

As shown above important up-stream processes of energy generation are not directly connected with the building, but have to be considered in order to avoid distorted assessment results.

Primary energy is energy found in nature that has not been subjected to any conversion or transformation process. It is energy contained in raw fuels as well as other forms of energy received as input to a system.

Examples of primary energy sources are:

- Biomass
- Fossil fuels
- Geothermal energy
- Hydro energy
- Nuclear fuels
- Solar energy
- Tidal energy
- Wave energy
- Wind energy

[13] Considering the primary energy demand this benefit may be nullified if the electricity needed for the heat pump is supplied by the grid as electricity from grid is charged with average primary energy factors of about 3 whereas building related PV-systems would allow to design nearly zero-energy buildings.

[14] Source: Brischke, L.A., Rationelle Energienutzung in elektrischen Anwendungen. In: Pehnt, M., Energieeffizienz, Springer, Berlin/Heidelberg, 2010)

If primary energy demand is calculated for a building, all processes of energy generation, transportation and distribution losses both inside and outside the building are summarized. From ecological as well as energy supply view regarding the primary energy and its distinction into renewable and non-renewable resources, not primarily the total amount is the significant figure which has to be lowered, but the non-renewable share (provided that energy saving measures are already implemented with respect to the useful and final energy demand of buildings). Energy saving has always priority over the use of renewable energies, as energy which need not be supplied is ranking higher than energy generated by regenerative sources.
Limitation of primary energy has to be considered with respect to exhaustible resources and the maintenance of non-renewable resources for future generations. Biomass-based energy resources are considered as energy resources with low non-renewable, but high renewable primary energy content. Therefore, it is insufficient to assess primary energy without a clear division into renewable and non-renewable energy sources.

Low primary energy factors (e.g. heating oil) are the result of high energy intensity of the considered energy carrier, high primary energy factors are caused by elaborate technological upstream processes (e.g. electricity from coal-fired power plants).
The total primary energy factor for wood is similar to coal or heating oil. If only the non-renewable part is considered the primary energy factor decreases significantly to 0.2 taking into account diesel use for wood processing, etc.

Primary energy factors vary depending on calculation methods and allocation models but the ranking of energy carriers is similar as the comparison of two sources applicable for the German market shows.[15]

Table 11: Primary energy factors (cited in EN 15603, Source: Oekoinventare für Energiesysteme – ETH Zürich):

	Primary energy factors f_p	
	Non renewable	Total
Heating oil	1.35	1.35
Natural gas	1.36	1.36
Anthracite coal	1.19	1.19
Brown coal	1.40	1.40
Coke	1.53	1.53
Wood chips	0.06	1.06
Wood	0.09	1.09
Beech wood	0.07	1.07
Fir wood	0.10	1.10
Electricity – hydropower plant	0.50	1.50

[15] Conversion factors especially for electricity generation are controversially discussed as the production mix varies substantially in different European countries and is highly dependent on the specific provider which can easily be changed by consumers. Furthermore, on-going improvements in the energy sector lead to significant changes in the mixture of energy supply which should be taken into account in the calculation of primary energy factors. Consistent conversion factors can only refer to an average production mix of electricity (or even oil extraction and production) within a region considered (e.g. EU or EU member state) being aware of the inaccuracy of data collection and current changes in power supply. Using primary energy demand as one of the main indicators for building assessment systems one must be aware that besides buildings' specifications also the quality of the whole energy sector is rated.

	Primary energy factors f_p	
	Non renewable	Total
Electricity – nuclear power plant	2.80	2.80
Electricity – coal-fired power plant	4.05	4.05
Electricity – UCTE mix	3.14	3.31

Table 12: Primary energy factors according to DIN 18599-1 (2009-10)

	Primary energy factor (non renewable) fp	Primary energy factor (total) fp
Heating oil	1.1	1.1
Natural gas	1.1	1.1
Liquid gas	1.1	1.1
Anthracite coal	1.1	1.1
Brown coal	1.2	1.2
Wood	0.2	1.2
District heating – 70% CHP (fossil)	0.7	0.7
District heating – 70% CHP (renew.)	0.0	0.7
District heating – heat plant (fossil)	1.3	1.3
District heating – heat plant (renew.)	0.1	1.3
Electricity	2.6	3.0
Ambient heat / Solar	0.0	1.0

Greenhouse gas (GHG) emissions

Main environmental impact of combusting non-renewable resources like fossil fuels is their substantial contribution to the anthropogenic greenhouse effect.
Fossil fuels emit on average ten times more greenhouse gases than renewable energies.
Within the European Union, the building sector is currently responsible for 40 % of all energy consumption and 36 % of total CO_2 emissions, a major part are residential buildings.
Due to political target values (Kyoto Protocol and following arrangements) and despite of uncertainties in calculation methods, Global Warming Potential (GWP) – quantifying the contribution of released substances to the greenhouse effect in kg CO_2-equivalents is becoming one of the leading indicators for assessing energy-intense processes.

7.2. EPBD 2002 and EPBD Recast 2010

EPBD 2002

The EPBD (Directive on Energy Performance of Buildings) adopted 2002[16] and its recast in 2010[17] are the main legislative instruments at EU level which aim to improve energy performance of buildings. To implement the directive into national law, in a first step the Member States had to apply minimum requirements (tailored to the local climate) regarding the energy performance of new buildings and large existing buildings that are subjected to major renovation. The level of performance as well as the methodology of calculation could be defined by the EU member states themselves according to the principles of subsidiarity and proportionality[18] which makes a comparison of energy indicators on a European wide level rather difficult.

To guarantee the achievement of the target values, the EU member states had to establish certification systems of the energy performance of buildings (via obligatory energy certificates which have to be revised accordingly). Furthermore, the technical, environmental and economic feasibility of alternative energy supply systems should be considered for large new buildings (with a total useful floor area above 1000 m²) such as decentralised energy supply systems based on renewable energy, CHP (Combined Heat and Power), district or block heating or cooling and heat pumps. The regular inspection of boilers and air conditioning systems both for new and existing buildings should improve the energy efficiency of heating and cooling systems. Is the boiler sizing (still) suitable to the heating requirements of the building or is a general replacement of boilers/cooling systems, their upgrading or alternative modifications necessary?

Diversity in the implementation of the EPBD in EU Member States

The study "Monitoring and evaluation of energy certification on practice with focus on central European States"[19] provides an overview of the diversity and multiplicity of the implementation of the EPBD in different EU Member States. Multiple are not only the main indicators displayed on the first side of the energy performance certificate, but also rating scales and if measured or calculated values are applicable, as Table 13 shows.

[16] Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings
[17] Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of Directive 2010/30/EU of the European Parliament and of the Council of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related product buildings
[18] "the general principles providing for a system of energy performance requirements and its objectives should be established at Community level, but the detailed implementation should be left to Member States, thus allowing each Member State to choose the regime which corresponds best to its particular situation." Paragraph 21, Directive 2002/91/EC
[19] Kopetzky, R.; Therburg, I.; Monitoring and evaluation of energy certification on practice with focus on central European States (ed. By ARGE Energieausweise Mitteleuropa; published by the Federal Ministry of Transport, Building, Urban Affairs and Spatial Development (BMVBS), BMVBS-Online Publikation 03/2010, February 2010)

Table 13: Main indicators after the implementation of energy performance certificates with focus on Central Europe (status 2008) (complemented excerpt)

	Methodology		Main indicators							Graphical display	
	Calculated values	metered values	Heating energy demand	Final energy	Primary energy	CO_2	Weighted factor	Artificial factor	Energy Costs	Energy classes	Speedometer
Austria	x		x	(x)						A^{++} G	
Belgium	x	x^1	(x)		x^5	(x)		x^5		A^{+} G	x
Czech Republic	x			x						A G	
Denmark	x			(x)			x		(x)	A1 G	
France	x^2	x^2			x	x				A I	
Germany	x^3	x^3		x	x						x
Great Britain	x	x^1		(x)		x^6			x^6	A G	
Luxembourg	x		x		x	x				A I	
Netherlands	x							x^7		A^{++} G	
Sweden		x		x^4						8 classes	

x^1 Belgium (Flemish Region), Great Britain: metering results only for public buildings, all other building types calculated values

x^2 France: for residential buildings depending on age and heating system calculated or metered values are used

x^3 Germany: the owner of existing buildings has the free choice between calculation based or metered figures (except for residential buildings with less than five flats)

x^4 Sweden: does not include electrical appliances

x^5 Belgium: depending on type of certificate and Region

x^6 Great Britain: depending on type of certificate

x^7 NL: artificial factor shall avoid discussions about the difference between the calculated energy demand and the metered energy, consumed by the user later on

(x) indicated, but not rated

Energy classes according to the European energy classes of household appliances
Speedometer: the actual value and the benchmark is shown graphically on a linear scale

EPBD Recast 2010

On 18 May 2010 a recast (2010/31/EC) of the Directive on energy performance of buildings (2002/91/EC) was adopted in order to strengthen the energy performance requirements and to clarify some of its provisions to achieve the following climate protection goals.

- reduction of the European Union's total energy consumption by 20 % by 2020
- reduction of overall greenhouse gas emissions by at least 20 % below 1990 levels until 2020 and 30 % in the event of an international agreement being reached

- 20 % share of energy from renewable sources by 2020[20]

The EU directive requires that all EU Member States endorse national plans and targets in order to promote the uptake of close to zero-energy buildings. Member States shall ensure that by 31 December 2020, all new buildings are nearly zero-energy buildings; and after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings. Intermediate targets for improving the energy performance of new buildings have to be implemented by 2015.

'Nearly zero-energy buildings' are not defined in detail in the recast of EPBD 2010 (apart from "a building that has a very high energy performance" Article 2, paragraph 2) as national, local and regional conditions differ. Indeed a great variety of high energy performance building concepts are used throughout Europe.

Definition of "nearly zero-energy buildings"

a) Passive house

One of the first integrated concepts was the "Passivhaus" construction standard which has been developed in Germany in the late 90ies of the last century. Its initiator Dr. Feist (Passive House Institute Darmstadt) describes the concept as follows:
"The key components are excellent insulation and high airtightness of the thermal envelope of a building, avoidance of thermal bridges and highly efficient heat recovery from exhaust air. A conventional heating system is superfluous due to the combined use of internal and solar heat gains. The passive house concept leads to the highest degree of comfort with minimal energy consumption." (IBO, Details for Passive Houses, 2009) The annual heating requirement is limited to 15 kWh/m²a and the primary energy requirement to 120 kWh/m²a (including heating, domestic hot water, ventilation, and all other electrical appliances).
A building envelope fulfilling the passive house standard is the ideal basis for a zero or plus energy building.
Besides the definition of passive houses as highly insulated buildings without conventional heating systems propagated in Central and Northern Europe, in the southern regions (e.g. Spain, Italy, Portugal, Greece) a passive house is defined as a building using passive technologies to reduce especially the energy requirement during the summer period.

The following definitions of zero and energy positive houses are cited from the info note of the EU commission "Low Energy Buildings in Europe: Current State of Play, Definitions and Best Practice" (Brussels, 2009),
http://ec.europa.eu/energy/efficiency/doc/buildings/info_note.pdf

b) Zero energy houses / zero carbon houses

"The specificity of a zero energy house / zero carbon house is that the remaining energy needs are entirely covered with renewable or carbon free energy sources. A house with zero net energy consumption annually can be autonomous from the energy grid supply, but in

[20] Renewable non-fossile energy sources are wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases (Directive 2010/31/EU, article 2, paragraph 6).

practice that means that in some periods power is gained from the grid and in other periods power is returned to grid (renewable energy sources are often seasonal).

c) Energy positive house

An energy positive house (also: plus energy house) is a house that on average over the year produces more energy from renewable energy sources than it imports from external sources. This is achieved using combination of small power generators and low-energy building techniques such as passive solar building design, insulation and careful site selection and placement."

All nearly-zero energy building concepts have to summarize the energy needs for heating, cooling, ventilation, hot water and lighting and may take into account benefits from local solar exposure conditions, active solar systems and other heating and electricity systems based on energy from renewable sources; electricity produced by cogeneration, district or block heating and cooling and natural lighting.

Minimum requirements

Not new in the EPBD recast is that minimum requirements for the energy performance of buildings have to be set by the EU Member States, whereas the demand for cost-effectiveness or cost-optimal levels is new. Cost-optimal means that this energy performance level "leads to the lowest cost during the estimated economic lifecycle" (Article 2, paragraph 14). Use patterns, outdoor climate conditions, investment costs, building category, maintenance and operating costs (including energy costs and savings), earnings from energy produced and disposal costs, where applicable, can be taken into account. This provision applies to the inspection reports of heating and air-conditioning systems as well as the energy performance certificate as recommendations for the cost-optimal or cost-effective improvement of the energy performance of a building (or building unit) shall be included. In order to ease the comparison and assessment for owners or tenants reference values such as minimum energy performance requirements will be integrated in the energy performance certificate. Therefore, the Member States have to define "reference buildings that are characterised by and representative of their functionality and geographic location, including indoor and outdoor climate conditions", assess their final and primary energy need, define energy-efficiency measures and calculate the costs of the energy efficiency measures during the expected economic lifecycle (see Annex III). A general harmonization of national calculation methods and parameters is not foreseen.

Only "a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements" will be provided by the European Commission. "Member States should use this framework to compare the results with the minimum energy performance requirements which they have adopted. Should significant discrepancies, i.e. exceeding 15 %, exist between the calculated cost-optimal levels of minimum energy performance requirements and the minimum energy performance requirements in force, Member States should justify the difference or plan appropriate steps to reduce the discrepancy." (Paragraph 14, EPBD Recast). The comparative methodology framework should be based on relevant European standards relating to the EPBD Recast and the

calculation of cost-optimal levels has to take into account "information on estimated long-term energy price developments" provided by the Commission (Annex III).
The energy performance certificate should also provide information about the actual impact of heating and cooling on the energy needs of the building, on its primary energy consumption and on its carbon dioxide emissions. A voluntary indication is the percentage of energy from renewable sources in the total energy consumption.
"The energy performance of a building shall be expressed in a transparent manner and shall include an energy performance indicator and a numeric indicator of primary energy use, based on primary energy factors per energy carrier, which may be based on national or regional annual weighted averages or a specific value for on- site production."(Annex I, paragraph 2)
Besides, the Member States are obliged to establish independent control systems for energy performance certificates and inspection reports.

The requirements of the EPBD recast are at least to some extent already anticipated in building assessment systems or drafts such as the Third Draft EU Eco-Label as well as Code for Sustainable Homes/BREEAM Ecohomes, DGNB, TQB, etc.

7.3. EU Ecolabel (Third Draft Criteria, May 2010)

The energy-related criteria in the third draft of EU Ecolabel[21] anticipate the integrated approach of the forthcoming revised EPBD (Energy Performance Building Directive) considering not only energy efficiency of heating, but also cooling/ventilation, hot water and other energy applications.
The nearly energy zero building concept is integrated in the requirements defined for heating. The heating demand as primary objective criterion in former energy efficiency certificates is replaced by the primary energy demand taking into consideration not only the thermal quality of the building envelope, but also the losses of all building services and the primary energy factor of the used energy source(s). The share of renewable energy is awarded twice: in the calculation method of the primary energy requirement of the building improving the overall result and explicitly in the demand that at least 50% of the energy used shall come from renewable sources.

The criteria in detail are the following:

Operational Energy

Mandatory criteria:

- "The primary energy requirement for heating shall be not higher than 30 kWh/m²/year (verified by the energy efficiency certification)." (Criterion 12)

[21] Commission Decision on establishing the ecological criteria for the EU Ecolabel for New buildings (Third Draft), May 2010
Minestrini, S.; Cutaia, L.; EU Ecolabel for Buildings: Supporting document to Third draft criteria (ed. ISPRA, May 2010

- “At least 50 % of the energy used for all purposes shall come from renewable energy sources (compliant evidence is provided by share and type of renewable energy).” (Criterion 13)

Optional criteria

- “The primary energy requirement for heating shall be not higher than 15 kWh/m²/year (verified by the energy efficiency certification).” (Criterion 47)
- “At least 50 % of the annual needs for ventilation and cooling shall be satisfied through passive systems (verified by documentation showing the total annual cooling and ventilation demand and the related sizing of plants)”. (Criterion 48)
- “At least 50 % of the annual needs for hot water production shall be satisfied through passive systems (verified by documentation showing the total annual cooling and ventilation demand and the related sizing of plants)”. (Criterion 49)

It is not precisely defined whether green power supply agreements fall under the definition of renewable energy (besides, the energy suppliers can easily be exchanged by consumers and the supply of green power is not a building specification, at all.)

The optional criterion 48 does not take into account that the cooling demand especially of residential buildings (in moderate Central European climate) should be optimised approaching zero and therefore need not be provided (or cannot additionally be reduced by 50 %) via passive systems (plants, etc.).
Priority should be given to strategies which enhance the thermal performance of buildings during the summer period. To that end, there should be focus on measures which avoid overheating, such as external or internal shading, natural ventilation or sufficient thermal capacity in the building construction, and further development and application of passive cooling techniques, primarily those that improve indoor climatic conditions and the micro-climate around buildings.

Ventilation systems with heat recovery lowering the heating demand to a large extent should not be “punished” for using electricity which is not provided by building- or site-integrated photovoltaics.

Energy and CO_2 embodied in materials

CO_2-Emissions (from building operation) are not explicitly mentioned and benchmarked (as they are to some extent correlated to the primary energy factors of energy sources) but will be taken into account if a Life Cycle Assessment (LCA) of the building would be carried out (optional criterion 33). Energy and CO_2 embodied in materials/products are separately assessed (optional criteria 39 and 45) exhibiting redundancies with criteria 40 “use or re-use of recycled materials/products”, 44 “labelled construction products (products awarded the EU Ecolabel or other national or regional ISO Type I Ecolabels)”, and criterion 33 “LCA of the building”.

Traffic-related energy issues

Energy or emissions from traffic to and from site are indirectly assessed within the optional criteria 42 and 43 “Use of materials/products locally produced - non-structural functions and structural functions”.
Mandatory is the restriction of car-places for residential buildings (max. 1 car-place per flat). The use of low-emitting vehicles as well as cycling are encouraged as the building shall have obligatory facilities for charging electric vehicles and open-space parking for LPG vehicles and adequate cycle storage facilities, either indoor or outdoor to ensure dry storage of bicycles. What “adequate” means is not yet specified in the Third Draft Criteria.

7.4. SBTool

Source: Reference: “An Overview of SBTool, September 2007 Release” (ed. iisbe, Nils Larsson)

Energy-relevant indicators are assessed both in section B “Energy and Resource Consumption” and in section C “Environmental Loadings”.

The assessment framework provides a clear division into non-renewable primary energy embodied in construction materials and used for facility operations as pointed out in the following overview.

B1 Total Life Cycle Non-Renewable Energy

B1.1. Annualized non-renewable primary energy embodied in construction materials.

Embodied primary energy used for structure, envelope (excl. glazing), and major interior components annualised over the expected life span of a building has to be taken into account (the proposal for rating ranges from 107 (acceptable practice) – 67 (best practice) MJ/m²a; assumed life span:75a).

B1.2. Annual non-renewable primary energy used for facility operations

Verification is provided by calculating the delivered energy in MJ per m² of net area, including fuel and electrical use, as predicted by means of an acceptable method or tool. SBTool applies conversion factors to this value to convert them into primary energy. The proposals for rating are 300 (acceptable practice) – 150 MJ/m²year (best practice) primary energy demand – electricity and 800 (acceptable practice) – 500 MJ/m²year (best practice) primary energy demand – total.

B2 Electrical Peak Demand for Facility Operation

Required is the average of peak monthly electrical demand for one year, W/m^2, as predicted by means of an acceptable method or tool. The rating scale ranges from 5 (acceptable practice) – 2 (best practice) W/m² for small residential buildings)

B3 Renewable Energy

B3.1. Use of off-site energy that is generated from renewable sources

The percentage of annual purchased electricity consumption planned to be obtained from sources that generate power by means of renewable energy is evaluated 15% (acceptable practice) – 30% best practice (ed. 2007).

B3.2. Provision of on-site renewable energy

> The amount of energy intended to be contributed by renewable energy systems, in MJ/m² per year, not including daylighting or Ground Source Heat Pumps (GSHP). The assessment proposal for small residential buildings ranges from 50 (acceptable practice) – 100 MJ/m² per year (best practice)

If a feasibility study concerning the use of renewable energy sources (e.g wind energy, small hydro, photovoltaics, solar air heating, biomass heating, solar hot water heating, passive solar heating and ground-source heat pumps) has been carried out, this is additionally awarded within subsection A2. Project Planning.

Electrical Peak Demand

SBTool assesses not only the annual energy requirement of buildings based on average climate data and user behaviour, but also the electrical peak demand (which are key parameters for the power supply systems). Not only the energy consumption averaged over one year should be lowered but also saisonal or daily peak loads.

Embodied Energy

Energy for constructing the building on site, for maintenance and refurbishment of building elements or HVAC systems or removal/disposal/recycling processes and the end of life-time are *not explicitly* mentioned. The focus lies on the first material input and the operation phase.

The same division as for energy (embodied in construction materials and caused by facility operations) is maintained for Greenhouse Gas Emissions (GHG). For all other atmospheric emissions calculated within the SBTool such as ozone-depleting substances, acidifying emissions or emissions creating photo-oxidants only facility operations are looked upon.

Traffic-related Energy Aspects

Besides the requirement for regional products for construction (B4.9), the main focus of assessment lies on private car journeys during the operation phase. Site Selection (A1) is evaluated by assessing the proximity of site to public transportation, distance between site and centres of employment, proximity to commercial and cultural facilities as well as public recreation areas and facilities. SBTool also awards initiatives of communities to decrease traffic by policies governing use of private vehicles, encouraging builders to provide mixed uses within the project and enhancing community design that provides support for walking in and around the project. The project layout shall consider bicycle storage facilities, where cycling paths are available, and provide a safe, convenient and attractive environment for walking.

Weightings

SBTool attempts to derive the weighting of categories and indicators from the expected extent of the potential effect (global or regional = 3, urban or neighbourhood = 2, building or site = 1), from the expected intensity of a potential effect (strong or direct = 3, moderate or indirect = 2, weak = 1) and from the expected duration of a potential effect (> 50 years = 3; > 10 years = 2; < 10 years = 1) leading to the following weighting within the categories "B

Energy and Resource Consumption" and "C Environmental Loadings" for a building e.g. in Ottawa, Canada:
Energy-related indicators (B1-B3) account for 34% within the category "B Energy and Resources" (8% within the whole criteria-catalogue), the residual issues within "Energy and Resources" refer to materials (55%) and potable water (11%). Within the category "C Environmental Loadings" greenhouse gas and other atmospheric emissions caused by facility operations or production of construction materials account for 30% (weighting within the total system: 8%).

Table 14: "Energy and CO2-emissions" related sub-categories and Weightings within sections "B Energy and Resources" and "C Environmental Loadings", Example: Location Ottawa, Canada

Weights within group	Weights, total system	Extent of pot. effect	Intensity of pot. eff.	Duration of pot. eff.		Categories / Indicators
22.5%					B	**Energy and Resource Consumption**
18.2%					B1	Total Life Cycle Non-Renewable Energy
25%	1.0%	3	3	1	B1.1	Annualized non-renewable primary energy embodied in construction materials.
75%	3.1%	3	3	3	B1.2	Annual non-renewable primary energy used for facility operations
5.5%					B2	Electrical peak demand for facility operations
10.9%					B3	Renewable Energy
50%	1.2%	3	3	1	B3.1	Use of off-site energy that is generated from renewable sources.
50%	1.2%	3	3	1	B3.2	Provision of on-site renewable energy syst.
27.0%					C	**Environmental Loadings**
15.6%					C1	Greenhouse Gas Emissions
25%	1.1%	3	3	1	C1.1	Annualized GHG emissions embodied in construction materials.
75%	3.2%	3	3	3	C1.2	Annual GHG emissions from all energy used for facility operations.
14.1%					C2	Other Atmospheric Emissions
52.9 %	2.0%	3	3	2	C2.1	Emissions of ozone-depleting substances during facility operations.
23.5 %	0.9%	2	2	2	C2.2	Emissions of acidifying emissions during facility operations.
23.5 %	0.9%	2	2	2	C2.3	Emissions leading to photo-oxidants during facility operations.

7.5. Code for Sustainable Homes (CSH) - BRE

The Code for Sustainable Homes (2009) deals with energy topics in several categories:
- first, in the main category “Energy and Carbon Dioxide Emissions (ENE)” which is weighted by more than one quarter of all achievable credits (29 of 104; total weighting 28 %) leaving all other 8 main categories behind – apart from Materials which is weighted by 23 %.
- second, in several other categories (e.g. Management, Pollution, Materials,..) as set out in the following sections.

For more details to weighting and overall assessment see appendix 13.2

(Operational) Energy and CO_2-Emissions

Category “Energy and Carbon Dioxide Emissions (ENE)” comprises the following issues:
- Ene 1: Dwelling Emission Rate (15 credits)
- Ene 2: Building Fabric (2 credits)
- Ene 3: Internal Lighting (2 credits)
- Ene 4: Drying Space (1 credit)
- Ene 4: Energy labelled white goods (2 credits)
- Ene 6: External lighting (2 credits)
- Ene 7: Low or zero carbon (LZC) technologies[22] (2 credits)
- Ene 8: Cycle storage (2 credits)
- Ene 9: Home Office (1 credit)

Ene1: Dwelling Emission Rate
The first issue of the CSH energy section assesses the percentage improvement in the Dwelling Emission Rate (DER) over the Target Emission Rate (*TER*) (the maximum emission rate permitted by Building Regulations in England)[23], where ≤ 10% improvement is leading to rating level 1 (lowest level – 1 credit), ≥ 25% improvement to level 3 (5 credits), ≥100% level 5 (14 credits) and “Zero Carbon Home” to the best achievable level 6 (15 credits). These energy levels are mandatory to achieve the corresponding Code level (1-6 star rating).

The difference between level 5 and level 6 results from the sum of energy appliances considered:
The Dwelling Emission Rate (DER) takes into account the energy in use for **heating, hot water and fixed lighting (**where energy efficiency of dedicated lighting is assumed 30 %). Calculation refers to SAP method (the Government’s Standard Assessment Procedure as the approved methodology for rating the energy performance of dwellings). The result (estimated carbon dioxide emissions per m² for the building, as designed) is compared to the Target Emission Rate (TER) defined as the maximum allowable carbon dioxide emissions per m² for energy use in heating, hot water and lighting which would meet the Building Regulations.

[22] Technologies recognised by the Department for Business Enterprise and Regulatory Reform (BERR) Low Carbon Buildings Programme (LCBP) may be considered as part of a low or zero carbon emissions solution.
[23] Dwelling Emisson Rate (DER) and Target Emission Rate (TER) are defined in AD L1A The Building Regulations for England and Wales, Approved Document L1A: Conservation of Fuel and Power in New Dwellings (2006). 2010, the building regulations will be revised with the overall aim to achieve a 25% reduction in carbon emissions as compared with the 2006 Regulations making level 3 mandatory.

To achieve the level of a "**Zero Carbon Home**" net carbon dioxide emissions resulting from all energy used in the dwelling are zero or better, including **space heating, cooling, hot-water systems, ventilation, all internal lighting cooking and all electrical appliance**. The requirements of level 5 have to be fulfilled and off-site renewable contributions can only be taken into account where these are directly supplied to the dwellings by private wire arrangement. An optimization only by the use of Low or Zero Carbon technologies is not sufficient to achieve "Zero Carbon level". The building envelope has to be optimized, too, as a Heat Loss Parameter (covering walls, windows, air tightness and other building design issues) of 0.8 W/m²K or less is required.

The Code of Sustainable Homes (and the BREEAM schemes in general) neither refer to the delivered energy nor to primary energy requirement (renewable/non-renewable) of buildings. The decisive indicator for assessing the overall energy performance of dwellings is the **reduction of CO_2-emissions** compared to a defined level (besides additional individual measures).

The calculation method considers CO_2 emissions from space heating, domestic hot water, lighting, mechanical cooling, CO_2 reductions from alternative electricity generation, biomass fuelled CHP (combined heat and power) systems (community systems as well as on-site) and from LZC (Low or Zero Carbon) technologies (solar hot water, photovoltaics, small scale hydro power, wind turbines, biomass single room heaters/stoves, biomass boilers, biomass community heating schemes, CHP and micro CHP for use with the following fuels: natural gas, biomass, sewerage gas and other biogases, community heating, including utilising waste heat, air source heat pumps (ASHPs), ground source heat pumps (GSHP), geothermal heating systems, fuel cells using hydrogen generated from a renewable source).

Green tariffs cannot be used to discount CO_2 emissions as these do not guarantee an increased renewable capacity and are not legally binding on occupiers.

The rating within CSH does not consider absolute or specific carbon dioxide emissions of a building or a dwelling unaffected by the energy carrier or fuel in use. "The Target Emission Rate (TER) may be higher for some technologies based on a particular fuel and therefore the improvement to this level easier to reach."
The editors of the Code for Sustainable Homes recognised this weak point and emphasize that the Code "does not intend to reward technologies that work against the objectives of the scheme. Hence, the future revisions to the Code will be aligned with revisions to Part L of the Building Regulations; minimum standards of fabric performance and air tightness are also likely to be introduced."…"The fuel factors used within the SAP calculation methodology are to be redefined subject to a consultation in 2009 on Part L of the Building Regulations to map out new requirements for introduction in 2010 and 2013."[24]

Ene 2 to Ene 7 award **individual measures** as follows:

[24] Code for Sustainable Homes: Technical Guide May 2009, Version 2; ed. Department for Communities and Local Government, 2009, p.53

- **Ene 2 Building Fabric:** Heat Loss Parameter[25] of each dwelling ≤1.3 or ≤1.1 W/m²K (1 credit or 2 credits)
- **Ene 3 Internal Lighting:** ≥40% or ≥ 70% of fixed internal fittings are dedicated and energy efficient[26] (1 credit or 2 credits)
- **Ene 4 Drying space:** provision of secure and sufficient **drying space** (internal or external) for drying clothes (energy consumption for tumble dryers should be avoided) (1 credit)
- **Ene 5 Energy Labelled White Goods:** including
  - A+ rating under the EU Energy Efficiency Labelling Scheme for fridges and freezers or fridge-freezers (1 credit)
  - A rating for washing machines and dishwashers and either washer-dryers or tumble dryers have a B rating (1 credit)
  - If **no (or not all) white goods are provided** but information on the EU Energy Efficiency Labelling Scheme of efficient white goods is provided to each dwelling the credit can be awarded, too.
- **Ene 6 External and Secure Lighting:** All external space lighting, including lighting in the common areas, is provided by dedicated energy efficient fittings (1 credit).
  - Burglar secure lights have a maximum wattage of 150 W, movement detecting control devices (PIR) and daylight cut-off sensors. All other security lighting has dedicated energy efficient fittings and is fitted with daylight cut-off sensors or timers (1 credit).
- **Ene 7 LZC technologies:** If energy is generated from local renewable or low carbon energy sources funded under the Low Carbon Building Programme (or similar), 2 additional credits can be achieved if this results in a 15% reduction of carbon emissions or one additional credit in case of a 10% reduction.

Summary – (Operational) Energy and CO_2-Emissions

The credits available are split approximately one half to the overall energy performance of a building (measured in CO_2emissions, but not in absolute figures, the reduction of the emission rate is compared to a reference level) and one half to individual measures which are to some extent already considered in the dwelling emission rate (such as heat loss parameter of the building fabric or contribution of low or zero carbon technologies from local sources) but they also consider user-relevant appliances (e.g. white goods, drying space, internal/external lighting) and traffic-related aspects (such as provision of cycle storage and home office).
There are no additional mandatory requirements (apart from the minimum percentage reduction in dwelling emission rate over target emission rate to achieve the corresponding Code levels).

[25] The Heat Loss Parameter is defined as the total fabric and ventilation heat losses from the dwelling divided by the total floor area (W/m²K) and is influenced by the external surface area, insulation value of construction, and airtightness
[26] The fitting must must be capable of only accepting lamps having a luminous efficacy greater than 40 lumens per circuit Watt (e.g. tubular fluorescent and compact fluorescent lighting fitting). The fixing must be permanently fixed to the ceiling or wall.

Traffic-related Energy Aspects

The last issues within “Energy and Atmosphere” explicitly relate to the reduction of emissions **from motorised traffic** which are

- **Ene 8 Adequate cycle facilities** (which means that the cycle storage is of sufficient size, secure, weather-proof and has convenient access) thus encouraging the use of bicycles for short ways (up to 2 credits)
- **Ene 9 Home office:** provision of adequate space and equipment thus reducing the commute traffic (1 credit)

Further traffic-relevant topics are considered, but not directly assessed in the Home User Guide (see next section).

Energy Information Policy (Home User Guide)

Energy-related issues are by the way also integrated in the requirements for the **Home User Guide** (Man 1) which must be provided for all future tenants or buyers of a dwelling unit.

The Home User Guide is divided into two parts:
Part 1 (Operational Issues) including information about environmental design/features, energy, water use, recycling and waste, use of low VOC products or the purchase of certified timber and emergency information.
Part 2 (Site and Surroundings) shall inform about recycling facilities nearby, sustainable (urban) drainage systems, public transport and local amenities, details of cycle storage and cycle paths in the area, responsible purchasing (e.g. organic food procurement/food growing/local produce/local food provision, e.g. farmers markets) and emergency information relating to the neighbourhood (nearest police/fire station, minor injuries clinics,..). Local amenities comprise the location of food shops, post boxes, postal facilities, bank/cash points, pharmacies, schools, medical centres, leisure centres, community centres, places of worship, public houses, children’s play areas, outdoor open access, public areas, other local amenities such as places of interest/cultural value, areas of beauty / wildlife / conservation / allotments etc.

Preventing energy consumption and emissions from traffic is one of the main objectives of this information initiative within the Code for Sustainable Homes.

Exceeding the system boundary of the assessed building and its immediate surroundings this issue tries to arouse awareness for comprehensive relations and climate protection measures (local food provision).

Energy-relevant information related to the building itself are detailed information about the building’s energy performance, the fixed building services and their maintenance in order to guarantee energy-efficient operation widely free of defects and to be maintained at a reasonable level within the lifecycle. Instructions which are easy to understand for householders shall be provided next to the relevant building services comprising the making of seasonal adjustments to control settings and what routine maintenance is needed. Details of the EU labelling scheme for white goods, high efficacy light fittings and lamps and possible energy savings are required, too.

Nitrogen Oxide (NO_x) emissions

Impacts associated with heating systems (for space heating and domestic hot water) are additionally assessed within the main category “Pollution (Pol)” under “reduction of NO_x emissions to the atmosphere (Pol2)”. The rating refers to dry NO_x levels[27] and/or boiler class of the primary and any secondary heating systems.

No credits are awarded for open flue heating or hot water systems, the maximum of credits where all space heating and hot water energy requirements are fully met by systems which do not produce NO_x emissions or the dry NO_x level is lower than 40 mg/kWh.
The emissions of heating systems based on electricity which is sourced from the national grid (e.g. electricity requirement for heat pumps) must be calculated with national NO_x factors.

Energy Use and CO_2-Emissions from Construction Site Activities

The objective of Management 3 (Man 3) criterion “Construction site impacts” is to lower the environmental impacts through construction site activities.

Besides the reduction of dust pollution, water pollution (ground and surface), water consumption on site and the responsible sourcing of site timber, a commitment to monitor, report and set targets for CO_2 production of energy use arising from site activities and from commercial transport to and from the site is suggested as one of several improvement measures.

To achieve 1 credit, two of the mentioned measures have to be implemented, to achieve 2 credits 4 of the mentioned measures have to be implemented.

The monitoring of the **energy use** must include:
- “Monthly measurements of energy use
- Appropriate target levels of energy consumption must be set and displayed (targets could be annual, monthly, or project targets)
- As a minimum, monitoring must include checking the meters and displaying some form of graphical analysis to show how actual consumption compares to the targets
- nomination of a responsible person for the monitoring and collection of data”

Site monitoring relating to **commercial transport** shall comprise:
- “The number of deliveries
- The mode of transport
- The kilometres/miles travelled for all deliveries
- Where applicable, calculation of CO2 emissions
- confirmation that “Construction Site Transport” ‘measures for traffic movements and distances’ (published April 2003) are met
- nomination of a responsible person for the monitoring and collection of data”

[27] Dry NO_x level comprises the NO_x emissions (mg/kWh) resulting from the combustion of a fuel at 0% excess oxygen levels.

Embodied Energy in Building Materials

The embodied energy in building materials is neither reflected within the energy section nor directly within the material categories.
The first criterion Mat 1: “Environmental Impact of Materials” assesses only impact categories (e.g. Global Warming Potential, Ozone Depletion Potential, Human Toxicity, Ecotoxicity to Water/Land, Nutrification Potential,..) and resource indicators such as water or mineral resource extraction. The consumption of renewable or non-renewable energy sources by production processes of building materials is not considered (for more details see chapter “Life Cycle Assessment (LCA)”).

GWP of insulations

Besides Green Guide rating of the building elements in Mat1, the **Global Warming Potential (GWP) of insulations** is rated separately under Pollution 1.
The credit must be withheld if one of the insulating materials (for roofs, walls, floors, hot water cylinder, pipe insulation, cold water storage tanks and external doors) uses substances which have a GWP ≥ 5 kg CO_2-equiv./kg. This requirement concerns foamed thermal and acoustic insulating materials manufactured outside the EU as such substances are prohibited within the Member States.

7.6. LEED rating systems (LEED for Homes / LEED-NC v2009)

The LEED rating systems are designed for rating new and existing commercial, institutional, and residential buildings. Each rating system is organized into 5 environmental categories: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, and Indoor Environment Quality. An additional category, Innovation in Design, addresses sustainable building expertise as well as design measures not covered under the 5 environmental categories. Regional bonus points are another feature of LEED and acknowledge the importance of local conditions in determining best environmental design and construction practices.

LEED® for Homes which is only applicable for small residential buildings (up to three storeys) assesses energy-related indicators under the main category “Energy and Atmosphere EA”.

There are two different pathways to show compliance with the requirements:

- “energy performance approach”: ENERY STAR®[28] labelled house (EA1.+EA7.+EA11.) or
- “prescriptive approach”: comprising individual measures and including all prerequisites of EA2.-EA10

Energy performance approach:

- EA1. Optimize Energy Performance:

[28] ENERGY STAR is a government-industry partnership managed by the U.S Environmental Protection Agency and the U.S. Department of Energy. The program’s website offers energy management strategies, benchmarking software tools for buildings, product procurement guidelines, and lists of ENERGY STAR-qualified products and buildings. http://www.energystar.gov

  - EA1.1. Performance of ENERGY STAR® for Homes (prerequisite, no additional points)
  - EA1.2. Exceptional Energy Performance: exceeds ENERGY STAR for Homes, depending on climate zone and percentage of HERS-Index[29] value (up to 34 points)
- EA 7. Water Heating
  - EA 7.1. Efficient Hot Water Distribution (2 points)
  - EA 7.2. Pipe Insulation (1 point): All domestic hot water piping shall have R-4 insulation.
- EA 11. Residential Refrigerant Management
  - EA 11.1. Refrigerant Charge Test (prerequisite): for all air conditioning systems (unless home has no mechanical cooling system)
  - EA 11.2. Appropriate HVAC Refrigerants (1 point): no use of refrigerants or use of non-HCFC-refrigerants or refrigerants with low GWP (Global Warming Potential) or low ODP (Ozone Depletion Potential)

For achieving EA1.1 prerequisite performance requirements of ENERGY STAR for Homes 2006[30], including third-party inspections, must be met.

<u>Prescriptive approach:</u>

Within the prescriptive approach a series of individual measures for the improvement of the overall energy performance has to be fulfilled (the measures are to some extent obligatory prerequisites such as basic insulation, reduced envelope leakage, good windows, reduced distribution losses from heating and cooling systems, good HVAC design and installation, ENERGY Star lights, refrigerant charge test).

Additional points can be earned through enhanced insulation, greatly reduced or minimal envelope leakage, enhanced or exceptional windows, greatly reduced or minimal distribution losses, high or very high efficiency HVAC, efficient hot water distribution, pipe insulation, efficient domestic hot water equipment, improved or advanced lighting, high-efficiency appliances (ENERGY Star labelled refrigerators, ceiling fans, dishwashers, clothes washers), water-efficient clothes washer, appropriate HVAC refrigerants. Design and installation of a

[29] Ratings provide a relative energy use index called the HERS Index.. "The HERS Index is a scoring system established by the Residential Energy Services Network (RESNET) in which a new home built to the specifications of the HERS Reference Home (based on the 2006 International Energy Conservation Code) scores a HERS Index of 100, while a net zero energy home scores a HERS Index of 0. (An existing typical home scores 150). The lower a home's HERS Index, the more energy efficient it is in comparison to the HERS Reference Home. Each 1-point decrease in the HERS Index corresponds to a 1% reduction in energy consumption compared to the HERS Reference Home." Reference: http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_HERS

[30] The performance requirements of Energy Star for Homes 2006 are published on the EPA website and include:
1) HERS (Home Energy Rating System) Index of 80 or lower in climate zones 6-8 or HERS Index of 85 or lower in climate zones 1-5.
2) completed Thermal Bypass Inspection Checklist, including slab-edge insulation in climate zones 4+.
3) duct leakage of less than 6 CFM to outdoors per 100 sq. ft.
4) at least one Energy Star qualified product (heating or cooling equipment; windows; 5 or more labeled light fixtures, appliances, or ventilation fans).
5) indoor and outdoor coils must be matched, in accordance with AHRI standards;
6) adaptive recovery for any programmable thermostats installed in homes with a heat pump.
7) maximum oversizing limit for air conditioners and heat pumps is 15% (with the exception of heat pumps in Climate Zones 5-8, where maximum oversizing is 25%).

Energy Star for Homes does not allow projects to meet the minimum HERS Index with renewable power systems. However, solar thermal domestic hot water systems may be used to meet the minimum HERS Index requirement.

renewable electricity generation system is awarded up to 10 points (of 38 possible energy points) depending on the percentage of the annual reference electrical load met by this system (1 point per every 3%).

The following examples shall illustrate the energy performance standard of LEED for Homes:

Example “Basic and enhanced insulation”

- Basic insulation must meet or exceed the R-value requirements of Chapter 4 of 2004 IECC[31] (International Energy Conservation Code).
- Enhanced insulation exceeds R-value requirements of Chapter 4 of 2004 IECC by at least 5%.

IECC 2004, Selected U-factors in SI units [W/(m²K)]

Climatic Zone	Ceiling	Wood Frame Wall	Massive Wall	Floor	Basement Wall	Crawl Space Wall
1	0.20	0.47	1.12	0.36	2.04	2.71
2	0.20	0.47	0.94	0.36	2.04	2.71
3	0.20	0.47	0.80	0.27	2.04	0.77
4 (except Marine)	0.17	0.47	0.80	0.27	0.34	0.37
5 (and Marine 4)	0.17	0.34	0.47	0.19	0.34	0.37
6	0.15	0.34	0.34	0.19	0.34	0.37
7 and 8	0.15	0.32	0.32	0.19	0.34	0.37

Source: Laustsen, J.; Energy Efficiency Requirements in Building Codes, Energy Efficiency Policies for New Buildings (IEA InformationPaper in Support of the G8 Plan of Action, March 2008), p. 44

IECC 2004, Climatic zones

Zone number	Thermal Criteria IP Units	SI units
1	9000 < CDD50℉	5000 < CDD10℃
2	6300 < CDD50℉ ≤ 9000	3500 < CDD10℃ ≤ 5000
3A and 3B	4500 < CDD50℉ ≤ 6300 and HDD65℉ ≤ 5400	2500 < CDD10℃ ≤ 3500 and HDD18℃ ≤ 5400
4A and 4B	CDD50℉ ≤ 4500 and HDD65℉ ≤ 5400	CDD10℃ ≤ 4500 and HDD18℃ ≤ 5400
3C	HDD65℉ ≤ 3600	HDD18℃ ≤ 3600
4C	3600 < HDD65℉ ≤ 5400	3600 < HDD18℃ ≤ 5400
5	5400 < HDD65℉ ≤ 7200	5400 < HDD18℃ ≤ 7200
6	7200 < HDD65℉ ≤ 9000	7200 < HDD18℃ ≤ 9000
7	9000 < HDD65℉ ≤ 12600	9000 < HDD18℃ ≤ 12600
8	12600 < HDD65℉	12600 < HDD18℃

[31] IECC = International Energy Conservation Code 2004. “IECC 2004 is a model building code or standard for energy efficiency of new buildings. It was devised by the International Code Council (ICC), and is based on US conditions and traditions for energy efficiency regulation. The code IECC 2004 sets rules for residential (with less than 4 floors) and for small and less complicated commercial buildings while it contains a reference for the ASHRAE for large and complex buildings. Rules are based on climatic zones, which are set based on cooling degree days CDD and heating degree days HDD and some humidity conditions. In general, the US is split into 8 different zones, based on the level of cooling and heating. Some humidity conditions divide the zones into dry, humid and marine areas. Rules are set as prescriptive values for building parts, heating and cooling systems, ventilation and lighting. Insulation requirements are set as R-values or U-factor where U = 1/R for each climatic zone separately. These values have to be fulfilled for each building part in the prescriptive model. …
IEEC also includes a trade-off model where some parts can be made with less energy efficiency as long as the total building still fulfils the same overall requirements which would be the result of fulfilling each single demand. .. The prescriptive model is described as Mandatory Requirements, while the trade-off model is referred to as Performance Based requirements.” Laustsen, J.; Energy Efficiency Requirements in Building Codes, Energy Efficiency Policies for New Buildings (IEA InformationPaper in Support of the G8 Plan of Action, March 2008)

CDD…Cooling Degree Days, HDD…Heating Degree Days

Source: Laustsen, J.; Energy Efficiency Requirements in Building Codes, Energy Efficiency Policies for New Buildings (IEA InformationPaper in Support of the G8 Plan of Action, March 2008), p. 44

Example: Air Infiltration (reduced envelope leakage)[32]

IECC climate zones		1 - 2	3 - 4	5 - 7	8
US unit [Ach50 – value for air change at 50 Pa]					
Reduced envelope leakage (mandatory)	[Ach50]	7.0	6.0	5.0	4.0
Greatly reduced envelope leakage (optional)	[Ach50]	4.0	4.25	3.5	2.75
Minimal envelope leakage (optional)	[Ach50]	3.0	2.5	2.0	1.5

For comparison: the German passive house standard defines 0.6 Ach50 as mandatory value for the airtightness of the thermal building envelope. DIN 4108-7[33] requires 3.0 Ach50 for new buildings (without mechanical ventilation systems) and 1.5 Ach50 for new buildings (with mechanical ventilation systems). Measurements have to be made in compliance with EN 13829[34].

Example Windows: ENERGY STAR requirements for windows and glass doors[35]

ENERGY STAR zone		Northern	North Central	South Central	Southern
		Mostly Heating	Heating & Cooling	Heating & Cooling	Mostly Cooling
US units: U-factor (whole window, including glazing, frame and spacers) [Btu/(ft^2·F·h)][36]					
Good windows	U-factor	<= 0.35	<= 0.40	<= 0.40	<= 0.55
Enhanced windows	U-factor	<= 0.31	<= 0.35	<= 0.35	<= 0.55
Exceptional windows	U-factor	<= 0.28	<= 0.32	<= 0.32	<= 0.55
SI units: U-factor (whole window, including glazing, frame and spacers) [W/(m^2K)]					
Good windows	U-factor	<= 1.99	<= 2.27	<= 2.27	<= 3.12
Enhanced windows	U-factor	<= 1.76	<= 1.99	<= 1.99	<= 3.12
Exceptional windows	U-factor	<= 1.59	<= 1.81	<= 1.81	<= 3.12

As triple glazings (in highly insulated frames) can reach U_W-values of ≤ 0.15 Btu/(ft^2·℉·h) or lower (corresponding to an U-value of 0.8 W/m^2K), the highest requirements of LEED for Homes for exceptional windows exceed this value approximately twice (0.28 Btu/(ft^2·℉·h) or 1.59 W/(m^2K)).

[32] Source: LEED® for Homes Rating System, Version 2008 including corrections, clarifications and new exemplary performance rulings (ed. U.S. Green Building Council, January 2010), p.61, table 17

[33] DIN 4108-7 (2009 – Normentwurf): Wärmeschutz und Energie-Einsparung in Gebäuden - Teil 7: Luftdichtheit von Gebäuden, Anforderungen, Planungs- und Ausführungsempfehlungen sowie –beispiele

[34]ON EN 13829 (2001- 05-01) Wärmetechnisches Verhalten von Gebäuden - Bestimmung der Luftdurchlässigkeit von Gebäuden - Differenzdruckverfahren (ISO 9972:1996, modifiziert)

[35] Source: LEED® for Homes Rating System, Version 2008 including corrections, clarifications and new exemplary performance rulings (ed. U.S. Green Building Council, January 2010), p.63, table 18

[36] In US costumary units, the U-values are given in BTU/(ft^2·℉·h) (BTU..British Thermal Unit, ft ….feet, F … Fahrenheit, h…hour,). Conversion factor: 1 BTU/(ft^2·℉·h) = 5.678 W/(m^2K).

The primary energy requirement of the building including all upstream processes of energy generation and raw materials extraction for the delivery of energy are not considered in “LEED for Homes”.

Greenhouse gas emissions from energy processes (for the operation of buildings – heating, ventilation, cooling, etc.) are not explicitly assessed. Corresponding LCA indicators are only considered in conjunction with the use of non-HCFC-refrigerants or refrigerants with low GWP (global warming potential) and/or ODP (ozone depletion potential) for HVAC-systems and renewable **electricity** generation systems. Optimisation measures are restricted either to the main causes of pollutant emissions (HCFC, products with high GWP and/or ODP) or to electricity applications and therefore offer only a limited range of possible further measures (use of renewable energy for heating, hot water preparation, passive cooling systems, night venting, etc.)

An overall assessment of the whole lifetime from cradle to grave or cradle to cradle (including energy for the production of materials, the construction process, maintenance and refurbishment cycles and disposal or re-use at the end of life-time) is not included in LEED.

LEED for Homes’ energy criteria will be revised till 2012, following the new ENERGY STAR for Homes Version 3 (edited in 2011).

LEED-NC v2009

The more comprehensive criteria catalogue of LEED-NC v2009 which is primarily applicable for commercial and institutional buildings and high-rise residential buildings of all sizes deepens the energy indicators.
Additionally, the commissioning of building energy systems and the implementation of a measurement and verification (M&V) plan (including meter specifications) are required for more complex buildings (compared to single-family houses and small residential buildings up to three storeys). The period of measurement and verification must cover at least 1 year of post-construction occupancy and corrective actions have to be taken if the energy savings are not being reached.

Renewable Energy Sources

Furthermore, the use of green power is awarded which means that the grid-source is based on renewable energy technologies on a net zero pollution basis. At least 35% of the building’s electricity must be provided from on- or off-site renewable sources (all purchases shall be based on the quantity of energy consumed, not the cost) and the energy contract has to last a minimum of two years. The renewable energy (e.g. solar, water, wind, biomass, and geothermal sources) must be certified as green by the Green-e Energy program or its equivalent (http://www.green-e.org).

Contrary to LEED for Homes, credits can also be earned for energy produced from on-site renewable sources as a percentage of the building’s annual energy cost, the range of assessment starts from 1% up to 13% renewable energy from on-site sources (which means “located within the project site”). A higher percentage than 13% (besides green power) does not earn more points. Best level could be more ambitious as European building assessment systems already refer to nearly-zero energy buildings or plus energy buildings (see EU Eco-Label).

Operational Energy

Demonstrate a percentage improvement of the building's energy performance compared with the baseline building performance rating referring to Annex G of ASHRAE Standard 90.1-2007 (range of assessment: 1 point for 12% energy cost savings, 19 points (max.) for 48% energy cost savings). All energy costs within and associated with the building project (process energy, service water heating for domestic or space heating purposes, interior and exterior lighting, air-conditioning, ventilation) have to be included.

Energy and Atmosphere EA		
Prereq 1	Fundamental Commissioning of Building Energy Systems	
Prereq 2	Minimum Energy Performance	
Prereq 3	Fundamental Refrigerant Management	
Credit 1	Optimize Energy Performance	1 to 19
Credit 2	On-Site Renewable Energy	1 to 7
Credit 3	Enhanced Commissioning	2
Credit 4	Enhanced Refrigerant Management	2
Credit 5	Measurement and Verification	3
Credit 6	Green Power	2
EA	Possible points EA (of 110 total points)	35

32% (35 of 110 total points) can be awarded within the category Energy and Atmosphere.

Embodied energy (production stage)

Embodied energy in building materials is not explicitly calculated but is intended to be reduced by resource criteria such as building reuse (maintain existing walls, floors and roof), materials reuse, recycled content, rapidly renewable and regional materials.

Traffic-related Energy Aspects

The reduction of individual traffic is not an issue for small residential buildings (within LEED for Homes) whereas LEED-NC 2009 (for high-rise residential buildings) evaluates alternative transportation under Sustainable Sites SS Credit 4.1.-4.4 (divided into public transportation access, bicycle storage and changing rooms, low-emitting and fuel-efficient vehicles and parking capacity). Parking capacity shall meet but not exceed local zoning requirements.

7.7. DGNB

Draft Criteria – residential buildings (May 2010)

DGNB offers the most comprehensive LCA view of all systems (although some materials, especially for HVAC systems and some stages of lifecycle (transport to and from site, construction process on-site, reuse at the end of lifetime – cradle to cradle) are not taken into account.

Energy-related indicators are the following:

Energy demand (primary energy non-renewable) within life-cycle[37]

One sub-criterion of "Ecological Quality" is the primary energy demand for construction, operation and disposal of the building assessing the use of non-renewable resources.
In addition to the construction materials for the building envelope and interior completion, heating systems are balanced whereas heat distribution and dissipation systems as well as further building services installed are excluded from the ecobalance. The operation phase comprises maintenance and renovation as well as supply with energy carriers within a period of 50 years[38] . For disposal, the following material groups are taken into account: metals, mineral building materials, materials with heating value, heat generation systems, materials disposable to construction waste landfills or household garbage dumps.

This life cycle assessment of the building is not only limited to resource indicators but is also required for selected impact categories such as global warming, ozone depletion, photochemical ozone creation, acidification, nutrification, and risks for the local environment.

Share of renewable resources[39]

The system boundary is the same as mentioned above. Renewable resources are biomass systems, solar hot water, photovoltaic, geothermal resources, hydro power, wind turbines, secondary fuels (e.g. tyres, waste oil, waste plastics), waste incineration.

Within the main category Economic Quality the life cycle approach is extended to Life Cycle Cost (LCC).

Traffic-related Energy Aspects

The site quality is not included in the final grade but is presented separately.
Emissions from individual traffic are not directly assessed. Access to public transport and cycle paths is evaluated by following indicators: time to reach the next (main) railway station via footpaths (assessment ranges from less than 3 minutes till 40 minutes as minimum requirement), access to the next public transport (bus, local train, tramway) (urban: 1 till 5 minutes; rural: 2 till 10 minutes), site connection to cycle and footpaths (direct connection, average access). The quality of public transport (timetables) is not yet included, but will be integrated in future versions.
Infrastructure criteria relate to proximity (300 - 1000m) of restaurants, shops, parks, educational and community services, medical care, leisure facilities.

[37] Steckbrief 10, Source: DGNB – residential buildings (Draft, May 2010)
[38] In the DGNB criteria for residential buildings (draft version May 2010), the expected life-time has been derived from office buildings, but may be even higher due to less changes in utilization and longevity of construction materials. In ON EN 15804 "Sustainability of construction works – Environmental product declarations – Product category rules"; the period of consideration is extended to 100 years.
[39] Steckbrief 11, Source: DGNB – residential buildings (Draft, May 2010)

7.8. TQB

TQB assesses the energy performance of a building (during operation phase) within the main category “Energy and Water” which is weighted by 20% within the overall criteria catalogue.

Operational Energy

The energy section within TQB is based on indicators complementing and building on each other. Possible redundancies are adjusted by the means of reduced weighting scores.
The indicators assessed are the following:

C1. Energy need for building operation

Option 1:

C1.1. Annual heating energy need (35 points)
C1.2. Annual final energy need (delivered energy) (30 points)
C1.3. Airtightness of the building envelope (10 points)
C1.4. Free of thermal bridges (10 points)

Option 2:

Optional to C1.1.-C1.4.: If the building is certifiable in accordance with the guidelines of the Passive House Institute Darmstadt, the highest score for C1.1. to C1.4. can be achieved by showing compliance with the requirements of PHPP (Passive House Planning (Design) Package)[40].

C2. Primary Energy / CO_2-Emissions (building operation)

C2.1. Annual Primary Energy Requirement (non-renewable) (65 points) or optional
C2.1a Use of renewable energy sources for space heating (25 points)
C2.1b Domestic hot water (solar collectors/heat pumps, insulation of buffer store, warm water connection for washing machines/dish washers) (20 points)
C2.1c Photovoltaic (10 points)
C2.1d Energy-efficient mechanical ventilation system (5 points)
C2.1e Energy-efficient lighting (5 points)

C2.2. CO_2-Emissions (building operation) (20 points)

Besides the main indicators, heating energy demand and final energy demand including the losses of transmission, ventilation, solar and internal gains and losses/gains of the building services, special attention is paid to thermal bridges and airtightness.
Rating starts with fulfilment of the actual Building Regulation requirements (2010 level). The highest level is defined by 10 $kWh/m^2_{conditioned\ gross\ floor\ area}$a heating energy need referring to the national calculation methodology (OIB-Guideline 6[41]). Final energy need [42] shall undercut the

[40] http://www.passivhaustagung.de/Passive_House_E/PHPP.html
[41] OIB Richtlinie 6: Energieeinsparung und Wärmeschutz (Hg.v. Österreichischen Institut für Bautechnik, Wien, April 2007) www.oib.or.at
Leitfaden Energietechnisches Verhalten von Gebäuden (Hg.v. Österreichischen Institut für Bautechnik, Wien, April 2007)
Erläuternde Bemerkungen zu OIB-Richtlinie 6: „Energieeinsparung und Wärmeschutz“ und zum OIB-Leitfaden „Energietechnisches Verhalten von Gebäuden“ (Hg. v. Österreichischen Institut für Bautechnik, Wien, April 2007)
[42] Final energy need or delivered energy is calculated in correspondence with ON H 5055 - ON H 5059.

energy need of a reference building by 5% (as minimum requirement) and by at least 80% (as highest level).
Free of thermal bridges respectively poor in thermal bridges is defined as follows: the average U-value of the conditioned building envelope may not raise more than 0.0 W/m²K [43] or 0.05 W/m²K by the influence of thermal bridges.
For buildings with mechanical ventilation a minimum air leakage rate of 1.5 per h (in case of heat recovery 1.0 per h) is required (at 50 Pascal overpressure or negative pressure).

Pathway 2 follows the guidelines of the Passive House Institute Darmstadt for certified buildings (heating energy demand <= 15 $kWh/m^2_{net\ floor\ area}a$; airtightness n_{50} <= 0.6 1/h, primary energy demand <= 120 kWh/m²a including all HVAC-systems and domestic appliances)

As long as national primary energy factors have not been published, the calculation of the primary energy demand and CO_2 emissions may either refer to the primary energy and CO_2 factors cited in ON EN 15603: 2008[44] or a simplified procedure is applicable by assessing individual measures (C2.1a –C2.1e).
The latter pathway awards high energy-efficient lighting and ventilation systems and the use of renewable energy sources for different appliances (space heating, hot water, power generation) taking into account the following systems: solar hot water, photovoltaics, biomass heating systems, heat pumps, Combined Heat and Power (CHP), district/community heating utilising mainly waste heat and/or heat from garbage incineration and/or are mainly based on biomass systems.

Category “B.1. Economic Quality and LCC” continues on an advanced level the life cycle approach and transfers material and energy data (gained from analyses within section C and E) into Life Cycle Costs, but it offers also a simplified method to assess design quality and the economic performance of a building (by checklists screening the design process and the expected operational costs).

Embodied Energy in Building Materials

The main section “E. Resource Efficiency” enables a direct rating of the embodied (non-renewable) energy by means of an LCA-indicator called OI3 comprising PE-, GWP- and AP-data of building materials and aggregating these data to a single performance score of the building. The indicator includes construction phase as well as renovation cycles within the lifecycle. The phase of removal is assessed by a so-called “disposal indicator”. The OI3 indicator as well as the disposal indicator is limited to construction materials, but the resource consumption for all type of building services is easy to complement as soon as appropriate standardised data to HVAC systems and electrical installations are available.

[43] The influence of two- or three-dimensional thermal bridges on the heating demand is determined by correction factors to the U-value of “undisturbed” construction elements. Negative thermal bridges can occur e.g. in case of highly-insulated outside-wall-corners. Negative correction factors reduce the effect of positive heat bridges on the overall result of the heating demand.
[44] ON EN 15603 (2008-07-01) Energieeffizienz von Gebäuden - Gesamtenergieverbrauch und Festlegung der Energiekennwerte

The requirement for regional products (at least for the heaviest masses of the building such as concrete, reinforcement steel, etc.) shall decrease the transport emissions to and from site whereas “reused and recycled materials” lower the resource consumption of the building.

Traffic-related Energy Aspects

Energy related aspects can also be found under “Infrastructure and Amenities” where numerous measures for reducing individual motorised traffic (from site selection, quality of local facilities, access and quality of public transport, cycle facilities and amenities of the building and dwellings) are assessed.

7.9. Summary and Conclusions Energy and CO_2-Emissions

Summary

Operational Energy

The detailed examination of energy indicators used for environmental or sustainable assessment of (small) residential buildings reveals that the heating energy demand has been replaced by CO_2 emissions and/or primary energy as key indicators for rating the energy performance of a building during the operation phase. Assessment is often not based on an absolute rating scale. Several systems refer at least partially to reference buildings constructed in accordance with the (national or regional) building regulations’ energy requirements and/or reference building services (CSH: Dwelling Emission Rate, LEED for Homes: HERS Index, TQB: final energy improvement compared to reference building[45], DGNB: PE and GWP reference values[46]). The base of comparison as well as the potential of enhancement may differ depending on the HVAC systems installed.

Considered indicators and life phases

Most of the analysed environmental or sustainable building assessment systems for (low-rise) residential buildings refer to either primary energy and/or CO_2 emissions as main indicators assessing the energy performance of a building or a building unit. In most cases, the system boundary is limited to the phase of operation till now.

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[45] defined in OIB-Richtlinie 6 and ÖN H 5056: 2010
OIB-Richtlinie 6: Energieeinsparung und Wärmeschutz (Hg. vom Österreichischen Institut für Bautechnik, OIB-300.6-038/07, Ausgabe 2007)
Erläuternde Bemerkungen zu OIB-Richtlinie 6 „Energieeinsparung und Wärmeschutz“ und zum OIB-Leitfaden „Energietechnisches Verhalten von Gebäuden“ (Hg. vom Österreichischen Institut für Bautechnik, OIB-300.6-038/07-001, Ausgabe 2007)
ON H 5056: 2010: Gesamtenergieeffizienz von Gebäuden - Heiztechnik-Energiebedarf (Hg. vom Österreichischen Normungsinstitut, 2010)

[46] calculated in accordance with the reference building’s requirements of DIN V 18599/EnEV 2009.
DIN V 18599: Energetische Bewertung von Gebäuden – Berechnung des Nutz-, End- und Primärenergiebedarfs für Heizung, Kühlung, Lüftung, Trinkwarmwasser und Beleuchtung. DIN Deutsches Institut für Normung e.V. Berlin: Beuth Verlag, 2007
Verordnung über energiesparenden Wärmeschutz und energiesparende Anlagentechnik bei Gebäuden (Energieeinsparverordnung – EnEV) vom 24.Juli 2007 in Verbindung mit: Verordnung zur Änderung der Energieeinsparverordnung vom 29. April 2009. Bundesgesetzblatt Jg. 2009 Teil I Nr. 23, S. 954-989.

Only one of the analysed assessment systems (DGNB) has implemented an approximately[47] comprehensive LCA view (from cradle to grave) using two core indicators for an energy-related life cycle assessment (non-renewable primary energy and percentage of renewable resources). A life cycle assessment with the same system boundary is additionally required for the following impact categories: global warming, ozone depletion, photochemical ozone creation, acidification, nutrification, risks for the local environment. Separate rating for operational energy alone or other preliminary stages is not intended. It is questionable if the high effort on producing LCA leads to a higher information content of the assessment results since fuzziness due to faulty data quality or questionable assumptions for allocation and scenarios or mistakes because of neglected post-consumer recycling may be high.

TQB considers all phases within the lifecycle of a building (from production and transport of materials, construction activities on site, operation and maintenance till disposal at the end of lifetime), but does not summarize all phases to single core indicators such as PE (e.g. disposal is not summarized in the LCA-indicator OI3, but assessed separately; construction site management includes recommendations instead of rating the energy consumption on site) due to emphasize necessary optimisation steps and to lay the attention to critical materials or weaknesses in conventional construction methods. A recent study has shown that the overall assessment of e.g. POCP (over the whole life cycle) may not stringently lead to those materials which are responsible for the environmental impact due to their low percentage on the total mass (LIPP, 2009)[48]. Therefore, they are often neglected in a life cycle assessment of complex systems like buildings.

BREEAM based schemes (like CSH) as well as LEED for Homes do not explicitly assess embodied energy in construction materials, but include indirect rating via different resource indicators as shown above.

SBTool's criteria assessing primary energy non-renewable and GHG emissions are divided into "embodied in building materials" (initial construction phase) and "from facilities operation". Maintenance and refurbishment within the lifecycle are not explicitly taken into account.

Traffic-related Energy Consumption

All analysed systems provide a descriptive qualitative rating (proximity to public transport and commercial facilities, easy access to recreation areas, quality of cycle pathways and cycle storage on-site, distance to employment centres,…) instead of a quantitative rating of the expected energy consumption or CO_2 emissions from individual motorised traffic (during operation). At least one system (SB-Tool) extends its rating even to public initiatives of communities.

[47] Material inputs for building services are limited to heat generation systems, and the processes of construction and disposal activities on site are not taken into account. Materials which comprise more than 1% of the total mass or contribute to more than 1% of the impact assessed have to be balanced, all other materials may be neglected.
[48] „Das POCP eines Gebäudes wird am besten direkt über die Vermeidung von Lösemitteln in den Bauprodukten bewertet, optimiert und reduziert."

Table 15: Indicators concerning “Energy and CO_2 Emissions” in the considered building assessment systems

		EU Ecolabel	SBTool	CSH (BRE)	LEED for Homes	DGNB	TQB
Main parameters	PE non renewable	● (1)	●			●	●
	PE renew. / Share of ren. sources	●	●			●	●
	CO_2 emissions		●	●		●	(●)(2)
Lifecycle Stages	Production process	● (7) (8)	●	(6)		●	●
	Construction on-site	● (7)					
	Operational Energy	● (1)	●	●	●	●	●
	Maintenance/Refurbishment	● (7)	(●)			●	●
	Disposal	● (7)	(3)			●	(3)
Subordinat. Paramet	Heat Loss Parameter / U-values			●	●		
	Heating Energy Need						●
	Final (delivered) Energy				●		●
Complem.ents	Individual Measures (4)		●	●	●		●
	Domestic Electr. Appliances(5)			●	●		(●only PH)

(1) only for heating purposes (comprises renewable and non-renewable energy sources or is not definitely restricted to non-renewable ones)
(2) CO_2 emissions will be integrated after implementation of national calculation method
(3) Disposal phase is taken into account but not through energy or CO2-related indicators.
(4) e.g. lighting, insulation of HVAC systems, energy-efficiency of ventilation systems, etc.
(5) (information on) labelled white goods or calculation method including efficiency of domestic appliances
(6) only indirect parameters (Green Guide Rating refers to GWP amongst other impact categories, but does not include embodied energy…)
(7) optional criterion: Building LCA according to ISO 14040 or CEN/TC 350 - prEN 15978 without benchmarks
(8) Energy / CO_2 embodied in materials / products (optional criterion),

Conclusions and recommendations

Operation phase

Highly aggregated results such as CO_2 emissions or primary energy demand – especially when summarized over the whole life cycle may lead to losses of important interim results and optimisation steps which are more relevant to target groups of building rating systems. End-consumers for example need comprehensible and sufficiently accurate information of the energy efficiency of both, building envelope and HVAC systems, and guidance which energy carriers are environmentally-friendly, secure and available at affordable costs.

Therefore, the following bottom-up approach is recommended:

f) Heating or – if more applicable for southern latitudes – cooling and heating energy demand (assessment of the building envelope, solar passive gains and passive cooling measures)

g) Delivered energy (assessment of the energy-efficiency of both envelope and HVAC systems)

h) Primary energy (restricted to the operational phase)

i) CO_2 Emissions (restricted to the operational phase)

j) NO_x Emissions, Particulate Matter (restricted to the operational phase)

a) Heating or – if more applicable for southern latitudes – cooling and heating energy demand

Apart from local climate conditions, heating energy demand is influenced by parameters that describe the thermal specifications of a building: average U-value, compactness, air-tightness of the building, avoidance of thermal bridges, ventilation losses, and passive solar gains, cooling energy demand by size of windows and passive cooling measures (like shading devices, thermal capacity of the building mass, night venting, etc.).
Individual measures (like reduction of heat loss parameters) are awarded in almost all sustainable building assessment systems[49] in order to focus on important optimisation strategies and to ensure that besides the efficiency of HVAC systems (see next section) the building itself meets defined quality requirements.
The authors try to avoid the rating of individual measures due to the complexity of regional and local specifics and market availability of components but recommend the assessment of the heating and cooling energy demand in addition to more comprehensive energy indicators like delivered or primary energy demand which are based on these basic figures (see sections b-e).
Because of the variety of calculation methods within the EU member states and the various main indicators used for energy performance certificates, a more consistent method is required for an EU Eco-label of buildings. Two options are possible:

[49] (apart from DGNB which uses highly aggregated indicators such as primary energy non-renewable or CO2-emissions over the whole life-cycle).

- referring either to EN ISO 13790[50] (in this case uniform calculation parameters have to be defined where national adaptations are allowed in principle[51] to guarantee the comparability of calculated figures for an EU-wide labelling of buildings)
- or the reference is the PHPP calculation method (Passive House Planning Package 2007) following the guidelines of the Passive House Institute Darmstadt.

Defining benchmarks for rating, an EU-wide Eco-label must not neglect regional climate conditions (heating/cooling degree days, solar radiation, etc.). A differentiation into at least three zones (cold, moderate and warm climate zones[52]) within Europe is recommended.

b) Delivered energy (including efficiency of HVAC systems)

The delivered energy <u>for each energy carrier</u> should be part of any consumer-oriented assessment system (rated in both absolute figures and in comparison to similar building services to be able to assess the energy efficiency of the system(s) installed). The delivered energy (defined as the final energy demand lowered by the gains of (solar) plants on the building site) is of significant relevance for the prospective buyer or tenant of a building or building unit. Energy costs are based on the delivered energy (to the building or building unit) including losses and gains of all HVAC systems installed (calculation is based on standardised conditions for user behaviour and climate and usually includes all energy services).

Power consumption for domestic appliances is not always included in the calculation methods of the final or delivered energy demand or, if taken into account, it is calculated only by default values as electrical appliances are usually not provided by the builders. However, home owners or tenants should at least be informed about the savings potential through energy-efficient domestic appliances (e.g. via energylabel, user guides, web links etc.).

c) Primary energy demand (restricted to the operational phase)

Delivered energy is an appropriate informative parameter for consumers but not sufficient as ecological key indicator for the whole energy consumption of the building sector. Important relevant energy generation processes are excluded from consideration. Energy scarcity and the upstream processes to generate energy delivered to the final consumer cannot be neglected. Therefore, it is necessary to include primary energy into a comprehensive building assessment method. Additionally, the authors recommend to rate renewable and non-renewable energy consumption separately, since availability and renewability of resources is an important ecological aspect. This can be done by rating the primary energy demand of non-renewable resources or by assessing both the total primary energy demand and the share of renewable resources.

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[50] EN ISO 13790: 2008 Energy performance of buildings - Calculation of energy use for space heating and cooling

[51] E.g. method of calculation (monthly balance/ heating (cooling) period balance, simplified or detailed hour-based simulation). internal gains from electrical appliances, etc. Climate data (heating degree days, solar radiation) and corresponding parameters (e.g. length of heating period) have to be defined regionally as consequence of methodology.

[52] Cold: above 4200 heating degree days, moderate: between 2200 and 4200 heating degree days and warm: below 2200 heating degree days per year (according to the study Boyano, A.; Wolf, O.; "Analysis and evaluation of 3rd draft criteria for Buildings and next steps: The application of the Ecolabel Regulation (EC66/2010) to Buildings: Draft Preleminary Study Task 1: Product Group Definition and Priorization Analysis of Previous Draft Criteria Studies (ed. JRC Institute for Prospective Technological Studies, October 2010)

Primary energy factors for different energy carriers (especially electricity and district heating with defined levels of production mix, e.g. >70%, > 50%, >35% Combined Heat and Power) must be consistent and based on the same datasource when assessing buildings within one rating system.

The highest level to achieve (zero energy/plus energy buildings) need clear distinction and a stringent definition of the balance boundaries (whether zero energy level will be achieved within a period of one year or at any time and renewable energy sources on-site/off-site are taken into account).

d) CO_2 Emissions (restricted to the operational phase)

Apart from causing emissions of pollutants such as SOx, NOx and particulate matter, energy generation and supply is one of the main sources of carbon-dioxide emissions thus contributing to man-induced greenhouse effect. Apart from industry production processes and transport, buildings are the main consumers of energy.
CO_2 based assessments of buildings will be inevitable in future taking into consideration the European environmental policy.

Not all member states have already implemented a CO_2 calculation method.
In this case the primary energy demand is acceptable as key indicator in order not to cause extra calculation expense. Where CO_2 indicators are already implemented it is recommended to add a rating for the CO_2 emissions for assessing the efficiency of climate protection measures in the building sector. [53]

e) NO_x emissions, Particulate Matter (restricted to the operational phase)

Minimum requirements for the NO_x and Particulate Matter emissions of the heating systems in regular operation shall be given in an EU-wide Eco-label for buildings.

Embodied Energy in Building Materials

The embodied energy in building materials shall be considered as a proxy indicator to assess the environmental performance of the building. For more details to lifecycle considerations see the following chapter "Life cycle assessment".

Traffic-related Energy Consumption

[53] Advantages and disadvantages of using CO_2 as key indicator for product rating (e.g. Product Carbon Footprint) are broadly discussed in the study "Quack, D.; Grießhammer, R.; Teufel, J.; Requirements on Consumer Information about Product Carbon Footprint (ed. Öko-Institut e.V. commissioned by ANEC, Freiburg, 2010)"

Transports to and from sites (for construction, refurbishment, and removal of buildings) are required in an overall LCA. They contribute to only 4% of the total embodied non-renewable primary energy over the whole lifecycle. An overall assessment of primary energy does not allow differentiation. Therefore, it is more effective to optimise the traffic-related energy consumption to and from site by indicators requiring the use of (low-emitting) vehicles with efficient diesel consumption than to limit the overall primary energy demand over the lifecycle.

8. LIFE CYCLE ASSESSMENT

8.1. Introduction

Scope

ANEC has commissioned several studies and already formed its opinion about LCA as well as its application in building assessment. Hence, the following chapter concentrates on the compilation of the main findings in the relevant studies and on recommendations concerning the use of LCA in building assessment systems.
A detailed analysis of the use of LCA in the existing building assessment systems is not carried out since LCA-methodology is clearly defined in ISO 14040 and 14044. The various building assessment systems differ concerning the used indicators, the considered life cycle stages and the weighting and benchmarking of the indicators. Besides, some findings about the use of LCA-indicators in building assessment systems were already listed in chapter "Energy and CO_2-emission".
Hence, we preferred relying the conclusions and recommendations concerning the use of LCA in building assessment systems on the following meta-studies (see also chapter "3.2 Background"):

- European Commission / Joint Research Centre: Environmental improvement potential of residential buildings (IMPRO-Building, 2008)
- European Commission / Joint Research Centre: Environmental Impact of Products (EIPRO). Analysis of the life cycle environmental impacts related to the final consumption of the EU-25 (EIPRO, 2006)
- ANEC / Öko-Institut, Ökopol: Environmental product indicators and benchmarks in the context of environmental labels and declarations (PRAKASH, REINTJES, 2008)

and on own experience with and knowledge of life cycle assessment of buildings.

(Very) short introduction to life cycle assessment (LCA)

Life cycle assessment (LCA) stands for "compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle" (ISO 14040). It is a technique to assess the environmental aspects and potential impacts associated with a product, process, or service, by:

- compiling an inventory of relevant energy and material inputs and environmental releases ("LCI - Life Cycle Inventory");

- evaluating the potential environmental impacts associated with identified inputs and releases ("LCIA - Life Cycle Impact Assessment");
- interpreting the results to help you make a more informed decision ("Interpretation").

LCA is standardised in ISO 14040 and 14044 and in more detail in "Life Cycle assessment: An operational guide to the ISO standards" (CML, 2001).

A methodology for the life cycle assessment of buildings shall be given by CEN TC 350 "Sustainability of construction works", sub-category "Assessment of environmental performance of buildings".

Characteristics of LCA are the quantification of environmental impacts and the aggregation over time and space. This leads to different indicators either direct from life cycle inventory (LCI) or from life cycle impact assessment (LCIA).

Indicators derived from LCI:

- Depletion of non renewable resources [kg Sb eq]
- Depletion of non-renewable resources other than primary energy [kg Sb eq]
- Depletion of non-renewable primary energy [MJ]
- Use of renewable resources other than primary energy [kg]
- Use of renewable primary energy [MJ]
- Use of freshwater resources [m^3]
- Non-hazardous waste to disposal [kg]
- Hazardous waste to disposal [kg]
- Nuclear waste (separate from hazardous waste) [kg]

Indicators expressed with the impact categories of LCIA

- Global warming potential (GWP) [kg CO_2-eq]
- Ozone depletion potential (ODP) [kg CFC-11 eq]
- Acidification potential (AP) [kg SO_2 eq]
- Nutrification potential (NP) [kg PO_4 eq]
- Photochemical ozone creation potential (POCP) [kg C_2H_4 eq]
- Emissions of radioactive isotopes [unit: kBq]

For other important environmental effects like loss of biodiversity, land use, toxicity, etc, no established scientific calculation model for quantification and aggregation of the impacts exists at the moment (or will never exist).

8.2. Background

EIPRO- and IMPRO-Report

The JRC report on "Environmental improvement potential of residential buildings" summarises the results of the "IMPRO - Building" project, which aimed to analyse the potential environmental IMprovement of PROducts in the field of housing.
IMPRO (2008) was carried out because the previous study, EIPRO (2006), had shown that the product category "Housing, furniture, equipment and utility use" made up 20 to 35 % of the (considered) impacts of all consumer products. In fact, room and water heating was one

of the most important contributors for each considered impact category. Residential structures also scored highly in most impact categories (3 to 4 % of all products). The next important products of the category "Housing, furniture, equipment and utility use" were energy-using domestic appliances, e.g. refrigerators and washing machines.

The IMPRO-study was meant to be a scientific contribution to the European Commission's Integrated Product Policy (IPP). The considered environmental impact categories were selected "based on scientific robustness, relevance and practicability" leading to the conventional LCA-indicators: acidification, eutrophication, climate change, ozone layer depletion, and photochemical pollution. The primary energy consumption was also quantified.

The study concentrated on residential buildings, including all relevant types of buildings used as household dwellings, from single-family houses to multi-apartment buildings, including existing and new dwellings in the EU-25. The environmental impacts were analysed for building structures and operation.

The (little surprising) results of the study concerning LCA of buildings were (IMPRO, page xvii – xviii):

- "The first finding […]" was "the similarity of trends shown over the different impact categories" reflecting "the important role of energy use in most of the environmental impacts quantified, first as a result of fuel combustion for space heating, and, second, as a result of the industry processes involved in the manufacturing of building products". "Consequently, both primary energy use and greenhouse gas (GHG) emissions are good proxy indicators to assess the environmental performance of the buildings."
- "The use phase of buildings, as dominated by the energy demand for heating is by far the highest for all buildings. For new buildings, the construction phase is also significant and its relative importance varies from one impact category to the other. The end-of-life phase is of much lower importance."
- "The use phase was also shown to be most important for new buildings with, however, a lower relative importance as a result of the better energy performance of these buildings. Regarding the new building construction phase, the impacts primarily stem from the construction of the exterior walls, the basement, and floors/ceilings. Interior walls, roof and windows only play a minor role."

The following improvement options for new and existing buildings were identified, focusing on use phase and construction phase:

- For **existing buildings** measures reducing the heating and infiltration losses were shown to be an "environmental hotspot" (IMPRO, page xxi).
- For **new buildings** the quantification of environmental improvement options has been limited to the impacts from the construction phase by changing the material composition of buildings. The results showed that significant environmental improvements could be expected only when "conventional" products like concrete, reinforced concrete, bricks were substituted by wood products. Precondition for this finding is that the wood is taken from a forest under sustainable management.

It has to be mentioned that obvious improvement options like the "new concepts of passive housing" and "zero CO_2 emissions buildings" were beyond the scope of the IMPRO-Building project. Furthermore HVAC (e.g. heating systems and cooling equipment/services, mechanical ventilation systems and building automation) were not considered “as they are not relevant for the identification of improvement options (p 22)” resulting in the exclusion of well-known improving options as for example the exchange of an old oil boiler.

ANEC / Öko-Institut, Ökopol: Environmental product indicators and benchmarks in the context of environmental labels and declarations

ANEC commissioned the Öko-Institut e.V. and Ökopol GmbH as subcontractor to conduct a research study on various issues related to environmental labels and declarations, which are of particular relevance to the consumers (PRAKASH, REINTJES et al, 2008). The issues involved: (a) the usefulness of life cycle assessment methodology for product labelling schemes, (b) feasibility of aggregation approaches, such as EcoGrade and Eco-indicator, for assessing the environmental performance of products, (c) inclusion of qualitative indicators not covered by the LCA-methodology, (d) the advantages and disadvantages of energy versus CO_2-indicators and (e) quality benchmarks for environmental data sheets.

According to ANEC (2010) the study shows that indicators based on Life Cycle Assessment (LCA) methodology may not be the best option to suitably characterise and declare the environmental performance of a product. LCA methodology offers unique advantages such as comparisons of system alternatives or providing orientation. However, it also suffers from serious limitations including omissions of many relevant environmental aspects (e.g. site-specific emissions such as noise, or non-quantifiable impacts such as biodiversity) and low accuracy and reliability of data. Hence, in many cases significant production or use phase indicators (e.g. energy efficiency, indoor emissions) derived from a variety of tools (e.g. chemical risk assessment) are a better choice for product labelling as these allow for differentiation of similar products compared to LCA indicators. A process for the identification of all relevant environmental aspects on a product by product basis, and involving all relevant stakeholders, is proposed.

The findings of PRAKASH, REINTJES et al (2008) are also a relevant basis for the recommendations below.

ANEC / FORCE Technology: Benchmarking and additional environmental information in the context of Type III environmental declarations

The study of SCHMIDT & POULSEN (2007) seeks to combine information of type III label with those of type I label. To point this out a so called “Environmental data sheet” (EDS) is introduced. An important feature of EDS is that it compares the LCA-results of the considered product to the “average” product within the product group and additionally between the product groups. For that reason the LCA-results are normalised using average annual environmental impact of a European citizen leading to the unit “milli Person Equivalents” (mPE). Of major importance as additional information in EDS is the potential compliance with ecolabel (e.g. European Ecolabel, Blue Angel, and Nordic Swan).

ANEC, 2009-1: “The Environmental Data Sheet concept, combining a product-specific selection of LCA indicators (for comparing different product categories) and indicators from other assessment tools in line with current ecolabelling practices, confirmed by this study, should be seen as the way forward and developed further."

Joint ANEC / ECOS comments on the ISO 14000 series review

A detailed critical review of the LCA / EPD approach and corresponding standards is given in the Joint ANEC / ECOS comments on the ISO 14000 series review, http://www.anec.eu/attachments/ANEC-ENV-2007-G-030final.pdf

8.3. Main findings of the studies

Incomplete coverage of environmental impacts

LCA can only account for issues which can be **quantified** and **aggregated** (summarised), such as energy consumption or greenhouse gases. Obviously many important environmental impacts are not quantifiable in a meaningful way, e.g. biodiversity. Or in case of quantitative indicators, such as noise, it might be better to build a separate (individual) category for them, without trying to aggregate them with other impacts e.g. to a human-toxicity indicator. Many impacts should not be aggregated as they are site-specific or depend on local concentrations of pollutants rather than on total life cycle releases (e.g. noise, dust, or indoor air pollution). These impacts may also depend on local conditions (e.g. water consumption in dry areas versus wet areas).
PRAKASH, REINTJES et al, 2008 (page 6): "The disregard of site-specific aspects is of conceptual nature and based on the fact that LCA seeks to aggregate environmental impacts over the whole life cycle of products."
Furthermore, some cause-effect relationships are not simple enough or sufficiently known with enough precision to permit quantitative **cause-effect modelling**. In such cases, it will be easier to work with qualitative and semi-quantitative indicators because the results are presented in a disaggregated way. In other cases **potential impacts** should be avoided following the precautionary principle (e.g. CMR-substances in building materials).

When such impacts are of significant environmental importance, their coverage becomes a **key requirement** for achieving the overall goal of environment assessment. Hence, LCA cannot replace other product specific assessment methodologies but can only accompany them.

PRAKASH, REINTJES et al, 2008 (page viii): "It is recommended to focus on different instruments, such as environmental impact assessment, chemical risk assessment etc. for measuring the non-LCA-indicators. The characterisation models in such cases would be rather formalised and not mathematical operationalisation of the environmental mechanisms. There may be a basic aggregation step, bringing text or qualitative inventory information together into a single summary, and/or summing quantitative inventory data within a category."

Correlation between LCA-indicators

As it was clearly shown in IMPRO (2008), LCA indicators correlate with energy consumption. This is especially true on building level where specific characteristics of building materials are averaged. But also on building material levels the indicators correlate in most cases perfectly with energy. Some exceptions:

- Higher POCP-values are often found together with plastics, but they are low compared to POCP-values caused by e.g. solvent-based bitumen-coatings. It's much easier to avoid products containing VOC than to calculate the POCP-value of the building (LIPP, 2009).
- The production of metals like copper causes relatively high values in the acidification potential.
- During the production of cement clinker CO_2 is released from limestone while sintering, resulting in a considerable global warming potential (GWP). This is also true – even though in a lesser extent – when limey clay is burned in brick plants.
- Depending of the system borders the CO_2-uptake of wood during photosynthesis can be credited.
- Ozone depletion is not correlated with energy but with the release of (forbidden) ozone depleting substances. ODP is only of relevance in connection with old insulation material where it can be better handled by operation measurements than by calculating its LCA.

Beside these process- or product-specific exceptions some allocation rules e.g. credits for recycling or substitution of fossil fuel through energy recovery can lead to a derivation of the direct energy-correlation.

IMPRO, 2008 (page xvii): "Consequently, both primary energy use and greenhouse gas (GHG) emissions are good proxy indicators to assess the environmental performance of the buildings"

Life cycle approach

As has been emphasized by the IMPRO-report (and many other studies before) the **energy consumption for space and warm water heating** plays an important role – within the overall energy consumption of residential buildings as well as of all consumer products.

For new buildings, the **product stage (cradle to gate)** is also significant. Its relative importance varies from one impact category to the other.

The **construction process** (transport and installation) can be neglected in an LCA-calculation as has been justified in several studies. LÜSNER (1996), for instance, showed that the construction process (including the transport of construction materials and products to the construction site) does not exceed 2 % (in some rare cases 9 %) of the life cycle impacts for bridges or roads. BRUCK & FELLNER (2004) came to similar results in regard to residential buildings: The energy consumption of building machines on-site as well as energy required for removal are negligible compared to the overall energy inputs for a building in-use. The efforts for collecting these data (if defaults will not be used) are rather high and the cost/benefit ratio is questionable.
IMPRO, 2008 (page 22): "On this basis, and since the major environmental impacts lie in the use phase (especially heating energy uptake), the construction operation can reasonably be neglected."

As has been shown in ZELGER et al (2009) and BRUCK & FELLNER (2004) necessary **renovation cycles** contribute to essential material and energy inputs during the whole life-cycle of buildings and have to be taken into account

Results of the study “ABC-disposal” (MÖTZL et al, 2009) showed that the LCA-indicators are in general not sensitive to **disposal processes**, except the global warming potential which mainly reflects thermal utilization of construction materials and recycling credits – both effects depending on the allocation rules applied. It can be said in principle, that LCA is not the fitting methodology for measuring the environmental impacts of the building’s disposal. One main reason for this is that landfilling of inert mineral waste – by far the biggest amount of waste left behind from dismantled buildings – does not have any LCA-relevant impacts (except some diesel for transportation and handling). Hence, qualitative methods can bear many more improvement options.

The more life stages of a product are aggregated, the more uncertainty of results rises due to uncertainty in data, methodology and scenarios. This leads us to the implication that different life stages of building structure shall be **handled separately**, at least in a first step of optimisation.

Data

Reliability of data used in LCA-methodology can be questioned, as many product systems and supply chains are more flexible than the LCA-databases and -calculations, leading to situations where LCA-results do not necessarily represent the actual environmental impacts at a given time (PRAKASH, REINTJES et al, 2008, p iv).
When using generic data one has to consider that differences between products in the same product group (e.g. for bricks from different plants) can be higher than difference between different product groups (e.g. brick or limestone).

Methodologies for aggregated evaluation of environmental product performances

One major question concerning LCA-results is how to interpret them in a reproducible way. The numerous indicators have to be grouped and weighted in order to calculate an aggregated estimated impact. The limitation of aggregated indicators shall be shown briefly on the example of the “Eco-Indicator”.
Eco-indicator links the inventory data via mid-point indicators (such as climate change, ozone layer depletion etc.) to three defined end-point indicators (damage to human health, damage to ecosystem quality, damage to resources). The panel approach, i.e. asking a group of LCA-experts, was used in order to weight and rank the damage categories according to their importance.
In spite of serious attempts for a clear reproducible methodological framework, strong questions remain concerning the data basis, the use of Disability Adjusted Life Years as functional unit for human health and the logical cause-chain from the inventory data to the end-point indicators. As for instance, it is impossible to predict the exact damage caused by climate change on human health (PRAKASH, REINTJES et al, 2008, p vi).

Improvement options in regard to the building structure

LCA allows comparisons between different products provided that the product differences are big enough (at least 30 - 50%) compared to the precision of the LCA. Normally this will not be the case for similar products but may be useful for comparisons of different product families (ANEC, 2009-1).

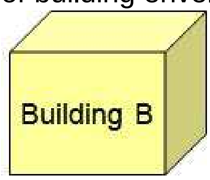
The LCA of the building structure can be improved by changing the material composition. The results of IMPRO (2008) showed that significant environmental improvements could be expected only when “conventional” products like concrete, reinforced concrete, bricks were substituted by wood products. Precondition for this finding is that the wood is taken from a forest under sustainable management. Another very effective improvement option is to replace cement by granulated slag.

Exchange of materials is very often the first improvement option designers think of in regard to the building structure. But as one can easily comprehend without carrying out an LCA, the environmental impacts will also diminish if the amount of used material is reduced. This can for instance be done by abstaining from some construction elements or – more easily – by increasing the compactness of the building. The latter is illustrated by the following example of a simplified model of a single-family house.

We consider a bungalow with the dimensions 12 x 10 x 3 meters, resulting in a gross floor area of 120 m^2 (“GFA”) and a total amount of 372 m^2 building envelope (“BE”). The building shall have no interior walls.

If this bungalow is built with conventional materials, the LCA-scores[54] shall be 72 per m^2_{BE} and 223 per m^2_{GFA}.
In the first step we optimize the materials and thus we achieve an LCA-score of 54 per m^2_{BE} and of 166 per m^2_{GFA}.

Finally we consider a building with exactly the same gross floor area, but now the building should be a 2-storey-building with the dimensions 6 x 10 x 6. This leads to 276 m^2 total area of building envelope.

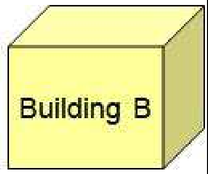


If this building is built with the same conventional materials as the bungalow, the LCA-score per m^2_{BE} will be again 72, but the LCA-score per m^2_{GFA} is now 166.

This example shall visualise that changing the compactness of the building leads to the same environmental improvement as exchanging the materials. This result could have been predicted without carrying out an LCA of course. Thus the compactness of the building could also be a good first proxy indicator for the environmental performance of the building.

[54] OI3-indicator; LCA-indicator used in Austria; detailed understanding of the indicator is not necessary to understand the example.

Table 16: Comparison of the LCA-scores of building A and B with different functional units (area of building envelope versus gross floor area): The example shows that the LCA-scores per area of building envelope are the same in the beginning (same material composition in both building for all walls and ceilings) and can be significantly improved by exchanging the material composition in building A (from 72 to 54 scores). But as one can also see is that the same effect can be reached by improving the compactness of the building.

			
	bungalow with conventional materials	bungalow with optimized materials	2-storey with conventional materials
Length (m)	12 m	12 m	6 m
Width (m)	10 m	10 m	10 m
Height (m)	3 m	3 m	2 x 3 m
Conditioned gross floor area	120 m^2	120 m^2	120 m^2
Volume	360 m^3	360 m^3	360 m^3
Total area of building envelope	372 m^2	372 m^2	276 m^2
LCA-Scores / m^2 build.env. (BE)	**72**	**54**	**72**
LCA-Scores / Gross floor area	**223**	**166**	**166**

8.4. Recommendations for the use of LCA in building assessment systems

LCA is an excellent tool for orientation purposes in the initial phase of environmental product labelling (or criteria setting) and for comparing system alternatives. Therefore, it will not be necessary to carry out complete LCAs by any means (as pursued by CEN/TC 350)

- since orientation studies like IMPRO show that the use phase (dominated by the energy demand for heating) is the most important for new buildings, while the end-of-life phase and the construction process are of much lower importance.
- since it can be shown that most LCA-indicators correlate strongly with energy (IMPRO, 2008).
- since the POCP-indicator of a building mainly results from the VOC-emissions of solvent-based building materials. In this case the criteria shall be based on the avoidance of the use of these products instead of an elaborate LCA-indicator (LIPP, 2010).

Based on this fundamental statement, we recommend the following implementation of LCA in building assessment tools:

Primary energy use and greenhouse gas (GHG) emissions are good proxy indicators to assess the environmental performance of the buildings (IMPRO, 2008). The gain in information by taking other LCA-indicators in account is questionable, whereas leaving them out saves oneself the question of weighting the indicators.

The compactness of the building could also be a good first proxy indicator for the environmental performance of the building.

We recommend considering the use phase (for more details see chapter “Energy and CO_2-emissions”) and the manufacturing of the construction materials (cradle to gate) within a proxy LCA. The construction operation can be neglected and the improvement options for disposal processes could be expressed much better with the help of qualitative indicators (MÖTZL, 2009). All considered **life-cycle stages** of the building should be regarded separately.
The renovation cycles should be taken into account – in principle, unless the service life of the building is limited with as short periods of service life as in IMPRO-study (40 years) or DGNB (50 years). Reference values for renovation cycles were proposed in ZELGER et al (2009) for instance.

According to IMPRO (2008) the impacts caused by the construction phase of new building primarily stem from the construction of the exterior walls, the basement, and floors/ceilings. Interior walls, roof and windows only play a minor role. Our own LCA-calculations however show that the roof (in single-family houses) and the windows play must not be underestimated. Hence, we recommend taking all listed constructions into account. Interior and exterior doors, paintings, adhesives, screws and other auxiliary materials can be neglected or roughly estimated.

Calculations can be made on the basis of (agreed) **generic data**. Methodological conventions (e.g. which energy mix to be used) must be established at the regulatory level in Europe. Standardisation should not be considered as sufficient to this end.

It is strongly recommended to focus on **different instruments**, such as environmental impact assessment, chemical risk assessment etc. for measuring the non-LCA-indicators. There is no need to restrict the environmental assessment to mathematical operationalisation of environmental mechanism as it is practised by CEN/TC 350 at the moment. As has been shown in building assessment systems and product labelling for many years, the characterisation models of non-LCA-indicators could be formalised operations based on measurements or qualitative inventory information.

It is recommended to use the same functional unit as for the energy performance assessment (e.g. per “conditioned gross floor area and year” in Austria).

Benchmarks could be set on national level e.g. based on a range of assessed buildings or on political targets.

9. DAYLIGHTING

9.1. Introduction

Daylight has great influence on the endogenous 24-hour rhythm of the human body, it affects the hormonal system and many metabolic processes and is therefore responsible for physical as well as mental well-being. Bright rooms and direct sunlight are among the most important parameters for consumers to lease a dwelling, apart from optimal layout and acceptable costs [55]. Besides the positive psychosomatic effect of daylight, energy savings can be achieved by reduction of artificial lighting and additional passive solar gains.

Daylight availability in buildings is influenced by various factors:

- the location (geographical coordinates)
- specific regional climate (foggy or cloudy days per year, temperature inversions in winter, valley,..) and solar radiation (altitude)
- cardinal orientation of the building or dwelling units
- visual connection between building and surroundings
- shading through neighbouring buildings, trees, mountains, etc.
- shading caused by building edges and overhangs (balconies, loggias, roof, etc.)
- size, form and depth of rooms
- size, orientation and location of windows
- height of the window lintel
- light transmittance of glazings
- light loss factors (such as dirt, depth of reveals, etc.)
- reflectance of interior surfaces (ceiling, floor, walls, furniture, etc.)
- reflectance of exterior surfaces (e.g. loggias, exterior walls of neighbouring buildings, surroundings: snow, etc.)
- use of daylighting systems (such as light tubes, light-directing prisms etc.)

The daylight factor allows to evaluate the visual quality of a room or building independently from the sunlight availability of a location. The daylight factor is defined as the ratio of interior illuminance to the exterior illuminance from overcast sky. A daylight factor of 1.5 % means that 1.5 % of the available exterior illuminance is reaching a defined point inside the building. The daylight factor DF is expressed (as a percentage) as follows: $DF = (E_i / E_e) \times 100$

E_i …interior illuminance (lx)

$E_{e....}$exterior illuminance (lx)

It is a geometry-related figure (independent from orientation of the building or direct sunlight) and determinable for all points of a room as a fixed parameter. Daylight factors can be averaged over a defined horizontal (or vertical) reference plane (e.g. 0.85 m height over floor). Daylight sections through these reference planes show the distribution of interior illuminance levels over the whole room depth (or height).

[55] Ornetzeder, M.; Rohracher, H., Nutzererfahrungen als Basis für nachhaltige Wohnkonzepte (Projektbericht im Rahmen der Programmlinie Haus der Zukunft, im Auftrag des Bundesministeriums für Verkehr, Innovation und Technologie, Wien, 2001), only available in German

Due to the complexity of interaction between the influence parameters mentioned above precise (calculation) results can only be achieved by computer simulation (e.g. 3Dlighting, Adeline, Radiance, etc.) or scale model measurements. Simplified calculation methods (as described in the following sections, e.g. EU Ecolabel or CSH) or field measurements (by using illuminance meters) give approximate results. The simplified calculation methods comprise three components: the sky component, the external and the internal reflectance component. Field measurements suffer from the lack of ideal sky conditions (“overcast sky”), but if the evidence needed for building assessment systems refers to a value range (e.g. > 2%) the results are sufficiently accurate.
Daylight requirements can be defined either as point or average daylight factors (for relevant rooms of dwellings) or averaged over the whole net floor area of a building (such highly aggregated result is less significant with respect to the visual quality of rooms where residents spend a lot of time).

As the availability of direct sunlight is definitely excluded from both, calculation and measurement, methods of the “Daylight Factor”, parameters such as sun hours per day in times of low position of the sun (winter) must be added to complement the daylight analysis of a building. Sunlight hours can be analysed via solar diagrams for specific locations or computer simulation taking into account the local shading effects (e.g. through neighbouring buildings, overhangs, etc.).

9.2. EU Ecolabel (3rd draft)

The sub-section “Health and Well-being” comprises 8 mandatory criteria for residential buildings[56] (criteria 18-25), more than half of them refer to daylight and lighting topics[57] . Apart from radon concentration, materials used for interior[58] and VOC emissions in indoor environment which are widely criteria relevant to health, the integrated indoor well-being (including thermal comfort, but also lighting and noise indicators) is assessed according to EN 15251 (22). Further daylight and lighting-relevant criteria are the following

- daylighting - common areas (19)
- lighting system control (20)
- glare control (21)
- daylight factor in each room (23)

The benchmarks in detail:

Daylight factor:

The daylight factor[59] in all common areas (e.g. halls, staircase, ..) shall exceed 5%, the daylight factor in each room of the building 3%. Criterion does not apply to store-rooms and

[56] Criterion 17 (dust generated by printers, copy machines, plotters) is only applicable for offices and schools.
[57] Criteria 19. Daylighting – Common Areas, 20. Lighting System Control, 21. Daylighting – Glare Control , 23. Daylighting – Daylight Factor
[58] Materials for interior shall not contain substances or preparations/mixtures meeting the criteria for classification as toxic, hazardous to the environment, carcinogenic, mutagenic or toxic for reproduction (CMR).
[59] The Daylight factor is defined as follows:
DF = SC + ERC +IRC
where:

other service-rooms. The evidence to provide is a technical report from a professional technician reporting the list of rooms taken into consideration, the assessment method used and the result values.
The definition of the daylight factor refers to sky component, externally reflected and internally reflected component. The point to consider is not determined, at all (plane of façade/window or in a room-depth of x metres, center of the window, height above floor,..). Therefore, the indicated benchmarks cannot be evaluated. It is striking that the requirement for common areas is higher (daylight factor > 5%) than for occupied spaces in residential buildings (> 3%) which probably takes into account the larger size and room-depth of halls, staircases, etc. This would speak for point daylight factors within the window plane.
Apart from point daylight factors, to which the calculations probably refer, it is not unusual to indicate an average daylight factor of a room in the height of a reference plane (above floor). In this case, the requirement for rooms within dwelling units should be higher than for common areas.

Daylight Clare Control

Rooms used during the day in residential buildings shall have a Daylight Glare Index (DGI)[60] lower than 20. The calculation takes into account the luminance of each part of the light source, the average luminance of the surfaces in the environment, within the field of view, the weighted average luminance of the window, in function of the relative areas of sky, obstruction and ground. The criterion explicitly applies to offices and school rooms and is limited in residential buildings to rooms used during the day as glare limitation is only required for daylight but not for other light sources.

Glare control indicators are often not assessed within rating systems applicable only for buildings for residential purposes (such as BREEAM Ecohomes/CSH, LEED for Homes, TQB, DGNB,..) as inhomogenous distribution of illuminance is mainly a problem of working places and areas where high visual tasks are to fulfil.
Nevertheless, depending on regional climatic conditions and the use of rooms within building units or dwellings (e.g.for homeoffices) glare control is a topic of increasing relevance.

Lighting system control

The criterion as defined in the Third Draft of EU Ecolabel is more an energy-efficiency issue than an indicator for health and well-being. The control of lighting systems is not linked to daylight provision which could be a useful amendment for working spaces and homeoffices in residential buildings due to guarantee continuous illuminance levels during dusk/dawn or overcast sky. Daylight sensors are not assessed.

SC = light from the patch of sky visible at the point considered, expressed as the sky component,
ERC = light reflected from opposing exterior surfaces and then reached the point, expressed as the externally reflected component,
IRC = light entering through the window but reaching the point only after reflection from internal surfaces, expressed as the internally reflected component.
[60] Bellia L, Cesarano A., Iuliano G.F., Spada G., Daylight glare: a review of discomfort indexes, Detec – Università degli Studi di Napoli Federico II

The criterion refers only to common areas of the building (such as staircases, hallways etc.). Lighting systems in these areas shall be equipped with automatic shutdown (due to energy saving potentials). Motion detection sensors are not required which would be more comfort-oriented.

Integrated Well-Being

EN 15251 defines benchmarks for thermal comfort, indoor air quality and ventilation rates, humidification/dehumidification, lighting and noise whereas the lighting section refers to EN 12464-1 and the illuminance defined therein for different visual tasks and building areas. Lighting requirements for residential buildings are explicitly excluded from the scope of standard EN 15251.

9.3. SBTool

For residential buildings, daylighting is assessed for primary occupancy areas within the main category "D. Indoor Environmental Quality" besides issues like Indoor Air Quality, Ventilation and Air Temperature / Relative Humidity.
Further lighting relevant criteria such as D 4.2. "Glare" and D 4.3. „Illumination levels and quality of lighting" are not applicable for residential buildings (these issues are explicitly restricted to non-residential occupancies).
The range of rating is defined as follows:
The predicted Daylight Factor in the living area of a dwelling unit located on the ground floor shall be at least 2.0 % (acceptable practise) till 3.0% (best practise).

The weighting of issues within SB-Tool is left to national teams which should adpapt this generic framework to local conditions.
The weighting proposal for a tiny residential building (location Ottawa, Canada) classifies the daylighting topic rather low: 4.9 % within section D. Indoor Environmental Quality, 1.2% within the total system. Indoor air quality counts for 65.6%, ventilation for 19.7% and Air Temperature and Relative Humidity for at least 9.8%. Section D is weighted in the overall system by 25%.

9.4. Code for Sustainable Homes (CSH)

Source: Code for Sustainable Homes: Technical Guide May 2009, Version 2 (ed. Department for Communities and Local Government, 2009) [61]

Daylighting issues are treated within the main category "Health and Well-Being", besides sound insulation, private space and lifetime homes. The credits to achieve are limited to 3 points (out of 104 total points), resulting in an overall weighting of 2.9%.

The Code's rating includes the following requirements:

- Kitchens must achieve a minimum *average daylight factor* of at least 2% (1 point).

[61] The analysis mainly refers to the edition 2009. In November 2010, a new version was issued: Code for Sustainable Homes: Technical guide – 2010 (there are no significant changes in daylight criteria). http://www.communities.gov.uk/publications/planningandbuilding/codeguide

- All living rooms, dining rooms and studies (including any room designated as a home office) must achieve a minimum *average daylight factor* of at least 1.5% (1 point).
- 80% of the working plane in each kitchen, living room, dining room and study (including any room designated as a home office) must receive direct light from the sky (1 point).

Evidence must be provided by daylighting calculations and plans showing the angle of visible sky, room dimensions, position and size of windows, external buildings and other obstructions, the position of the no-sky line[62] in the room and percentage of area of the working plane[63] that receives direct light from the sky. It is acceptable that daylighting calculations are carried out in selected dwellings when the reasoning behind selection of dwellings (or rooms) clearly demonstrates that the rooms in the dwellings for which the calculations are not provided will perform better than those backed up by the calculations.

The *average daylight factor* is defined as the average indoor illuminance (from daylight) on the working plane within a room, expressed as a percentage of the simultaneous outdoor illuminance on a horizontal plane under an unobstructed CIE Standard Overcast Sky. The Code awards credits for meeting the minimum *average daylight factor* suggested by *BS 8206-2*.

Calculations of the average daylight factor may use the following formula (method described in *Littlefair (1998)* as set out in BS 8206–2)[64] or computer simulation or scale model measurements for more complex rooms and external obstructions.

$DF = M \cdot W \cdot T \cdot \theta / (A (1-R^2))$

Where:
M = a correction factor for dirt
W = total glazed area of windows or roof lights
T = glass transmission factor
A = total area of all the room surfaces (ceiling, floor, walls and windows)
R = area-weighted average reflectance of the room surfaces
θT = angle of visible sky

The *average daylight factor* formula can be used to model daylighting conditions in any simple rectangular room with a continuous external obstruction or none. Where external obstructions are of complex geometry and cannot be approximated by a continuous object, it is advised to use methodology in Littlefair (1998). More complex room geometries can be modelled using computer simulation software, physical scale modelling or advanced manual calculations

For construction stage, an inspection report confirming the input data for calculations or on-site measurements in the same rooms assessed during design stage is required.

[62] The *no-sky line* divides those areas of the working plane which can receive direct light from the sky, from those which cannot. It is important as it indicates how good the distribution of daylight is in a room. Areas beyond the *no-sky line* will generally look gloomy.

[63] The *working plane* is a notional surface, typically at about desk or table height, at which *daylight factor* or the *'no-sky line'* is calculated or plotted. For the calculations required here, it is at 0.85m above the fl oor.

[64] Littlefair, P. J., Site layout planning for daylight and sunlight, A guide to good practice", BRE Press, 1998.
BS 8206 "Lighting for buildings - Code of practice for daylighting Part 2", 1992.
Information Paper IP 23/93 "Measuring daylight", BRE, 1993.

9.5. BREEAM Multiresidential 2008

Source: BREEAM Multi-residential 2008 Assessor Manual (BREEAM BRE Environmental & Sustainability Standard BES 5064: Issue 1.0; ed. © BRE Global, 2008, http://www.breeam.org)

BREEAM *Multi-residential scheme* is intended for use on multi-occupancy residential buildings which are not suitable for assessment under the Code for Sustainable Homes (CSH) or EcoHomes (e.g. student halls of residence; key worker accommodation, sheltered housing, etc.)
Daylighting and lighting relevant comfort criteria are assessed within subsection Health & Wellbeing (HEA) including the following issues:

- Hea1 Daylighting
- Hea2 View out
- Hea3 Glare control
- Hea4 High Frequency Lighting
- Hea5 Internal and external lighting levels

Hea1 Daylighting

The requirements to be met are differentiated into requirements for residential and communal areas:

Adequate daylighting **for residential areas** is defined in full compliance with the requirements of CSH (Code for Sustainable Homes).
At least 80% of floor area in each *occupied space* must be adequately daylit which means:
a) In kitchen areas an average daylight factor of at least 2% must be achieved.
b) All living rooms, dining rooms and studies (including any room designated as a home office) must achieve a minimum daylight factor of at least 1.5%.
c) 80% of the working plane in each kitchen, living room, dining room and study (including any room designated as a home office) must receive direct light from the sky.

For **communal areas** where people will be working and desk-based are likely undertaken the average daylight criterion of 2% is complemented by either calculations showing that a uniformity ratio of at least 0.4 or a minimum point daylight factor of at least 0.8% is achieved or a view of sky from desk height (0.7m) is achieved and the room depth criterion is satisfied taking into account room depth, room width, window head height from floor level and average reflectance of surfaces in the rear half of the room.
Additionally, the provision of daylight must be designed in accordance with the guidance in CIBSE Lighting Guide 10 Daylighting and window design, BS8206 Part 2 and the BRE Site Layout Guide.

Hea2 View out

The following demonstrates compliance:
1. All living rooms (in self contained flats), communal lounges and individual bedrooms/bedsits in sheltered housing are within 5m distance of a wall with a window or

permanent opening providing an *adequate view out*, where the window/opening is ≥20% of the total inside wall area

2. All other *relevant building areas* are within 7m distance of a wall with a window or permanent opening providing an *adequate view out*, where the window/opening is ≥20% of the total inside wall area *(*refer to compliance notes for a definition of *relevant building areas* and *adequate view out)*.

Hea3 Glare Control

An occupant-controlled shading system on all windows, glazed doors and rooflights in all *relevant building areas is required*.

Hea4 High Frequency Lighting

All fluorescent and compact fluorescent lamps are fitted with high frequency ballasts.

Hea5 Internal and external lighting levels

All internal and external lighting, where relevant, is specified in accordance with the appropriate maintained illuminance levels (in lux) recommended by CIBSE[65].

Hea6 Lighting zones & controls

Is not assessed in this scheme.

Daylighting and lighting issues are not obligatory to achieve a BREEAM Multiresidential rating. The section core of Health and Well-being (HEA) is 11.8% (comprising daylighting, lighting, thermal comfort and indoor air quality topics). 5 of 14 available points for Health and Well-Being are achievable through adequate daylighting and lighting as defined above resulting in a section weighting of 36% and an overall weighting of approximately 4%. An additional innovation credit can be achieved if exemplary level requirements exceeding the benchmarks for daylighting mentioned above are met.

9.6. LEED for Homes / LEED-NC 2009

Source: LEED Reference Guide for Green Building Design and Construction (for the Design, Construction and Major Renovations of Commercial and Institutional Buildings Including Core & Shell and K-12 School Projects (ed. US. Green Building Council, Washington, 2009)

Daylight topics **are not covered in any LEED for Homes** category (which means that daylighting is regarded of no or subordinated relevance for low-rise residential buildings).

In the new version LEED v3 for New Construction & Major Renovations (LEED-NC 2009) applicable for high-rise residential buildings (more than 3 storeys) daylight topics (earning max. 2 points of 110) are assessed by indicators for **Daylight and Views** as follows:

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[65] *Code for Lighting: Part 2*", CIBSE, 2004; Lighting Guide 7 "*Office Lighting*", CIBSE 2005; Lighting Guide 6 "*The Outdoor Environment*", CIBSE 1992; Lighting Guide 9 "Lighting for Communal Residential Buildings", CIBSE, 1997
BS 5489 Part 1 "Code of practice for the design of road lighting: lighting of roads and public amenity areas", BSI, 2003

IEQ Credit 8.1: Daylight and Views / Daylight (1 point)

For earning an IEQ Credit 8.1 the space should be designed to maximize daylighting opportunities through one of the 4 following options. Strategies to consider include building orientation, shallow floor plates, increased building perimeter, exterior and interior permanent shading devices, high-performance glazing.

OPTION 1) Simulation
Demonstrate through computer simulation that 75% or more of all regularly occupied spaces areas achieve daylight illuminance levels of a minimum of 25 footcandles (fc)[66] and a maximum of 500fc in a clear sky condition on September 21st at 9.a.m. and 3 p.m.

OPTION 2) Prescriptive
Use a combination of side-lighting and/or top lighting to achieve a total daylighting zone that is at least 75% of all regularly occupied spaces.

For the Side-Lighting Daylight Zone:

a) Achieve a value, calculated as the product of the visible light transmittance (VLT) and window-to-floor area ratio (WFR) of daylight zone between 0.150 and 0.180.
b) The ceiling must not obstruct a line in section that joins the window-head to a line on the floor that is parallel to the plane of the window. Is twice the height of the window-head above the floor in, distance from the plane of the glass as measured perpendicular to the plane of the glass.
c) Provide sunlight redirection and/or glare control devices to ensure daylight effectiveness.

For the Side-Lighting Daylight Zone:

a) The daylight zone under a skylight is the outline of the opening beneath the skylight, plus in each direction the lesser of:
    - 70% of the ceiling height
    - OR ½ the distance to the edge of the nearest skylight
    - OR the distance to any permanent opaque partition farther than 70% of the distance between the top of the partition and the ceiling.
b) Achieve skylight riff coverage between 3% and 6% of the roof area with a minimum 0,5 VLT
c) The distance between the skylights must not be more than 1,4 times the ceiling height.
d) A skylight diffuser, if used, must have a measured haze value of greater than 90% when tested according to ASTM D1003. Avoid direct line of sight to the skylight diffuser.

OPTION 3) Measurement
Demonstrate through record of indoor light measurements that a minimum daylight illumination level of 25 fc has been achieved in at least 75% of all regularly occupied areas. Measurements must be taken on a 10-foot grid for all occupied spaces and recorded on building floor plans.

[66] One footcandle is equal to approximately 10.764 lux.

OPTION 4) Combination
Any of the above calculation methods may be combined to document the minimum daylight illumination in at least 75% of all regularly occupied areas. The different methods used in each space must be clearly recorded on all building plans.
In all cases, glare control devices shall be provided to avoid high-contrast situations that could impede visual tasks.

IEQ Credit 8.2: Daylight and Views / Views (1 point)

For earning an IEQ Credit 8.2 the space should be designed to maximize views opportunities. Strategies to consider include building lower partitions, high-ceiling reflectance values, interior glazing and automatic photocell-based controls.

Determine the area with a direct line of sight by totaling the regularly occupied square footage that meets the following criteria:

a) In plan view, the area is within sight lines drawn from perimeter vision glazing
b) In section view, a direct sight line can be drawn from the area to perimeter vision glazing.

Achieve a direct line sight to the outdoor environment via vision glazing between 30 inches and 90 inches above the finish floor for building occupants in 90% for all regulary occupied areas.
The line of sight may be drawn through interior glazing. For private offices, the entire square footage of the office maybe counted if 75% or more of the area has a direct line of sight to perimeter vision glazing. For multi-occupant spaces, the actual square foot with a direct line of sight to perimeter vision glazing is counted.

9.7. DGNB

Draft Criteria – residential buildings (May 2010)
Visual Comfort is defined by the following parameters (weighting within the sub-category included):

1. Daylight availability (40%)
2. Views out (20%)
3. Color rendering index (20%)
4. Sun hours per day (20%)

1. Daylight availability

Daylight is sufficiently available according to the guidelines of DGNB where a minimum average daylight factor of 1% for at least 50% of the occupied spaces (net floor area) is achieved. An average daylight factor of 2% for the same area defines the most ambitious requirement for residential buildings.
The daylight factor is defined as illuminance due to daylight at a point on the indoors working plane compared to the simultaneous outdoor illuminance on a horizontal plane from an unobstructed hemisphere of overcast sky in %. Calculations are based on daylight simulation programmes.

As the daylight factor depends on the various parameters (e.g. specific geometry of each room, the degree of reflection of the room's surfaces, the shading caused by overhangs, jutties and neighbouring buildings varying on each floor and façade) the evidence to provide for residential buildings to achieve an average daylight factor for at least 50% of the net floor area is rather complex. Evidence referring to the same type of rooms may lower the expenditure of time and costs for assessment.

2. Views out

Views may not be limited by shading or glare devices. Assessment refers to manufacturer's data or photo documentation.

3. Color rendering index

The color rendering index of shading or glare devices and glazings has to exceed 90 as maximum requirement and 80 as minimum requirement.

4. Sunlight penetration (wintertime)

The minimum requirement is more than 1 hour winter sun on January 17th (according to DIN 5034-1) for at least 1 room for 80% of the dwellings. The maximum requirement is 4 hours on January 17th. Evidence must be provided for the centre of the window in parapet height within the façade plane.

9.8. TQB

TQB evaluates the access to daylight for residential buildings by two complementary indicators as follows:

1) Daylight Factor:

At least, a point daylight factor >= 2% has to be achieved for the living rooms (in 2m room depth, 1m distance from a side wall, reference plane: 0.85m) for more than 85% respectively 25% of the dwellings (as maximum or minimum requirement). The day light factor is influenced by the light transmission value of the glazings, geometry and degree of reflection of the room's surfaces, shadings through overhangs (balconies, roofs,..), obstructions by neighbouring buildings, trees, landscape,….

2) Winter Sun:

On 21st december more than 1.5 sun hours per day have to be achieved in the living rooms for more than 85% respectively 25% of the dwellings (as maximum or minimum requirement).

Evidence is provided by calculations in the design stage and on-site measurements after construction.

The highest requirement levels of both indicators award 50 of 1000 available points (resulting in 5.0% overall weighting). Within the subsection Health and Comfort, daylighting issues are awarded by a quarter of all points (50 of 200 available points), besides thermal comfort, noise protection and indoor air quality which are equally weighted.

9.9. Summary and Conclusions Daylighting

Summary Daylighting

Daylighting and lighting related issues are recognized as relevant comfort and health topics in most of the analysed building assessment systems for (small and large-size) residential buildings.
Daylight factor is the only indicator common to almost all systems, although definition, calculation methods and benchmarks may vary.
Apart from this indicator, views out, glare control, and illuminance levels are frequently used parameters to define visual comfort.
Sun hours per day (in wintertime), daylight availability, color rendering index (CRI) of glare or shading devices are less common. Nevertheless, the first two indicators complement the daylight factor by important information on façade orientation or daylight availability on site due to the specific location.
Requirements for lighting control systems and high frequency lighting overlap partially with energy efficiency issues.

Table 17: Use of daylighting and lighting related indicators in different building assessment systems

	EU Ecolabel	SBTool	CSH (BRE)	BREEAM Multires.	LEED f. Homes	LEED NC2009	DGNB resid.	TQB resid.
Daylighting criteria								
Daylight Factor	●	●	●	●			●	●
Window/floor ratio				●		●		
Direct sky light			● (2)			●		
Glare Control	●	● (1)		●				
Views out				●		●	●	
Illuminance	● (1)	● (1)		●		●		
Winter sun							●	●
Daylight availability							●	
CRI							●	
Lighting criteria								
Lighting control	●							
High frequ. lighting				●				

(1) defined only for non-residential buildings

(2) no-sky line has to be defined for rooms

Conclusions Daylighting

Daylight factor requirements can be defined either as point or average daylight factor(s) (for relevant rooms of dwellings) or averaged over the whole (or a defined percentage of the) net floor area of a building. Optimisation strategies are more effective if rooms / dwelling units are considered separately and the overall rating is based on an arithmetical mean value of single scores of all dwelling units. Net floor area based ratings consider all rooms independently of their functions and daylight requirements ignoring the fact that darker zones are acceptable for retreat areas, corridors, bathrooms, etc.

The authors recommend to assess the geometric prerequisites of the building by defining a minimum **point daylight factor** in living rooms (in order to ease verification) as well as **direct sunlight** in the dwelling units **(by using sun hours in winter-time)** for the rating of the visual quality of residential buildings.

As the calculation of daylight factors refers only to geometrical and surface-related data of rooms without consideration of latitude, orientation and access to direct sunlight, the rating has to be complemented by an indicator assessing the daylight availability on site. Sun-drenched rooms are one of the most important purchasing criteria for consumers. Access to direct sunlight in dwelling units can be evaluated by parameters such as sun hours per day especially in wintertime (at low positions of the sun). By these means, criteria like “views out” and “direct sky light” are automatically fulfilled.
As for northern latitudes the optimization potential for winter sun is limited, it is recommended to define regional benchmarks adapted to country-specific conditions.

Glare control (for balanced luminance distribution in the visual field) is of greater significance for office buildings, rooms with workstations, schools, etc. and need not generally to be integrated in a catalogue tailored for residential buildings (apart from mixed use or southern European countries with higher solar radiation).

Lighting control is not considered to be an important indicator for residential buildings.

10. CONSTRUCTION SITE MANAGEMENT

The following examination will focus on environmental as well as health-related aspects of construction site activities and their implementation in the analysed assessment systems EU Ecolabel (3rd draft), SBTool, CSH (Code for Sustainable Homes), LEED for Homes, DGNB, and TQB.
The main topics are construction waste management, noise and dust attenuation, social responsibility with respect to all groups affected by construction site activities (including health protection and safety measures and avoidance of accidents, etc.).Transports to and from site and the related emissions to air are dealt with in chapter "Energy and CO_2-emissions"[67].

10.1. EU Ecolabel (3rd draft)

(Construction) Waste Management

The main focus of waste management strategies within the Third Draft of EU Ecolabel lies explicitly on the operation and demolition of the building. Construction-site related waste is only considered within the optional Section B which means that measures undertaken to reduce construction waste may contribute to achieve the EU Ecolabel, but are not obligatory.

Mandatory waste management criteria are only referring to the use stage (Crit 16) and to the demolition stage of the building.
Waste management strategies referring to the construction phase are optional criteria. To gain 3 additional points within category "Planning – Project – Construction" it is required that "at least 75% of construction and demolition wastes generated during the construction phase shall be reused or recycled". Verification refers to the waste management plan and relative documentation showing compliance with the criterion.

In order to be awarded with the EU Ecolabel, the building must score a minimum of 6 points for optional criteria within the sub-sections "Documentation", "Planning-Project-Construction" and "Impact on site issues".
Compliance is demonstrated by process-related assessments (concerning waste management during construction as well as other design and construction topics), e.g.

- experience of the designers with environmental building design (32.) in terms of energy and water efficiency, waste reduction, etc.. At least two relevant projects carried out in the last five years are required for verification. (2 points)
- QMS (33.): "Companies in charge of the construction of the building shall have a Quality Management System according to the ISO 9001 standard." (2 points)
- EMS (35.): "Companies in charge of the construction of the building shall have an Environmental Management System according to EMAS regulation (2 points) or ISO 14001 standard (1 point)"

[67] Transport of materials and products from factory gate to the building site including intermediate storage and distribution are taken into account. Transport of construction equipment (cranes,…) to and from site are not considered.

- In Crit. 34 an LCA-calculation for the building according to the ISO14040 standard or to prEN 15978 is required, without setting any benchmarks or optimisation steps.

Social responsibility (loadings on neigbourhood,…)

"Social responsibility during the construction phase" (criterion 5) is defined as mandatory in the Third Draft of EU Ecolabel, but not yet specified. It refers to prEN 15643-3:2010[68] where loadings from construction site activities are not yet taken into account.

Annex B gives an outlook on criteria for the construction stage to be dealt with in future standardisation work: It is intended to develop assessment criteria evaluating the impacts on neighbourhood (from traffic and noise) and to develop social standards of construction process (safety, neighbourhood protection).
Society-related issues shall comprise

- Social standards of companies involved (CSR – Corporate Social Responsibility standards and reporting)
- Social facilities on construction site (toilets, kitchen, etc.)

Health and safety aspects related to construction workers are definitely excluded from the first generation of standards.

As the current version is restricted to the use stage and awaits further development, assessment criteria for construction site activities cannot be derived for the EU Ecolabel from this draft standard. Besides, "levels, classes or benchmarks for measuring performance" will generally not be dealt within this standard.

10.2. SBTool

(Construction) Waste Management

Waste-relevant issues occur in the following sub-categories:

		Resid.	Mixed use
A.2.	Project Planning		
	A.2.7. Collection and recycling of solid wastes in the community or project		•
B.4.	Materials		
	B.4.4. Use of durable products	•	•
	B.4.10 Design for disassembly, re-use or recycling		•
C.3.	Solid Waste		
	C.3.1. Solid waste resulting from the construction and demolition process		•
	C.3.2. Solid waste resulting from facility operations	•	•

For (small) residential buildings, waste reduction is assessed only by two indicators both reflecting the use stage of the building.

[68] prEN 15643-3:2010: Sustainability of Construction Works - Assessment of Buildings - Part 3: Framework for the assessment of social performance

*Solid waste resulting from the construction and demolition proc*ess (C.3.1.) is only taken into consideration for mixed use buildings of greater size as well as collection and recycling facilities of solid wastes in the community or project (A.2.7.).
The assessment criteria are specified as follows: A construction waste management program with sorting, re-use and recycling measures shall ensure that at least 15 % (acceptable practice) or 75 % (best practice) by weight, of construction waste are re-used (on or off the site) or re-cycled.
Community-related is the second criterion that requires that "a general plan exists to collect, store and send to off-site recycling facilities at least 50 % (acceptable practice) / at least 90 % (best practice) of inorganic solid wastes".

Loadings on Neighbourhood

The loadings caused by construction site activities mainly refer to environmental impacts and do not consider health-relevant aspects such as noise or dust attenuation.

C.5.1. is only applicable for large-scale developments of mixed use requiring a plan that ensures that "the construction process will create a minimum disturbance to existing water courses or physical features of the site or adjacent lands, and to at least maintain the ecological diversity of pre-construction conditions." The second criterion, which is also recommended for residential buildings, shall ensure "that neither the construction process nor the operations of the building will cause significant respectively any soil erosion in best case on the site or adjacent lands."

		Resid.	Mixed use
C.5.	Impacts on Site		
	C5.1. Impact of construction process on natural features of the site		•
	C5.2.Impact of construction process or landscaping on soil erosion.	•	•

Additionally an Environmental Impact Assessment should be carried out following the recommendations of A.2.2 within the main category A.2. Project Planning.

Social responsibility

SBTool referring to social aspects in section F requires the minimization of construction accidents by the means of appropriate measures for large-scale developments. Target rate for accidents on the jobsite requiring hospitalization per 100,000 hours worked shall not exceed 3.0% (acceptable practice) or be even lower than 0.5 % in best case.
The construction of small residential buildings is excluded from assessment.

10.3. Code for Sustainable Homes (CSH)[69]

(Construction) Waste Management

Classified as one of the 9 main categories CSH stresses the importance of waste reduction[70] which is weighted by 6.4 % within the overall assessment.
The main focus lies on the operation phase contributing more than 70 % of the achievable points. Construction Site Waste Management (issue Was1) is awarded 2 points (30% within subsection Waste, overall weighting 2.8 %).

1) Site Waste Management Plan (SWMP)

The first issue (development and implementation of a Site Waste Management Plan) sets a mandatory performance requirement with no available credits. This requirement must be met if a Code rating is to be achieved and includes:
"Monitoring and reporting of waste generated on site in defined waste groups, and compliance with legal requirements as set in SWMP regulations 2008 for and with *best practice*. The plan should include the setting of targets to promote resource efficiency in accordance with guidance from WRAP, Envirowise, BRE and DEFRA[71]. Specific quantitative targets are not set within this Technical Guidance. It is the responsibility of the client and/or the principal contractor (as defined by the SWMP regulations 2008) to ensure that appropriate targets are set for the site."[72]

Details of the amount of waste produced, reduced, re-used, recycled or otherwise recovered on or off site need to be monitored and reported for the following waste groups:

- Bricks
- Concrete
- Insulation
- Packaging
- Timber
- Electrical and electronic equipment

[69] The analysis mainly refers to the edition 2009 (*Code for Sustainable Homes: Technical Guide May 2009, Version 2; ed. Department for Communities and Local Government, 2009)*. In November 2010, a new version was issued: Code for Sustainable Homes: Technical guide – 2010 (there are no significant changes in site waste management or other building site-relevant issues).
http://www.communities.gov.uk/publications/planningandbuilding/codeguide

[70] "..the Government is considering in conjunction with the construction industry, a target to halve the amount of construction, demolition and excavation wastes going to landfill by 2012 as a result of waste reduction, re-use and recycling" (DEFRA, 2007).

[71] WRAP: SWMP templates for standard, good and best practice details and registration for download available at: www.wrap.org.uk/construction
WRAP: The Requirements suite for setting SWMPs early within projects (client summary and waste minimisation and management guidance for delivering on the requirements): www.wrap.org.uk/construction
Envirowise: GG493 Saving money and raw materials by reducing waste in construction: case studies: www.envirowise.gov.uk
Envirowise: GG642 An Introduction to Site Waste Management Plans: www.envirowise.gov.uk
BRE: SMARTWaste Plan (Site waste management planning tool), SMARTStart, waste benchmarks/EPIs and guidance: Reduction of Site Construction Waste, Recycling and Reuse of materials: A Site Guide and A Project Management Guide: www.smartwaste.co.uk
DEFRA (Department of Environment, Food and Rural Affairs), Non Statutory Guidance for Site Waste Management Plans: www.defra.gov.uk/constructionwaste
DEFRA: Site Waste Management Plans Regulations 2008 (2008/314 in the following website: http://www.opsi.gov.uk/si/si2008/uksi_20080314_en_1#l1g5)

[72] Code for Sustainable Homes (CSH), Technical Manual, p. 163

- Canteen/office/adhoc
- Oils
- Asphalt and tar
- Tiles and ceramics
- Inert
- Metals
- Gypsum
- Plastics
- Floor coverings (soft)
- Furniture
- Liquids
- Soils
- Hazardous
- Architectural Features
- Other/Mixed

2) Minimising Construction Waste

Points are not achieved until the minimization of construction waste is guaranteed by the following measures.

"The Site Waste Management Plan must include procedures and commitments for reducing waste generated on site in accordance with best practice[73] and the defined waste groups (1 point).
AND
The Site Waste Management Plan must include procedures and commitments to sort and divert waste from landfill (reuse, recycle, compost or otherwise recover) according to the defined waste groups. This must be performed either on site or through a licensed external contractor, in accordance with best practice (1 point)."

Checklists for monitoring and documentation are provided within the technical manual of CSH.

Social (and environmental) responsibility

Man2: Considerate Constructors Scheme:

Assessing the impacts of construction site activities, CSH follows a comprehensive approach requiring a specific score within the so-called **"**Considerate Constructors Scheme**"**[74] which is a voluntary UK certification scheme encouraging the considerate management of construction sites with respect to environmental and especially social aspects. The scheme

[73] "Best practice relating to construction waste minimisation credits is a combination of commitments to:
• reduce waste generated on site
• develop and implement procedures to sort and recycle construction waste on site
• follow guidance from:
– DEFRA (Department of Environment, Food and Rural Affairs)
− BRE (Building Research Establishment)
− Envirowise
− WRAP (Waste & Resources Action Programme)"
[74] http://www.ccscheme.org.uk

is operated by the Construction Confederation since 1997 and was developed from local schemes in the City of London and City of Westminster. The certification scheme is more target-oriented than e.g. QMS (Quality Management System) as it is tailored to assess the site itself and all impacts from construction site activities in contrary to general processes within the building construction firms. The main areas of concern within the "Site Code of Considerate Practice" fall into three main categories: the environment, the workforce and the general public.

Points are awarded in increments of 0.5 over the following eight sections:

- Considerate
- Environmentally Aware
- Site Cleanliness
- Good Neighbour
- Respectful
- Safe
- Responsible
- Accountable

To achieve certification under this scheme a score of at least 24 is required.

CSH awards 1 point "where there is a commitment to meet Best Practice under a nationally or locally recognized certification scheme such as the Considerate Constructors Scheme" and 2 points "where there is a commitment to go significantly beyond Best Practice".
Best practice is defined as "achieving a score of at least 3 in every section, and a total score between 24 and 31.5, of the Considerate Constructors Scheme's Code". "Going significantly beyond best practice" requires a total score of 32 - 40.
The overall weighting of this criterion within CSH is 2%.

Site inspections are made by independent monitors selected from the senior ranks of the construction industry (third-party certification), the inspection reports are based on detailed checklists for monitoring and optimization (see 2010 Site Registration Monitors' Checklist)[75]. The general requirements are specified as follows:

> "**Considerate:** This section is intended to discover whether the site is fully aware of all those who may be affected by the work (traders and businesses, site personnel and visitors, and the general public, special attention is to be given to the needs of those with sight, hearing and mobility difficulties) and thereafter to see what efforts are made to minimise any nuisance or inconvenience.
>
> **Environmentally Aware:** This section examines how aware the site is of its impact on the environment (energy, waste, pollution, resources, ecology, etc) and examines what is done to minimise this and make a positive contribution.
>
> **Site Cleanliness:** The working site is to be kept clean and in good order at all times. Site facilities, offices, toilets and drying rooms should always be maintained to a good standard. Surplus materials and rubbish should not be allowed to accumulate on the site or spill over into the surroundings. Dirt and dust from construction operations should be kept to a minimum.
>
> **Good Neighbour:** General information regarding the Scheme should be provided for all neighbours affected by the work. Full and regular communication with neighbours, including adjacent residents, traders and businesses, regarding programming and site activities should be maintained from pre-start to completion.
>
> **Respectful:** Respectable and safe standards of dress should be maintained at all times. Lewd or derogatory behaviour and language should not be tolerated under threat of severe

[75] http://www.ccscheme.org.uk/images/stories/site-registration/downloads/monitor-checklist2010.doc

disciplinary action. Pride in the management and appearance of the site and the surrounding environment is to be shown at all times. Operatives should be instructed in dealing with the general public.

Safe: Construction operations and site vehicle movements are to be carried out with care and consideration for the safety of site personnel, visitors and the general public. No building activity should be a security risk to others. Required is a proactive approach driving up standards.

Responsible: As an employer, is the site' responsible' to the operatives on site and to the public in general (security measures, first aid,..)? Is the contractor also playing a role in the recruitment and training of the industry's future workforce (by apprenticeships, work experience or placements; contact to schools/universities); does the company have Equal Opportunities/Diversity Policy?)

Accountable: The Considerate Constructors Scheme poster is to be displayed where clearly visible to the general public. The contractor shall be accountable and accessible through contact details obvious to anyone affected by the site's activities. What is being done to create a sense of pride in working in construction?"

References: Site Code of Considerate Practice (January 2010)[76]
2010 Site Registration Monitors' Checklist (January 2010)

Table 18: Examples: Sections "Environment" and "Neighbourhood" (extracted from the 2010 Site Registration Monitors' Checklist)

2. Environment *This section examines how aware the site is of its impact on the environment(energy, waste, pollution, resources, ecology, etc) and examines what is done to minimise this and make a positive contribution.*	
Does the company have an environmental policy? Is it clearly displayed?	
How have site specific environmental issues been identified? What action has been taken to address these? How is this monitored?	
What water and energy saving measures are in place? Is there a monitoring procedure?	
How is waste avoided, reduced, reused, and/or recycled? Is there a Site Waste Management Plan? How is this monitored?	
What is done to source and reuse recycled/sustainable materials and products used during the construction process?	
What feedback is received on site as to how much waste is diverted from landfill?	
Have plants, trees, watercourses and wildlife been identified and protected and how is this monitored?	
What is done to reduce/remove noise, light, water and air pollution?	
What efforts are made to use local labour, suppliers, subcontractors and materials?	
What and how are environmental issues covered in the site induction/toolbox talks?	
Are secure designated areas provided for hazardous substances such as oils, paints and chemicals? Is suitable spillage equipment available?	
Have alternative energy sources been considered for the construction process?	
Are targets set for improving environmental performance? How are these monitored?	
Is the site's carbon footprint measured? What steps are being taken to reduce carbon emissions?	
Has the site carried out any activities that would give an environmental and ecological benefit to the area? How is this publicised and promoted?	

76 http://www.ccscheme.org.uk/index.php/site-registration/site-managers-information-site-reg/site-code-of-practice-site-reg (January 2010)

2. Environment *This section examines how aware the site is of its impact on the environment(energy, waste, pollution, resources, ecology, etc) and examines what is done to minimise this and make a positive contribution.*	
Does the site monitor the embodied energy of materials used during the construction process? Where possible, what efforts are being made to use products with a lower level of embodied energy?	
4. Good Neighbour *How well is this site communicating with those that may be interested/affected? When the project is complete, what impression will the contractor leave behind?*	
What measures are taken to reduce noise and inconvenience affecting neighbours? Are site working hours monitored and flexible?	
Is the hoarding/fencing visually appropriate to the surroundings of the site? Is it well maintained?	
How are neighbours notified prior to any noisy/disruptive work or of any significant changes to site activity that may affect them?	
What arrangements are in place to ensure a reasonable telephone response during working hours?	
Is there a compliments/complaints/comments procedure with a record of contacts' names and telephone numbers?	
Is the Site Manager able to deal with complaints? Have all complaints been properly dealt with?	
Are operatives told about compliments?	
What measures have been taken to enhance the image of the site and to respect neighbours' privacy; for example, where scaffolding is used?	
Has the site been actively involved with the community? Have there been any public relations events?	
Are those who are interested/affected routinely advised regarding the progress of the work?	
Are there viewing points in the hoarding and, if so, are regular checks made to ensure that they give the right impression?	
Is site lighting directional and shielded from neighbours?	
Is a 24 hour hotline displayed on the site boundary or otherwise easily available to the public? Are neighbours advised of it? Is it monitored to ensure a suitable response?	
Have any goodwill gestures been made?	
What has the site done to be a positive influence in the area?	

Construction Site (Environmental) Impacts

Besides the certification scheme "Considerate Constructors", where environmental topics resulting from construction site activities are already dealt with (but without setting specific target values to achieve), impacts to soil, water (ground and surface) and air (dust, CO_2 emissions) are separately assessed by management issue "Man 3 Construction Site Impacts" and the ecological criterion "Eco1 Ecological Value of Site".

<u>Man 3 Construction Site Impacts</u>

This issue is a management criterion as well as the certification scheme "Considerate Constructors ", the difference lies in the more ambitious requirements encouraging a process of setting target values (adapted to the specific site), monitoring and reporting against these targets. Apart from site timber, the Code refuses to define specific targets to achieve and leaves this process to the responsible project managers. For guidance on setting targets

CSH refers to DTI's Construction Industry KPI Pack, this series of documents guides the reader through how to set targets for their own projects.

To show compliance with issue Man 3, procedures that cover 2 or more of the following items are required (for achieving 1 point) respectively 4 or more of the items listed below (for achieving 2 points):

- Monitor, report and set targets for CO_2 production or energy use arising from site activities
- Monitor and report CO_2 or energy use arising from commercial transport to and from site
- Monitor, report and set targets for water consumption from site activities
- Adopt best practice policies[77] in respect of air (dust) pollution arising from site activities (e.g. 'dust sheets', regular proposals to damp down the site in dry weather, covers to skips etc.)
- Adopt best practice policies[78] in respect of water (ground and surface) pollution occurring on the site
- 80% of site timber is reclaimed, re-used or responsibly sourced

Eco1 Ecological Value of Site

One credit is achieved where compliance is shown with the following requirements:

- The construction zone is of low ecological value[79].
- All land outside the construction zone will remain undisturbed by the construction works in areas of ecological value.

The construction zone includes any land used for buildings, hard standing, landscaping, site access and any land where construction work is carried out (or land is being disturbed in any other way), plus a 3m boundary in either direction around these areas. It also includes any areas used for temporary site storage and buildings.

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[77] Further information can be obtained from DTI/BRE publications 'Control of Dust from Construction and Demolition Activities' and Pollution Control Guide Parts 1–5 provide good practice guidelines on construction related pollution.

[78] Best practice guidelines:
PPG 1 – General guide to the prevention of pollution. Environment Agency
PPG 5 –Works in, near or liable to affect watercourses. Environment Agency
PPG 6 – Working at demolition and construction sites. Environment Agency available at www.netregs.gov.uk

[79] Development sites with low ecological value are defined as follows (reference: checklist Eco1 of the CSH, Technical Guide, p.248):
a) land which is entirely within the floor plan/s of existing building/s or building/s demolished within the past two years
b) land which is entirely covered by other constructions such as sporting hard surfaces, car parking or such constructions which have been demolished within the past two years
c) land which is contaminated by industrial or other waste to the extent that it would need decontamination before building
d) land which is a mixture of either existing building, hard surfaces and/or contaminated land
e) 80% of the land within the *development site* complies with a)-c) and the remaining 20% of the ground area of the building extend into land which has been either; used for single-crop arable farming for at least five years, OR consists of regularly cut lawns and sports fields

Where the site contains any trees or hedges above 1m high or with a trunk diameter greater than 100mm, the site cannot be regarded of low ecological value as well as if there are

- any ponds, streams or rivers on, or running through the site
- any marsh or other wetland present on the site
- any meadows or species-rich grassland present on the site
- any heath land, consisting of heather and/or scrub present on the site

If it is not known exactly where buildings, hard standing, site access, temporary storage and buildings will be located it must be assumed that the construction zone is the development site. The aim of this issue is to discourage the development of ecologically valuable sites.

All construction-site relevant issues within the Code for Sustainable Homes (Was 2, Man 1, Man 2 and Eco 1) achieve 7 points at maximum (resulting in an overall weighting of 6.7%).

10.4. LEED for Homes / LEED-NC 2009

Construction Waste Management

Waste within LEED for Homes is restricted to construction waste und does not take into account household garbage during the use phase. Management of construction waste is assigned to the main category “Materials and Resources (MR)”.

MR 3.1. Construction Waste Management Planning - Prerequiste

The mandatory performance level (MR 3.1.Construction Waste Management Planning) is easy to comply with:

- Local options of diversion (e.g. recycling, reuse) of all anticipated major constituents of the project waste stream have to be investigated and
- The diversion rate for construction waste has to be documented for land clearing and/or demolition, if applicable (e.g., on gut rehab project), separately from the rate for the new construction phase of the project.

MR 3.2. Construction Waste Reduction

Maximum 3 points are awarded by additional measures for waste reduction and diversion resulting in a weighting of 19 % within “Materials and Resources” (and an overall weighting of 2.2 %). LEED for Homes offers two options to comply with the requirements:

a) Reduced construction waste. Generate 2.5 pounds (or 0.016 cubic yards) or less of net waste (not including waste diverted for reclamation or recycling) per square foot of conditioned floor area. Use column 1 or 2 and column 5 of Table 19 to determine the score.

b) Increased waste diversion. Divert 25 % or more of the total materials taken off the construction site from landfills and incinerators. Use column 3 or 4 and column 5 of Table 19 to determine the score; calculate the percentage using either weight or volume.

Note: Land clearing and demolition waste (e.g. from removal of preexisting structures on the site) should not be counted in this calculation.

Table 19: Table to determine the score for increased waste diversion[80]

Amount to landfills and incinerators				
Reduced Construction Waste		Increased Waste Diversion		Points
Pounds/ft²	Cubic yards/1,000 ft²	Percentage waste	Percentage diverted	
4.0	25.5	100%	0%	0.0

[80] LEED for Homes Rating System, p.84

Amount to landfills and incinerators				
Reduced Construction Waste		Increased Waste Diversion		Points
Pounds/ft²	Cubic yards/1,000 ft²	Percentage waste	Percentage diverted	
3.5	22.3	88%	13%	0.0
3.0	19.1	75%	25%	0.5
2.5	15.9	63%	38%	1.0
2.0	12.8	50%	50%	1.5
1.5	9.6	38%	63%	2.0
1.0	6.4	25%	75%	2.5
.5	3.2	13%	88%	3.0

Acceptable strategies for waste diversion include: Recycling; Third-party scrap reuse; On-site grinding of engineered lumber, untreated cellulosic material, and gypsum for use as a soil amendment.
Unacceptable strategies for waste diversion include: Scrap reuse by the builder; Burying unground material on-site; Packing unused material into wall cavities; Grinding treated / finished wood as soil amendment; Incineration, even waste-to-energy applications
If waste is processed by a waste management facility, the average monthly or annual diversion rate for the entire facility may be used for the purposes of this credit. This option is only acceptable if the waste facility data is available and verified by the Green Rater."

Construction Site (Environmental) Impacts

Only impacts to soil are considered within LEED for Homes with respect to construction site activities (summarized to the subcategory SS1 Site Stewardship):

- SS1.1 Erosion Controls during Construction
- (which is a mandatory measure to achieve LEED rating)
- SS1.2 Minimize Disturbed Area of Site

All other issues assessed under the main category Sustainable Sites (SS) refer to the use stage of the building (Landscaping, Reduction of Local Heat Island Effect, Surface Water Management, Non-Toxic Pest Control and Compact Development). Construction site related issues (SS1.1 und SS1.2) contribute to one of 22 achievable points (within Sustainable Sites) and are therefore marginally weighted although the requirement for erosion controls during construction is a prerequisite.

<u>SS 1.1 Prerequisite: Erosion Controls During Construction</u>

"Erosion control measures must include all of the following:

a) Stockpile and protect disturbed topsoil from erosion (for reuse).

b) Control the path and velocity of runoff with silt fencing or comparable measures.

c) Protect on-site storm sewer inlets, streams, and lakes with straw bales, silt fencing, silt sacks, rock filters, or comparable measures.

d) Provide swales to divert surface water from hillsides.

e) If soils in a sloped area (i.e., 25%, or 4:1 slope) are disturbed during construction, use tiers, erosion blankets, compost blankets, filter socks and berms, or some comparable approach to keep soil stabilized."

The scheme LEED New Construcion & Major Renovations (2009) which is applicable for high-rise residential buildings (> 3 storeys) specifies the SS prerequisite 1 (Construction Activity Pollution Prevention) as follows:

"For achieving a SS Prerequisite 1 an erosion and sedimentation control plan during design phase of the project must be created. The plan must conform to the erosion and sedimentation requirements of the 2003 EPA Construction General Permit[81] or local standards and codes, whichever is more stringent.
The plan must describe the measures implemented to accomplish the following objectives:

- To prevent loss of soil during construction by stormwater runoff and/or wind erosion, including protecting topsoil by stockpiling for reuse.
- To prevent sedimentation of storm or receiving streams
- To prevent pollution of the air with dust and particulate matter

Consider employing strategies such as temporary and permanent seeding, mulching, earthen dikes, silt fencing, sediment traps and sediment basins."

Whereas the current version of LEED for Homes applicable for small residential buildings (< 4 storeys) does not consider any measures to attenuate dust from construction site activities (the focus lies on erosion control and prospective planting), the more advanced (and comprehensive) scheme of LEED-NC 2009 re-names issue SS1 as "Construction Activity Pollution Prevention" and includes prevention measures of dust as well as particulate matter.

SS 1.2 Minimize Disturbed Area of Site (1 point)

To achieve one point, the following requirements have to be met depending on the lot's size and its previous status:

"Where the site is not previously developed[82]:
a) Develop a tree or plant preservation plan with "no-disturbance" zones clearly delineated on drawings and on the lot (see Note 1 below).
b) Leave undisturbed at least 40% of the lot area, not including area that is legally protected from disturbance, not including area under roof. Only softscapes can be counted toward this credit; projects cannot receive credit for preserving preexisting hardscapes, such as driveways.
OR
Where the site is previously developed:
c) Develop a tree or plant preservation plan with "no-disturbance" zones clearly delineated on drawings and on the lot (see Note 1 below), and rehabilitate the undisturbed portion of the lot by undoing any previous soil compaction, removing existing invasive plants, and meeting the requirements of SS 2.2 (see Note 2, below).

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[81] The EPA's (U.S. Environmental Protection Agency) construction general outlines the provisions necessary to comply with Phase I and Phase II of the National Pollutant Discharge Elimination System (NPDES) programm. More information is available under http://cfpub.epa.gov/npdes/stormwater/cgp.cfm
[82] Undeveloped sites with substantial amounts of garbage and/or invasive weeds should be treated as previously disturbed sites.

OR
d) Build on site with a lot area of less than 1/7 acre, or with housing density for the project that is equal to or greater than 7 units per acre. For multifamily buildings, the average lot size shall be calculated as the total lot size divided by the number of units.

Notes:
1. Any “non-disturbance” zones must be protected from parked construction vehicles and building material storage. Soils compacted by vehicles or stored materials can cause major difficulties in establishing any new landscaping.
2. Homes on previously developed lots that disturb the entire lot during construction can earn this credit by meeting the requirements in part c) above.”

Social Responsibility

Noise or dust attenuation during the construction phase as well as further social criteria taking into account the interests of affected groups (neighbours, operatives, visitors on site, or the public in general) are not part of LEED for Homes rating system. LEED-NC 2009 takes into account air pollution prevention measures with respect to dust and particulate matter.

10.5. DGNB

Draft criteria – residential buildings (May 2010)

Apart from related issues, the DGNB scheme for residential buildings summarizes all construction-site relevant aspects in one sub-category named “Construction Site – Construction Process (Steckbrief 48)” under the main category “Process Quality” assessing:
1. Low-noise construction sites
2. Low-waste construction sites
3. Low-dust construction sites
4. Avoidance of soil contamination

These four issues are weighted equally within the sub-category “Construction Site – Construction Process.”

The following analysis assigns these topics to the headings used above to categorise construction-site related effects reverting to resource efficiency (construction waste management), social impacts (noise, dust, safety,..) and environmental impacts (erosion control,…).

Construction Waste Management

Low-waste construction sites[83]

The highest performance level is achieved in case of
- the statutory minimal requirements of the Waste Recycling and Management Law[84] are met,

[83] Subissue of “Construction Site- Construction Process"
[84] Kreislaufwirtschafts- und Abfallgesetz: Gesetz zur Förderung der Kreislaufwirtschaft und Sicherung der umweltverträglichen Beseitigung von Abfällen

- training of all employees in diverting and reducing construction waste
- monitoring of unmixed waste diversion at central waste separation points through construction site management
- separation of building materials into at least mineral waste, recyclable fractions, mixed construction debris, dangerous substances und asbestos-containing waste.

Life Cycle Assessment

Impacts as well as waste disposal from construction site activities are definitely excluded from the scope of Life Cycle Assessment which is required for the following impact and resource criteria GWP; POCP, ODP, AP, NP, non-renewable primary energy and total primary energy demand as the effects of construction site activities are regarded as insignificant and negligible within the whole lifecycle of a building whereas transports will be integrated in one of the next versions[85].

Waste disposal must be assessed for all materials at the end of lifetime of the building and all replaced building materials during use stage (phase of consideration 50 years). Ways of disposal ways are prescriptive for the following product groups as listed below:

(1) Metals - recycling
(2) Mineral materials – processing of construction rubble
(3) Materials with heating value (wood, plastics, etc.) – thermal utilisation
(4) Heating generation systems – according to data in Ökobau.dat[86]
(5) All other materials disposable to construction waste landfills or household garbage dumps – disposal to landfill

Life Cycle Costs

Neither waste disposal costs for constructing nor for demolishing the building are taken into account in the calculation method of LCC (Life Cycle Costs) as defined in the draft version of DGNB certification system for residential buildings[87].

Design for reassembly, reuse and recycling is one main criterion within DGNB considering buildings as resources for future building materials. The optimisation and reduction of site-related construction waste is not dealt with.

Environmental Impacts (to soil)

Within the sub-category "Construction Site – Construction Process" environmental impacts resulting from construction site activities are assessed only with respect to soil

4. Avoidance of impacts to soil
Soil contamination through chemical substances must be prevented as well as harmful soil compaction or mixture of different soil layers.

Technische Anleitung zur Verwertung, Behandlung und sonstigen Entsorgung von Siedlungsabfällen (Dritte Allgemeine Verwaltungsvorschrift zum Abfallgesetz) vom 14. Mai 1993
Verordnung über die Nachweisführung bei der Entsorgung von Abfällen

[85] DGNB Draft Scheme Residential Buildings - May 2010, Steckbriefe 1-5, 10-11

[86] Ökobau.dat (Informationsportal Nachhaltiges Bauen > Baustoff- und Gebäudedaten)

[87] DGNB Draft Scheme Residential Buildings - May 2010, Steckbrief 16

Social Responsibility

Within the main category “Process Quality”, several issues refer to social aspects ensuring noise and dust attenuation as well as adequate working conditions and health protection measures at the building site. Procedures for pre-selecting construction firms and the complete documentation of all materials and substances used at the construction site (including handling instructions for workers) shall both increase safety.

48. Construction Site – Construction Process

1. Low-noise construction sites[88]
Noise arising from construction site activities shall be lower than the outdoor ambient noise level or requirements defined in tender documents. Verification must be provided by measurements (for the best level to achieve).

3. Low-dust construction sites
As specified within DGNB certification system, dust attenuation is especially a topic of workplace safety. The impacts on neighbourhood and corresponding prevention measures are not taken into account although neighbourhood indirectly benefits from the dust prevention measures described below:
Machines have to be equipped with efficient exhaustion according to the state of technology. Dust has to be collected and disposed as close as possible to its **place of origin in order to avoid distribution to working areas which are not affected.** Wet or suction processes are to prefer. Machines and technical equipment to avoid dust have to be regularly maintained.

45. Optimisation of the Planning Process

Even more attention on safe working conditions at the building site is paid by the requirement for a so-called “SiGe”-Plan[89] within the issue “Optimisation of the Planning Process”. A coordinator responsible for all safety and health protection measures at the building site has to be appointed and a safety plan (specified to the building site) developed and implemented. Apart from this site related safety measures, energy and water saving strategies, optimisation proposals for daylighting, design variants, strategies to ease maintenance and monitoring as well as waste management concept and design for reassembly, reuse and recycling are awarded within this issue. The planning results shall be approved by an independent third party.

46. Integration of sustainability requirements in tendering and award procedures

Scores are awarded within the main category “Process Quality” if requirements for e.g.

- Recycling management
- Waste Management on site

[88] References cited in the draft version: „§ 27 des Bundes-Immissionsschutzgesetzes vom 15. März 1974 (BGB1I S. 721), neu gefasst durch die Bekanntgabe vom 14. Mai 1990 (BGB1 III 2129-8)
RAL, 2007, Grundlage für Umweltzeichenvergabe Lärmarme Baumaschinen RAL-UZ 53
EG,2000, Richtlinie über umweltbelastende Geräuschemissionen von zur Verwendung im Freien vorgesehenen Geräten und Maschinen Outdoor-Richtlinie 2000/14/EG“
[89] Sicherheits- und Gesundheitsschutzplan, Baustellenverordnung (BaustellV) 01.07.1998
The requirements set with respect to safety and health protection does not exceed regulations

- Safety at work
- Building materials with low environmental impacts
- Basic and advanced training of operatives etc.

are implemented in tendering documents
The selection of companies may consider SA900-Standard (Social Assessment) and Ökokauf-Criteria developed by IFZ Graz (http://www.ifz.tugraz.at/oekoeinkauf/).

49. Qualification of Constructors

By fulfilling the requirements of pre-qualification constructors demonstrate their reliability, expertise and technical capability.

50. Quality Assurance of the Construction Process

Required is the documentation of all materials and substances used (including material safety data sheets and handling instructions for workers at the building site).
Measurements (of airtightness, noise attenuation, ..) shall demonstrate compliance with the targets set in the design stage.

10.6. TQB (Total Quality Building)

Construction site related issues are assessed within the category “B2. Construction Site Management” which is weighted by 15 % within the main category “B. Economic and Technical Performance” resulting in an overall assessment of 3 %[90] (30 of 1000 points).

TQB distinguishes between large-scale[91] and average building sites and construction sites including refurbishment measures. For large-scale buildings, the requirements for transport management, sorting of construction waste, the coordination of environmental protection measures at the building site as well as information policy are tightened compared to average building sites. For urban revitalization projects combined with the extensions of buildings, the recommended measures have been adopted to the specifications of inner-city building sites. The detailed assessment criteria follow the recommendations of RUMBA[92] and are defined as follows:

[90] TQB-Kriterienkatalog (TQB catalogue of criteria), status 22.07.2010
[91] Large-scale building sites are defined as follows: > 50,000m² gross floor area (including underground parking) and > 15,000m² plot area
[92] RUMBAGuidelines for Sustainable Building Site Management: Short Report (Project of the EU-LIFE program; ed. Vienna City Administration, Office for Urban Planning, Development and Construction of the city of Vienna; project partners: OEKOTECHNA - Entsorgungs- und Umwelttechnik Ges.m.b.H.; Rosinak & Partner ZT GmbH, raum & kommunikation, Austrian Institute for Applied Ecology, Oct. 2004)

Table 20: TQB assessment criteria for construction site management

Average construction sites	**Points**
Transport management: Site-related truck traffic volume is reduced by avoiding empty (unloaded) drives from the building site. The use of low-emission trucks (according to Euro IV and V) and low-polluting wheeled loaders and other construction machines used at the construction site is prescribed in the tender documents in order to lower particle and CO_2 emissions.	5
Containers are provided for sorting construction waste. The diversion of waste fractions exceeds the regulations' requirements[93].	5
Reduction of disposal trips through the use of 10m³ containers instead of 8m³ containers.	5
No free storage of sand and debris by the use of small containers, evacuation of the containers with a net coverage, coverage of the containers with nets outside the operation hours of the building site	5
Excavated material is at least partially re-used at the building site (e.g. for refilling or landscaping), interim storage of the excavated material is provided at the construction site	5
Water supply connection exists at the building site, waste groups during the reloading are wetted.	5
Large-scale construction sites	
Site-related truck traffic volume is reduced by avoiding empty (unloaded) drives from the building site. Existing railway connecting lines (rolling-container-transport system RCTS) or waterways are used for transports – if applicable. Building logistic management: documentation of the transports (central building site access), in particular for the heavy transportation groups excavation, pre-fabricated parts, site-mixed concrete and other carcass materials	5
One or more sorting stations for construction waste management are installed at the building site, waste is diverted by qualified persons[94]. Waste sorting exceeds the regulations' requirements.	5
No free storage of sand and debris by the use of small containers, coverage of the containers with nets outside the operation hours of the building site, evacuation of the containers with a net coverage	5
Excavated material is at least partially re-used at the building site (e.g. for refilling or landscaping, ...), interim storage of the excavated material is provided at the construction site.	5
Gravel or paved building site streets for trucks and construction machines, current cleaning of tires in a tire washing plant, wetting of the waste groups during the reloading in order to avoid dust	5
Appointment of an environmental co-ordinator, information for visitors, suppliers, complaining point, consulting for operating companies, training and a shaping of consciousness of the foremen at the start of the project	5
Construction sites including refurbishment	
Separate collection of the building wastes in collecting facilities (e.g. containers). Waste sorting exceeds the regulations' requirements.	5
Reduction of disposal trips through the use of 10m³ debris and bulky goods containers instead of 8m³ containers.	5
No free storage of sand and debris by the use of small containers, evacuation of the containers	5

[93] Baurestmassenverordnung - Verordnung des BM für Umwelt, Jugend und Familie über die Trennung von bei Bautätigkeiten anfallenden Materialien BGBl. 259/1991 in der jew. güligen Fassung
Abfallwirtschaftsgesetz AWG, BGBl. 325/1990 in der jew. güligen Fassung
Deponieverordnung 2008 BGBl. II Nr. 39/2008 in der jew. güligen Fassung

[94] Sorting stations are cheaper than the principle of the individual disposal of mixed building wastes by the professionists themselves.

with a net coverage, coverage of the containers with nets outside the operation hours of the building site.	
Wetting of the waste groups during reloading, current cleaning of the free pavements and parking areas	5
Installation of blinds and dust shield nets Fencing and installation of overhead barriers of the entire building site range including pavement, parking area, cycle lane and green areas	5
Use of crane containers instead of debris chutes in order to avoid noise and dust	5

Max. 30 points are achievable, mandatory requirements are not defined.

Construction Waste Management

The target values for sorting waste shall exceed the established practice of statutory requirements. But not only the utilization-ratio of building wastes shall be improved by detailed separation already at the building site. Emissions (and noise) resulting from transports of waste from the site shall be reduced by the use of large-scale containers. Waste Management at the end of lifetime of a building is assessed by using a so-called "disposal indicator" (see chapter LCA).

Environmental Impacts

Besides air pollution (resulting from transports to and from the construction site), environmental impacts to soil and biodiversity are taken into account. The ecological value of the site is assessed (before construction will start) and measures ensuring biodiversity after completion of construction activities are awarded (A2.2. Quality of construction site). Environmental impacts to ground water or water courses on site are not assessed.

Social Indicators

Noise and dust attenuation are primarily considered as loadings on the neighbourhood. Noise emissions are reduced by lowering the truck traffic volume to and from the site. Additional noise limitation requirements for construction machines are not integrated into the assessment as statutory occupational health protection measures cover this topic anyway. Measures to avoid dust are defined for almost all relevant processes at the building site leading to a noticeable reduction of dust emissions as demonstrated in several pilot projects in Vienna[95]. Occupational safety and health protection measurements have not been included into the assessment of construction sites due to high regulation requirements in Austria[96].

[95] Thürnlhof, Wien-Simmering: approximately 900 dwellings at two building sites
Kabelwerk, Wien-Meidling: new quarter with approximately 900 dwellings, offices, a hotel, and culture and leisure facilities; Weyringerstr., Wien-Wieden: small-size residential building

[96] ArbeitnehmerInnenschutzgesetz (ASchG): Bundesgesetz über Sicherheit und Gesundheitsschutz bei der Arbeit, zuletzt geändert durch BGbl. II, Nr.221/2010
Bundesgesetz über die Koordination bei Bauarbeiten (Bauarbeitenkoordinationsgesetz - BauKG), BGBl. I Nr. 37/1999, zuletzt geändert durch BGBl. I Nr. 42/2007
BauV – Bauarbeiterschutzverordnung, Verordnung des Bundesministers für Arbeit und Soziales über Vorschriften zum Schutz des Lebens, der Gesundheit und der Sittlichkeit der Arbeitnehmer bei Ausführung von Bauarbeiten, BGBl.Nr. 340/1994, zuletzt geändert durch BGBl. II Nr. 21/2010 (AM-VO und BauV-Novelle*)*
Sicherheit am Bau Die Baumappe - eine Arbeitshilfe für alle, die Verantwortung für die für die Gesundheit der am Bau Beschäftigten und für den Betrieb tragen(Hg. von AUVA, Bundesinnung Bau, Wien, Juni 2010)

Detailed information of neighbours and the public in general (including contact points for complaints) are reserved to large-scale building sites in the current version of TQB, but will probably be integrated for "average" building sites in future versions.

10.7. Summary and Conclusions – Construction Site Management

Summary

Construction sites are responsible for various impacts, especially at a local level. These arise from disturbance (noise, dust, etc.), pollution and waste. The weighting of construction site related issues is usually marginal (at about 3% of all achievable credits)[97] compared to criteria assessing the use stage of the building. Nevertheless, they illustrate a phase within the building's lifecycle in which social impacts are extended to neighbourhood and workers at the building site.
The analysed building assessment systems refer to similar impacts caused by building site activities (construction waste, noise, dust, environmental impacts to soil, water), but use different indicators for rating.
Ratings differ in scope and subject of assessment, extent of impact and groups affected by the considered impact.
Example "dust": Dust avoidance in DGNB primarily refers to working conditions and handling of construction machines generating dust (main target group: operatives). TQB considers dust prevention measures primarily in order to avoid disturbance of neighbours, although workers benefit as well from dust attenuation at the building site (e.g. interdiction of free storage of sand and debris; grave or paved building streets; wetting of waste during reloading, etc.).

Apart from CSH and DGNB, working conditions during construction are not part of assessment systems of buildings.

CSH, the Code for Sustainable Homes offers the most comprehensive evaluation for construction sites using an established **third-party certification** scheme of the construction industry ("Considerate Constructors") to detect and assess all relevant impacts of construction site activities including operational safety and health protection measures and cleanliness of site as well as information policy and a code of behaviour for operatives.
Besides this certification scheme, CSH additionally awards the **ecological value of site** and its conservation, monitoring of **energy and water consumption** of building site activities and responsibly resourcing of construction timber.

Third Draft for EU Ecolabel mainly relies on **process-related criteria**. It asks for certification of constructors (e.g. QMS, EMS) and approved experience of designers in ensuring quality of planning and construction. CSH, the Code for Sustainable Homes as well as all BREEAM (based) schemes refer to QMS and EMS by assessing the production process of materials, but not construction site activities.
DGNB also includes several process-related assessment criteria (such as integration of sustainability requirements in tender guidelines, quality of design process, quality of

[97] CSH, TQB, LEED for Homes

constructors, quality assurance of construction, integrated design process) which do not include target values to achieve, but processes to pass.

LEED for Homes mainly focuses on construction waste management and **protection measures for soil** to guarantee prospective planting and landscaping.

Reduction, diversion, re-use, recycling of **construction site waste** is assessed in almost all systems (apart from SBTool applicable for small residential buildings where the waste arising in the construction phase is neglected).

E**nergy and water use** are minor impacts in relation to the overall impacts of the building and therefore usually not assessed (CSH requires setting targets for site-related energy and water consumption and monitoring measures for verification).

Emissions resulting from transports to and from site are usually not directly assessed, but taken into account by the requirement for **regional materials and products**. Reduction of the **building site traffic** by avoidance of unloaded trips (from the site) and by higher usage of trains or waterways (if applicable) is only assessed within TQB (for more information to traffic-related issues; see also chapter “Energy and CO_2 Emissions).

Table 21: Construction site management related indicators in different building assessment systems

	EU Eco-label	SBTool resid.	SBTool mixed use	CSH (BRE)	LEED f. Homes	DGNB resid.	TQB resid.
Construction Site Management							
Waste Management							
Construction phase	● (1)		●	●	●	●	●
Environmental Impacts							
Erosion Control		●	●	● (5)	●		
Soil contamination				● (5)		●	
Ecological diversity			●	● (5,6)	●		●
Impact to water			●	● (5,6)			
Monitoring of energy, water consumption on site				●			
Building site timber responsibly sourced				●			
Traffic-related emissions	● (13,14)	● (14)	● (14)		● (14)	(10)	● (14,15)
EMS (constructors)	● (1)						
LCA (incl.constr.site)	● (1)					(10)	
Social Responsibility							
Noise attenuation	● (2)			● (5)		●	●
Dust attenuation - neighbourhood	● (2)			● (5,6)	● (8)		●
Dust attenuation - operatives						●	
Workers’ health and safety			●	● (5)		●	

	EU Eco-label	SBTool resid.	SBTool mixed use	CSH (BRE)	LEED f. Homes	DGNB resid.	TQB resid.
Social facilities (site)	● (2)			● (5)			
Information of neigh-bours / public				● (5)			● (12)
Contact point for complaints				● (5)			● (12)
Certification Schemes / Process Quality							
Certification Scheme site-related				● (7)			
Certification Scheme constructors	● (3)					● (11)	
Experience of designers (in waste reduction,…)	●	●					
Target values defined in tender documents	●					●	●

grey font: not yet specified

(1) only optional criterion
(2) not yet specified, reference to prEN 15643-3:2010 where these issues are not yet defined
(3) QMS, EMS, CSR
(4) Use of durable products
(5) assessed within Considerate Constructors Scheme
(6) assessed within Considerate Constructors Scheme and additionally within separate criterion
(7) Considerate Constructors Scheme: site related third-party certification
(8) only in LEED-NC 2009 applicable for high-rise buildings (> 3 storeys)
(9) building stage is integrated in LCA (assessing GWP, POCP, ODP, NP, AP, PE non-ren., PE total)
(10) Effects of construction site activities are regarded as insignificant within the LCA of a building whereas transports will be integrated in one of the next versions (the same is applicable for LCC)
(11) pre-qualification of constructors
(12) only applicable for large-scale building sites
(13) considered within required LCA of the building
(14) use of regional materials and products
(15) transport management system (reduction of unloaded drives from the site), use of railways and waterways, if applicable; documentation of the transports (central building site access), in particular for the heavy transportation groups; use of regional products

Conclusions

Construction site activities are responsible for environmental impacts (e.g. soil erosion, soil contamination, loss of biodiversity, air pollution, waste) and nuisances such as dust and noise (caused by traffic from and to the building site, construction machines, etc.).
The analysis of different building assessment systems shows two different approaches in defining criteria to minimise these effects:

- Process-oriented ratings (i. e. existence of Quality Management Systems, experience of designers in waste reduction, implementation of Environmental Management Systems or other certification schemes by constructors). These criteria aim at a continuous improvement of processes on the construction site, but do not guarantee the fulfilment of definite objectives.
- Target-oriented ratings: require specific measures to be set on construction site and provide detailed information to achieve defined target values or levels of quality.

The authors recommend preferring target values which allow clear benchmarks and comparison of rating results achieved in different projects.

The main issues of concern as defined in most of the analysed environmental building assessment systems are the following:

- avoidance of traffic related emissions and noise attenuation through building logistic management:
    - lowering the truck traffic volume to and from the site,
    - using alternative means of transports,
    - claiming obligatory documentation of all transports to and from site),
    - use of low-emitting and low-noise trucks and construction machinery complying with ecolabel criteria (e. g. blue angel[98])
- dust attenuation
    - wetting of the waste groups during reloading,
    - interdiction of free storage of sand and debris,
    - pavement of site roads,
    - cleaning of tires in a tire washing plant,
    - installation of dust shield nets during renovation, etc.
- appropriate information policy for neighbours and public in general
    - contact point for complaints (on site),
    - appointment of a responsible person
- appropriate waste management
    - detailed waste sorting and instruction of workers
    - reuse of excavation material on site – if possible
- erosion control and protection of the ecological biodiversity on site – where relevant

Energy and water consumption at the construction site is considered to be negligible in comparison to the operation phase of the building and need not to be monitored as well as material flows for construction activities (e.g. building site timber and its responsible sourcing)

LCA-based approaches (using main indicators such as primary energy, GWP, ODP, POCP, AP, NP,..) underemphasize construction site relevant impacts (on human health and local environment), the effects of this phase disappear in comparison to long-lasting phases such as operational or renovation phases. They may provide additional information on impact categories and resource consumption (including construction site activities) but do not already include optimisation steps.

Therefore, indicators (in form of detailed measures as defined above) are recommended to detect the weaknesses of construction site activities and to optimise all relevant processes.

[98] Low-Noise Construction Machinery (RAL-UZ 53): Basic Criteria for Award of the Environmental Label “Der blaue Engel” (ed. RAL German Institute for Quality Assurance and Certification, Febr. 2007)

11. CHEMICALS IN BUILDING MATERIALS AND EMISSIONS TO INDOOR AIR

11.1. Background

Overview

High quality of indoor air is an essential condition for the protection of health, both in the living and working environment. Progress has been made concerning the restriction and ban of some particularly toxic substances in building materials, such as asbestos and pentachlorophenol. Nevertheless, the last years have seen increasing complaints about harmful effects on well-being (e.g. sick building syndrome) caused by the largely unregulated use of potentially toxic substances in building materials and furnishings. Additionally, saving energy by making buildings more airtight has had the effect of more effectively trapping gases released through the use of cleaning products or air fresheners, heating or cooking and last but not least from furniture and construction materials. In addition, outdoor sources may contribute to indoor air pollution. Microbiological contaminants also require consideration.
Hence, indoor air may contain over 900 different chemicals, particles, and biological materials with potential health effects (SCHER, 2009). The concentrations of these chemicals are usually higher indoors than outdoors. Since human beings generally spend more than 90 % of their lifetime indoors nowadays, these circumstances may lead to a daily intake that is close to or in some cases even higher than the tolerable daily intake value (TDI) set for these individual substances. The reaction to indoor air pollutants differs within the population and has been dealt with in a large number of publications. Examples of potential serious effects are respiratory disorders, including asthma, irritation of the mucous membranes of the eyes, nose and throat, effects on the nervous system and long-term effects as cancer. Data suggest e.g. that increased chemical exposure in indoor environments may be one reason behind the rapid rise in childhood asthma, for example.

Among the sources for indoor air pollutants building materials are of particular importance. This means that we need chemical requirements also to be set for building materials. This is especially true when considering the protection of sensitive population groups as children, old or ill people. But substances contained in or emitted from building materials may not only

- affect the health and productivity of the inhabitants, but may also
- cause health occupational or other acute or chronic diseases of craftsmen and
- have harmful impacts on the environment during manufacturing and disposal (e.g. toxic red slag disaster in Hungary).

Hence, many organisations occupying themselves with the environmental performance of buildings believe that it is appropriate to apply the precautionary principle when selecting and specifying building materials. In principle two different lines can be taken in order to avoid disadvantageous impacts from hazardous chemicals in building materials:

1. Ban of hazardous substances (ban of classes of substances (CMR PBT)
2. Limits for emissions to indoor air

Building assessment systems as well as programs for improving the environmental performance of products (ecolabels, green public procurement) pursue both directions.

European legislation regarding hazardous substances in building products

In POULSEN et al (2010) an investigation on the European legislation regarding chemicals in consumer products was carried out. Two types of legislation were reviewed: product legislation[99] and chemical legislation (i.e. REACH).
The authors overall conclusion from the review is "that the current legal framework is insufficient because very few chemical requirements in general exist for consumer products. Chemical requirements are:
- missing entirely in the General Product Safety Directive (only "products must be safe"),
- inadequate in REACH, Toy Safety Directive and ROHS (too few substances restricted or not strict enough to protect human health), or
- just related to regulations in Member States (Construction Products Directive)."

Another area of criticism is the use of weak phrases in the product legislations instead of using specific limit values or other more "solid" requirements. Weak phrases like "products must be safe" or "human health may not be endangered" are difficult to act on. They should be replaced by either specific limit values or harmonised standards that set limit values.

The following chapters summarise the main findings of POULSEN et al (2010) concerning the European legislation (REACH, Toy safety directing, GPSD, ROHS, CPD and CPR) as far as they touch topics related to construction products.

Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)

The new European Chemicals regulation REACH[100] stands for the Registration, Evaluation, Authorisation and Restriction of Chemicals. REACH regulates the handling of chemicals, no matter whether they have hazardous properties or not.

All substances manufactured or imported in quantities greater than 1 tonne per year must be **registered** within ECHA (European Chemicals Agency).

The adequacy of the registered data and the quality of dossiers is **evaluated** in three ways (ECHA 2010):
- compliance check whether or not the information submitted is in compliance with the law
- examination of testing proposals.
- substance evaluation whether the use of a substance may cause a serious risk to human health or the environment

Substances subjected to authorisation are listed in Annex XIV of REACH ("**Authorisation List**"). The following substances may be included in Annex XIV (according to article 57 of the REACH Regulation):
(a) carcinogenic substances (category 1 or 2 according to 67/548/EEC);
(b) mutagenic substances (category 1 or 2 according to 67/548/EEC);
(c) substances which are toxic for reproduction (category 1 or 2 according to 67/548/EEC);

[99] Product legislation is legislation where products are in focus, like e.g. General Product Safety Directive and Toy Safety Directive.

[100] REACH Regulation (EC) no 1907/2006 of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals

(d) persistent, bioaccumulative and toxic substances (PBT substances) according to the criteria set out in Annex XIII to the REACH Regulation;
(e) very persistent and very bioaccumulative substances (vPvB substances) according to the criteria set out in Annex XIII to the REACH Regulation;
(f) substances - such as those having endocrine disrupting properties or those having persistent, bioaccumulative and toxic properties or very persistent and very bioaccumulative properties, which do not fulfil the criteria of points (d) or (e) - for which there is scientific evidence of probable serious effects to human health or the environment which give rise to an equivalent level of concern to those of other substances listed in points (a) to (e) and which are identified on a case-by-case basis in accordance with the procedure set out in Article 59.

According to this Article 59 substances of very high concern (SVHC) may be identified in the framework of the authorisation process. These SVHC are candidates for eventual inclusion in the “Authorisation List” and therefore compiled in the so called “Candidate List". The Candidate list can be downloaded from the website of the European Chemical Agency (ECHA): http://echa.europa.eu/chem_data/authorisation_process/candidate_list_table_en.asp#download

Dangerous substances, mixtures and articles subjected to restrictions on manufacture, placing on the market and use are listed in Annex XVII to Regulation (EC) No 1907/2006.

POULSEN’s et al (2010) concerns in relation to REACH are:
- REACH has many good intentions (e.g. burden of proof lies on the producer) but the implementation period is long and procedures (e.g. for substance evaluation, authorisation restrictions) are slow (25 substances/year - 1500-2000 (SVHC) chemicals - 60-80 years).
- The data requirements of REACH depend primarily on the amount of substance sold and not on the hazardness of the substances.
- REACH implements almost no requirements towards content of chemicals in consumer products.
- REACH relies to a large extent on industry self-assessments.

Furthermore, the market surveillance of illegal consumer products (because of hazardous chemical substances) should be much more focused on and more intensely to ensure that only safe products are on the market.

General Product Safety Directive (GPSD)

The General Product Safety Directive (GPSD)[101] can be taken as an example to support the criticism concerning the use of weak phrases: The GPSD is intended to ensure a high level of product safety throughout the EU for consumer products that are not covered by specific sector legislation (e.g. cosmetics). It shall protect the consumers from dangerous products. "Dangerous products" means products that are not safe because of their physical shape or because of the content of dangerous chemicals ("products must be safe"). A numerous list of European harmonised standards based on the GPSD has been established. Examples are general safety requirements for outdoor furniture, stationary training equipment, children furniture, soothers for babies and young children.
The Directive provides for an alert system (the RAPEX system – rapid exchange of information on dangerous consumer products) between Member States and the Commission. Under certain conditions (e.g. urgency is required or when Decisions are the most effective way of eliminating the risk), the Commission may adopt a formal Decision requiring the Member States to ban the marketing of an unsafe product, to recall it from consumers or to withdraw it from the market. A Decision of this kind is only valid for a maximum of one year.

Chemical requirements are neither set in the GPSD nor are they a general feature in the standards related to the GPSD. In the few cases where chemical requirements were specified in the related harmonised standards, only a few chemicals were listed (like certain heavy metals and nitrosamines). Almost all of the related harmonised standards merely refer to the physical safety of the products.
Additionally, as the RAPEX notifications show, most of the unsafe products that are withdrawn are withdrawn for physical reasons. Notifications for chemical reasons are mainly made due to the lack of compliance with restrictions on chemical substances e.g. REACH annex XVII (DMF, phthalates, aromatic amines) or because they do not comply with the harmonised standards connected to the GPSD. Only few notifications (if any) are made due to "products must be safe". This means that loose statements do not seem to work for market surveillance either. It is much easier to handle limit values.

Finally, the General Product Safety Directive does not provide an instrument to establish chemical requirements for consumer products other than emergency measures for one year and the instrument to establish standards. This means that only provisional rules can be set by use of the General Product Safety Directive.

A committee procedure (comitology) is, however, in place for the process of adopting product specific safety requirements which serve as a basis for mandates and existing (non-mandated) standards connected to the General Product Safety Directive.

Restriction Of the use of certain Hazardous Substances (ROHS) Directive

The intention of the ROHS[102] Directive is to reduce the content of hazardous substances in waste by e.g. limiting the presence of certain hazardous substances in products (preamble no. 3). (POULSEN et al, 2010).

ROHS restricts the use of lead (Pb), mercury (Hg), cadmium (Cd), hexavalent chromium (Cr VI), polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE) in electrical

[101] Directive 2001/95E/EC on general product safety
[102] Directive 2002/95/EC of 27 January, 2003

and electronical equipment (called "EEE"). The maximum concentration limits for these substances are 0.1 % (w/w) in homogenous materials for all substances except cadmium where the maximum concentration limit is 0.01 % (w/w) for homogenous materials (Commission Decision 618, 2005, acc. to POULSEN et al, 2010).
It is valid for large and small household appliances, IT and telecommunication equipment, consumer equipment, lighting equipment, electrical and electronic tools (with the exception of large-scale stationary industry tools), toys, leisure and sports equipment, and automatic dispensers.
The Öko-Institut claims that ROHS should be extended to other hazardous substances (TBBP-A, HBCDD, DEHP, BBP, DBP). Four of these substances (HBCDD, DEHP, BBP, DBP) are listed in Annex III of the new ROHS proposal (POULSEN et al, 2010)

Regulation of nanosubstances

A special topic which has also been investigated in POULSEN et al (2010) is the use of nanosubstances. Whilst the Commission considers the current regulatory framework sufficient to address risks relating to nanomaterials and only in need of some modifications at the implementation level, this position seems more than doubtful to the authors and is also not supported by the EU Parliament. Reasons for the doubt are various. The exposure behaviour and impacts on the environment are not investigated sufficiently yet, existing testing methods may not be appropriate for nanosubstances and will have to be adopted, and clear-cut assessment is missing.

Construction Products Directive (CPD) and Regulation (CPR)

For building materials the Construction Products Directive (CPD) and the proposal for the Construction Products Regulation (CPR) are of special interest.
The objective of the Construction Products Directive (CPD)[103] is to ensure that reliable information of construction products is presented in a common technical language. The manufacturer of the construction product is responsible for the attestation that the product is in conformity with the technical specifications set out by CEN in the harmonised standards, European Technical Approvals and national technical specifications. Hence, the CPD provides a framework for a harmonised testing and declaration scheme, but the building regulations are in the remit of the Member States. Member States are free to specify product requirements as long as they use the harmonised specifications. Annex I of the CPD lists essential requirements (ER) that the construction works has to satisfy:

1. Mechanical resistance and stability
2. Safety in the case of fire
3. Hygiene, health and the environment
4. Safety in use
5. Protection against noise
6. Energy economy and heat retention

The essential requirements shall be given in a concrete form in interpretative documents.

[103] Council Directive of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products, http://ec.europa.eu/enterprise/sectors/construction/construction-products/index_en.htm

With the Construction Products Regulation (CPR)[104] a new regulation will replace the existing Directive, but the goals and concepts stay the same as those of the CPD.

CPD and CPR do essentially not establish product requirements. This is also true for the "essential requirements" and the corresponding interpretative documents. Consequently, also chemical requirements are missing.
ER3 "Hygiene, health and the environment" specifies that "the construction works must be designed and built in such a way that it will not be a threat to the hygiene or health of the occupants or neighbours, in particular as a result of any of the following:

- The giving-off of toxic gas
- The presence of dangerous particles or gases in the air
- The emission of dangerous radiation
- Pollution or poisoning of the water or soil
- Faulty elimination of waste water, smoke, solid or liquid wastes
- The presence of damp in parts of the works or on surfaces within the works."

The Interpretative Document of the European Commission to the ER 3 "Hygiene, Health and Environment" (1994) explicitly mentions that indoor pollutants, e.g. volatile organic compounds (VOC), shall be avoided and controlled.
Meanwhile, in Annex I of the CPR the entire life cycle of the construction works is mentioned and it is specified that emissions of dangerous substances, volatile organic compounds, greenhouse gases or dangerous particles into indoor or outdoor air are not wanted. But still concrete requirements are missing.

Additionally, the specification of requirements is up to the Member States. If a Member State has no requirements on a specific parameter, the values will even not have to be declared ("No performance determined"). If e.g. a harmonized testing and declaration scheme on indoor air emissions from building materials is provided by CEN/TC 351 (see next chapter concerning European regulations concerning VOC-emissions), this will have no consequence in most Member States since only Germany and France have defined corresponding requirements yet.

Conclusions (POULSEN et al, 2010): "Neither the CPD nor the proposed CPR is an instrument to set requirements for chemicals in construction products, as they only are instruments that provide the framework for ensuring harmonised testing and declaration schemes. Furthermore, as the requirements themselves have to be prepared by the individual Member States, the CPD/CPR is not an instrument to ensure common European requirements for chemicals."

European Commission: "The objective of the CPD (and the CPR alike) is thus not to define the safety of construction products, but to ensure that reliable information is presented in relation to their performance. This is achieved by providing, mainly in standards, a common technical language, to be used not only by manufacturers, but also by public authorities when defining their requirements on construction works, directly or indirectly influencing the demands placed on the products to be used in them".
(http://ec.europa.eu/enterprise/sectors/construction/construction-products/index_en.htm)

[104] COM(2008) 311 final (proposal of 23 May 2008); the proposal has been approved while finalising the study

European regulations regarding emissions from building materials to indoor air

Emissions of hazardous substances to indoor air

Building products are important indoor sources of volatile organic compounds (VOC) which belong to the most common indoor air pollutants. VOC are an extremely heterogeneous and multifaceted group of substances and a standard definition is still missing. The definition in use is always linked to the applied sampling method. The most usual VOC definition in Europe (in the context of solvents) is the VOC definition of the Solvent Emissions Directive (EC Directive 1999/13/EC). According to this directive VOCs are functionally defined as organic compounds having at 293.15 K (i.e. 20 °C) a vapour pressure of 0.01 kPa or more, or having a corresponding volatility under particular conditions of use. For hydrocarbon solvents, a vapour pressure of 0.01 kPa at 20 ºC grossly corresponds to a boiling point in the range 215–220 ºC. The EU "Paint Directive" 2004/42/EC and the European Eco-Labelling scheme (2002/739/EC amending 1999/10/EC) for paints and varnishes define a VOC as an organic compound having an initial boiling point lower than or equal to 250 ºC at an atmospheric pressure of 101.3 kPa. (ESIG)
VOC in a broader sense has been defined by a working group of the World Health Organisation (WHO):

- Very volatile organic compounds (VVOC): boiling point from 0 °C to 50–100 °C
- Volatile organic compounds (VOC): retention range from C_6 to C_{16} (boiling point from 50–100 °C to 240–260 °C).
- Semi-volatile organic compounds (SVOC): retention range from C_{16} to C_{22} (boiling point from 240–260 °C to 380–400 C)
- Organic compounds associated with particulate matter or particulate organic matter (POM, e.g. PAH): boiling point > 380 °C

Experience shows that with increasing Total Volatile Organic Compounds (TVOC) concentration the likelihood of complaints and adverse health effects also increases. So TVOC can be and is widely used as a measure for indoor air quality. Nevertheless a common approach for TVOC definition along with an upper limit for TVOC is still missing. Additionally, there is a consensus that TVOC should not be used alone as an indicator.

VOC emissions from building products can be measured in **test chambers**. Harmonised European standards are still not available but elaborated by CEN TC 351. In the meantime ISO 16000-series standards – with variations – are mostly used for measurement. Important parameters that have an influence on the result are temperature, air exchange rate, relative humidity, air velocity in the test chamber, the amount or surface area of the material in the chamber and the method of sample preparation.

European regulation

While much progress has been made in Europe in tackling outdoor air pollutants with Community legislation, the European Community recognised only in recent years the importance of indoor air pollutants. „Action 12“ of EU Action Plan on Environment and Health (COM (2004) 416 final) intends to develop work on improving indoor air quality (SCHER, 2007).

Nevertheless, restrictions for emissions from construction products are sparse till now. It is primarily voluntary labelling systems for material emissions that are available in different EU countries. Only Germany has adopted an assessment scheme for flame retardant floor coverings and glues for indoor use (AgBB) which is part of the technical approval requirements since October 2004.

In France a mandatory labelling of emissions of building materials based on the “Grenelle de l’environnement” is in preparation.

In some member states directives concerning the emission of formaldehyde exist. The formaldehyde release from wood-based-panels can be determined in test chambers. The product can be classified as E1 if the equilibrium concentration of formaldehyde in the air of a test chamber is ≤ 0.1 ml/m³ (≤ 0.12 mg/m³). In the following countries the class E1[105] is required for specified wood-based-panels in order to use the CE mark, place the product on the market and / or use it:

- Austria
- Germany
- Denmark
- Sweden

<u>CEN TC 351</u>

Despite the common market there is no harmonised system for material emission rating available in Europe. Consequently the European Commission has developed a mandate (M/366) to CEN for the implementation of the essential requirement No 3 "Hygiene, health and the environment" of the Construction Products Directive (89/106/EEC)[106]
As a response to the mandate, CEN established the Technical Committee CEN/TC 351 "Construction product: Assessment of the release of dangerous substances”. This CEN/TC will adopt harmonised test methods to determine the emission of dangerous substances from construction products in support of requirements for health safety and environment. These methods will then be incorporated in the technical specifications for the standardisation and authorisation of construction products taking into account the intended conditions of use of the product (AGBB 2005).

The draft Standard “Determination of emissions to indoor air” comprises:

- Sampling at the production site
- Creating a test specimen
- Analysing the chamber air on VOC
- Reporting the concentration of emitted VOC and SVOC

In contrast to diverse statements and expectations, CEN TC 351 will not give any requirements on dangerous substances used in or emitted from building materials. All it aims for is to develop harmonised testing methods which will be implemented in the product specific standards. These standards won’t include any requirements or benchmarks. Additionally, CEN TC 351 deals only with regulated substances, which means that dangerous substances which are not regulated in any member state won’t be considered.

[105] determination and parameters not exactly defined in the same way yet
[106] and the Construction Products Regulation (CPR) respectively

Ecolabels for building products

Ecolabels are voluntary schemes to encourage businesses to market products and services that are kinder to the environment than other one. Products and services awarded an ecolabel carry a logo, allowing consumers to identify them easily. On the other side it helps manufacturers, retailers and service providers to gain recognition for good standards. While the logo may be simple, the environmental criteria behind it are rather complicated in most cases considering the impact of the product or service on the environment throughout its life-cycle. The criteria should be based on a consultation with experts and all interested parties.

The International Standards Organisation has provided a standard with requirements for an ecolabelling scheme (ISO 14024). This standard includes the following key criteria:

- the reliability of information (i.e. are there adequate procedures in place for validation and compliance monitoring?);
- the transparency of the administrative procedures of the scheme;
- the existence of a formal process of consultation with stakeholders.

EU Eco-Label and governmental national ecolabels

The European Union established its voluntary ecolabel award scheme in 1992. The EU Eco-Label is intended to promote products with a reduced environmental impact during their entire life cycle and to provide consumers with accurate, non-deceptive, science-based information on the environmental impact of products. It is part of a broader action plan on Sustainable Consumption and Production and Sustainable Industrial Policy adopted by the Commission on 16 July 2008. The initiative for an EU Eco-label award scheme for Buildings has already been mentioned several times in this report.

Beside the EU Ecolabel plenty of national ecolabels still exist, e.g. German Ecolabel ("Blue Angel"), Austrian Ecolabel ("Hundertwasserzeichen") or Nordic Ecolabel ("Nordic Swan").

natureplus and non-governmental Ecolabels

natureplus is an international ecolabel for sustainable building and accommodation products uniting the leading non-governmental ecolabels for building products in Europe. It is carried by a private association involving all groups interested in building processes. The natureplus-label embodies health-awareness, environmental soundness and technical performance of the tested products. Products with this label are made predominantly from renewable and sustainable sources of raw materials. Testing methods cover life cycle assessment, laboratory analysis of ingredients and emissions, visits to the production facilities and compliance test. Comparable to the ecolabels from the government, plenty of private national ecolabels exist.

Table 22 gives an overview about the mentioned ecolabels.

Table 22: Selection of ecolabels throughout Europe:
Name, link to website, logo, products covered by guidelines

EU Ecolabel: http://ec.europa.eu/environment/ecolabel/index_en.htm	
	- Wooden coverings - Textile coverings - Hard floor coverings - Indoor paints and varnishes - Outdoor paints and varnishes
natureplus: http://www.natureplus.org	
	- Insulation materials - Masonry elements - Mortar and plaster - Wood and derived timber products - Building boards - Floor Coverings - Roof tiles - Paints, varnishes - Adhesives and sealants
Nordic ecolabel: http://www.svanen.se/en/	
	- Panels for the building, decorating and furniture industry - Floor coverings - Chemical Building Products - Durable Wood - Windows - Indoor Paints and Varnishes
German ecolabel: http://www.blauer-engel.de/	
	- Thermal insulation materials - Wood products - Floor coverings - Floor covering adhesive - Wallpapers - Wall paints, varnishes - Bitumen coatings and adhesives - Sealants for interior use
Austrian ecolabel: http://www.umweltzeichen.at/	
	- hydraulic bonded bricks - insulation materials - floor coverings - varnishes and glazes - wood based products and boards

Environmental product declaration (EPD)

Besides ecolabels (“Type I” according to ISO 14024) so called environmental product declarations (EPD) according to ISO 14025 (Type III environmental declarations) exist. EPDs provide quantified environmental data of products using predetermined parameters and, where relevant, additional environmental information. Environmental product declarations (EPDs) are primarily intended for use in business-to-business communication, but their use in business-to-consumer communication under certain conditions is not precluded. EPDs usually are limited to offer information about the product, and are abstaining from assessing and benchmarking. Nevertheless they are often mixed up with ecolabels since manufacturer may be allowed to use logos from the program operator. Additionally the consumers may have difficulties to distinguish the EPDs from ecolabel reports and the marketing statements may emphasize this confusion.

11.2. Building assessment systems and related instruments

EU-Ecolabel Award Scheme for Buildings (Third Draft Criteria, May 2010)

Materials used for the interiors

"Materials and products used for interiors (floor coverings, windows, doors, partitions, paint and varnishes, plasters and their components and auxiliary materials - glue, resins, foams, ..) shall not contain

- substances or preparations/mixtures meeting the criteria for classification as toxic, hazardous to the environment, carcinogenic, mutagenic or toxic for reproduction (CMR), in accordance with Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures OJ L 353, 31.12.2008, p. 1., or
- substances referred to in Article 57 of Regulation (EC) No 1907/2006 of the European Parliament and of the Council of18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency OJ L 396, 30.12.2006, p. 1. or
- substances that meet the criteria of Article 57 of Regulation (EC) No 1907/2006 and that are identified according to the procedure described in Article 59 of that Regulation, present in mixtures, in an article or in any homogeneous part of a complex article in concentrations higher than 0,1 % (weight by weight).

Assessment and verification: The applicant shall provide EU Ecolabel certification or Material Safety Data Sheets."

VOC-content and emissions to indoor air

The draft criteria for the EU Ecolabel states that "The VOC emissions from the building products used for interiors shall comply with the EN ISO 16000-9 to -11 standard.
Assessment and verification: Test report based on the outlined method in EN ISO 16000-9 to -11."
This criterion disregards the fact that the ISO16000 series just specify the test methods for determining the VOC-Emissions without assessing them. A product category specific threshold needs to be defined as a pass/fail criterion.

Code for sustainable homes (CSH)

VOC-content and emissions to indoor air

The only time VOCs are mentioned in the CSH-Technical Guide is in the checklist for the "Home User Guide", phrase e "Sustainable DIY" (Checklist Man 1-Home User Guide, p 230): "Environmental recommendations for consideration in any home improvement works, such as the use of low VOC products or the purchase of certified timber".
VOC-emissions from building materials are no matter in the CSH.

BREEAM Multiresidential 2008

BREEAM Multiresidential is intended for use on multi-occupancy residential buildings which are not suitable for assessment under the Code for Sustainable Homes (CSH) or EcoHomes (e.g. student halls of residence; key worker accommodation, sheltered housing, etc.). Contrary to CSH, this scheme includes criteria assessing VOC emissions to indoor air:

Hea 9 – Volatile Organic Compounds
Credit is awarded if the emissions of VOCs and other substances from key internal finishes and fittings comply with best practice.

Table 23: Requirements for the emissions of VOCs and other substances in BREEAM Multiresidential 2008

Product group	Formal-dehyde	Preserva-tives	VOC	others
Wood Panels (Particleboard, Fibreboard including MDF, OSB, Cement-bonded particleboard, Plywood, Solid wood panel and acoustic board)	●	●		
Timber structures (Glued laminated timber)	●			
Wood flooring (e.g. Parquet flooring)	●	●		
Resilient, textile and laminated floor coverings (vinyl / linoleum, cork / rubber, Carpet)	●	●		
Suspended ceiling tiles	●			asbestos
Flooring adhesives			carc&sens VOC	
Wall-coverings (finished wallpapers, wall vinyls and plastic wallcoverings, wallpapers for subsequent decoration, heavy duty wall-coverings, textile wall-coverings)	●			VCM, heavy metals, toxic substances
Adhesive for hanging flexible wall-coverings		●		
Decorative paints and varnishes			VOC-content	Fungal and algal resistant

Formaldehyde	Release of formaldehyde according to various BS EN standards
Preservatives	Verify that regulated (wood) preservatives are absent and of the minimum content
carc&sens	carcinogenic and sensitising volatile substances
VCM	release of vinylchlorid monomer

HQE (France)

One of the 14 targets in HQE concerns indoor air quality. Within this criterion HQE sets standards concerning the section of low-emission building products: VOC emissions shall be evaluated according existing protocols in Europe: M1, GUT, EMICODE, AgBB, AFSSET.

LEED for Homes rating system

VOC-content and emissions to indoor air

In LEED for Homes the restriction to VOC is part of the criterion “low emissions” which together with the criteria “environmentally preferable products” and “local products” form the criterion MR 2.2 Environmentally Preferable Products (0.5 points each, maximum 8 points) (LEED Guide, January 2008, p 79ff).

Within this criterion LEED defines credit standard for low VOC-content in paints and coatings, e.g. max. 50 g/l VOC-content in paints applied to interior walls in flats. References for the prescribed standards are quoted (e.g. Green Seal Standard GS-11 for paints or South Air Quality Management District Rule for adhesive and sealants).
Carpets get 0.5 points if they comply with Carpet&Rug Institute Green Label Plus program, hard floorings automatically get 0.5 points for 100 % hard surface flooring and additional 0.5 points for using a product that is SCS Floor Score certified.
“Roof AND floor AND wall” get 0.5 points per component if they comply with California “Practice for Testing of VOCs from Building Materials Using Small Chambers”.

We appreciate the crediting of low-emissions products. However, it is questionable if the applicable standards of LEED actually meet the requirements of environmentally preferable products or simply express the state of the technology in some countries (e.g. “< 850 g/l sheet-applied rubber lining operations”, “< 550 g/l adhesive primer for plastic”, etc.).

Total Quality Building

HFC (hydrofluorocarbon)-free materials

Table 24: Ban of HFC in TQB, status 22.07.2010

Criterion	Points
E.1.1 HFC-free insulation materials.	10
E.1.1 HFC-free polyurethane foam.	5

It should be added that the use of fluorocarbons including HFC is forbidden in Austria (HFKW-FKW-SF6-Verordnung, BGBl. II 447/2002). There are only some exemptions left, e.g. for the use of HFC with a GWP < 300 CO_2-eq in insulation panels > 8 cm.

Low-emissions products

In TQB credits are awarded for the use of specified low-emissions products (the scores are also credited if no product of the specified product group is used.

Table 25: Credits for low emissions products in TQB, status 22.07.2010

Criterion	Pre-certificate	Certificate
D 2.2.1 Low-emission adhesives for floors (Emicode EC1 standards)	8	5
D2.2.2 Low emissions floor covering (applicable standards for VOC-emissions) or uncovered hard floorings	12	7

Criterion	**Pre-certificate**	**Certificate**
D2.2.3 Low emission derived timber product OR unglued and untreated solid wood products (apart from highly resinous wood, e.g. larch, pine, etc.)	12	7
D2.2.4 Low-emission paints for ceiling and walls (applicable standards of VOC-content)	8	5
D2.2.5 Measurement of VOC 4 weeks after completion of flooring (applicable limits for TVOC)	-	10
D2.2.6 Measurement of formaldehyde 4 weeks after completion of flooring (applicable limits for formaldehyde)	-	6
E1.3 Solventfree bitumen coatings and adhesives (Giscode BBP10)	5	5

Avoidance of polyvinyl chloride (PVC)

Table 26: Credits for PVC-free products in TQB, status 22.07.2010

Criterion	Points
E1.2 PVC-free water and sewer pipes inside building (buried PVC-pipes are allowed)	5
E1.2.1 PVC-free pipes for supply and exit air	5
E1.2.2 PVC-free electrical equipment (cable, pipes, sockets)	10
E1.2.3 PVC-free sheetings	5
E1.2.4 PVC-free flooring	5
E1.2.5 PVC-free wall paper	5
E1.2.6 PVC-free windows	10
E1.2.7 PVC-free doors	5
E1.2.8 PVC-free roller shutter	5

“Products’ management”

Total Quality Building and the other Austrian building assessment systems (klima:aktiv Haus, IBO ÖKOPASS) are very often combined with a program called “Products’ management” (in German: “Produktmanagement” or “Chemikalienmanagement”).
Products’ management means the proper selection and quality control of building products in order to avoid the emission of indoor air pollutants. It is carried out by independent third parties (intern or extern) und comprises

- introduction of environmentally sound criteria in call for tender and the award contract,
- control and release for use of all building materials,
- regular check on the building site.

The successful application is documented in a report and has to be proved by indoor air measurement.

Products have to be considered, if they are

- building chemicals applied to the room covering (exterior and interior)
- building materials which are applied inside of the rooms (airtight layer and all building materials inside of it)

Relevant product groups to be considered are:

- Timber and derived timber products:
  - - Timber Panels
  - - Solid Wood, coated
  - - Solid Wood, untreated
- Floor Coverings:
  - - Resilient Floor Coverings
  - - Textile Floor Coverings
  - - Wood Flooring
  - - Laminated Wood Flooring
- Chemicals
- Paints
- Varnishes
- Adhesives, especially flooring adhesives
- Sealings

The criteria used originate from Austrian Green Public Procurement programs (harmonized standards of “ÖkoKauf Wien” and “baubook oeg”) and are published on http://www.baubook.at/oeg/ (together with products fulfilling these criteria) and integrated in the tendering software ABK.

In the Austrian building assessment system “klima:aktiv haus“ for service buildings the „products’ management“ itself is awarded with credits (max 50 points out of 1000)

AgBB (Germany)

A German task force of public health authorities, the AgBB, developed an approach for implementing health related requirements (i.e. VOC emissions) in the German registration procedure for construction products used for indoor application. The procedure has been notified (Principles of health assessment of construction products in indoor environments, Notification No. 167/2009/D, http://ec.europa.eu/enterprise/tris/public_info/). Germany supports a class system for indoor relevant products based on the AgBB scheme in the European discussion concerning the declaration in the CE-mark (KIRCHNER, 2010).

The requirements comprise limitations to emissions of a sample stored in a test chamber for 3 days and 28 days. The 3 day test is representative of a building renovation case with early re-occupancy and prohibits excessively high initial VOC emissions and the presence of carcinogens. The 28 day test is representative of long-term emissions (EUROFINS, 2006).

The AgBB scheme considers individual substances as well as a sum parameter for VOC with retention range from C_6 to C_{16} (TVOC), and semi-volatile organic compounds (SVOC), respectively. The TVOC and TSVOC limits can be extracted from Table .

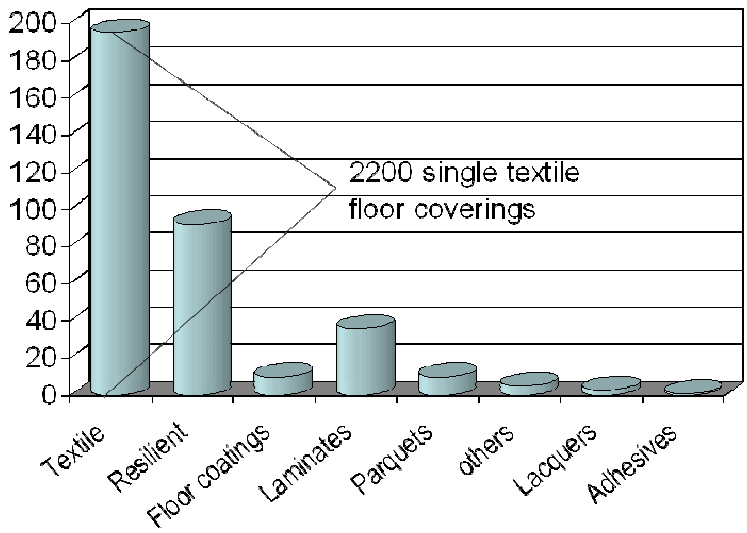
For a large number of VOC found in indoor air a list of so-called LCI values (Lowest Concentration of Interest) have been derived from maximum permitted workplace concentrations (Maximale Arbeitsplatz-Konzentrationen – MAK values). The MAK values belong to the most comprehensive evaluation system for specific VOC. However, under typical conditions much higher substance concentrations are generally encountered in workplaces than in living spaces. On the other hand, much shorter exposure times occur at workplaces. The MAK values have therefore been adjusted by suitable factors when deriving the LCI values for normal indoor living spaces (AgBB 2005). Table 27 shows exemplarily some AgBB-LCI values.

Table 27: Some AgBB-LCI values in the LCI list as quoted in (ECA-EAQ. 2010)

	Substance	CAS No.	LCI [µg/m³]	Remarks**
12-1*	1.4-Dioxane	123-91-1	73	EU: Carc. Cat. 3
12-2	Caprolactam	105-60-2	240	Individual substance evaluation
12-3*	N-Methyl-2-pyrrolidone	872-50-4	400	EU: Repr. Cat 2 (31.ATP) Individual substance evaluation
12-4	Octamethylcyclo-tetrasiloxane (D4)	556-67-2	1200	EU: Repr. Cat.3, Individual substance evaluation
12-5	Hexamethylene-tetramine (Formaldehyde-release)	100-97-0	30	OELs Norway, Sweden: 3 000 µg/m³
12-6	2-Butanonoxime	96-29-7	20	EU: Carc. Cat. 3 Individual substance evaluation
12-7*	Tributyl phosphate	126-73-8		SVOC, EU: Carc. Cat. 3
12-8*	Triethyl phosphate	78-40-0	25	cf. Tributyl phosphate (OELs Denmark, France: 2500 µg/m³, TLV (ACGIH): 2200 µg/m³)

Figure 1 shows the amount of technical approvals according to the AgBB scheme up to now (status Sept 2010).

Figure 1: Amount of technical approvals (in total 325; status 2010/9/1). Source: KIRCHNER (2010)



Grenelle de l'environnement (France)

According to MAUPETIT (2010) voluntary actions (product labels, EPDs, green building certification, NEHAP initiatives) have not been successful in France for providing information on emissions of volatile compounds from building products. Therefore mandatory requirements have been decided on in the framework of the "Grenelle de l'environnement" consensus action.

From 2004-2008 the first French NEHAP defined 45 actions, including 12 high priority actions. Action n°15 (high priority) described a procedure for the evaluation of VOC and formaldehyde emissions from building products, called the AFSSET protocol. It stated that emissions from building products should be evaluated on a voluntary basis. According to MAUPETIT (2010) 50% of the products were evaluated in 2010. In public buildings the use of evaluated products is mandatory.
The AFSSET protocol (first version in 2006) prescribes the use of ISO 16000 standards. The assessment procedures are based on ECA and AgBB, standards are the LCI derived from IAQ guidelines and OEL. For more details see:
http://www.afsset.fr/upload/bibliotheque/834140219913200241733014951209/COV_rapport_2009VF.pdf

The next important action in France was the creation of "grenelle de l'environnement" in 2007 by French Government, followed by the adoption of "Grenelle 1" law[107].
Article 40 of the "Grenelle 1" law states regarding indoor air:

- Emissions of building, finishing and furnishing products will be labelled on a mandatory basis.
- CMR compounds category 1 and 2 will be banned in building, finishing and furnishing products.
- A study on the opportunity to extend mandatory labelling of emissions to other indoor sources will be published.
- IAQ in some public buildings will be monitored.
- An opportunity to create indoor air consultants for people suffering from respiratory diseases (green ambulances) will be given.

Mandatory labelling of emissions is in preparation and notified to European Commission (98/34/EC directive) on 23rd December 2009

- Draft Decree relating to the labelling of construction products with their volatile pollutant emissions (Décret)
- Draft Order relating to the labelling of construction products with their volatile pollutant emissions (Arrêté)

Draft Decree relating to the labelling of construction products with their volatile pollutant emissions (Décret):

- Products may only be made available on the market if they are accompanied by a label, applied to the product or its packaging, indicating their emissions of volatile pollutants, hereinafter referred to as "substances".
- The list of substances and emission thresholds are defined in the draft Order.
- Manufacturers, their authorised representatives or importers, are responsible for the information provided on the labels.

Provisions of this Decree shall enter into force on:

- 1st September 2011 for products newly placed on the market
- 1st September 2013 for all products

[107] Loi n°2009-967 du 3 août 2009 de programmation relative à la mise en oeuvre du Grenelle de l'environnement

Draft Order relating to the labelling of construction products with their volatile pollutant emissions (Arrêté)

- Methods for the characterisation of emissions : EN ISO 16000 parts 9, 10 and 11
- Methods for sampling and analyses : ISO 16000 parts 6 and 3
- Emission scenarios : reference room defined by CEN TC351, WG2, document N 124 (12 m^2, 30 m^3)

Building and decoration products may only be placed on the market if their emissions of CMR compounds are below 1 µg.m^{-3} after 28 days. Additionally 4 emission classes have been defined in Draft Order for the mandatory labelling of emissions. Table 28 shows the corresponding limit values for specified substances.

Table 28: Limit values for the 4 emission classes according to Draft Order for the mandatory labelling of emissions.

			emission classes (values in µg.m^{-3})			
Substances	**CAS**	**standard**	**C**	**B**	**A**	**A+**
formaldehyde	50-00-0	ISO 16000-3	> 120	< 120	< 60	< 10
acetaldehyde	75-07-0	ISO 16000-3	> 400	< 400	< 300	< 200
toluene	108-88-3	ISO 16000-6	> 600	< 600	< 450	< 300
tetrachlorethylene	127-18-4	ISO 16000-6	> 500	< 500	< 350	< 250
xylene	1330-20-7	ISO 16000-6	> 400	< 400	< 300	< 200
1,2,4-trimethylbenzene	95-63-6	ISO 16000-6	> 2000	< 2000	< 1500	< 1000
1,4-dichlorobenzene	106-46-7	ISO 16000-6	> 120	< 120	< 90	< 60
ethylbenzene	100-41-4	ISO 16000-6	> 1500	< 1500	< 1000	< 750
n-butyl acetate	123-86-4	ISO 16000-6	> 10000	< 10000	< 7500	< 4800
2-butoxyethanol	111-76-2	ISO 16000-6	> 2000	< 2000	< 1500	< 1000
styrene	100-42-5	ISO 16000-6	> 500	< 500	< 350	< 250
TVOC		ISO 16000-6	> 2000	< 2000	< 1500	< 1000

Ecolabels for building products and green public procurement

The following chapter shall give an idea of the regulations concerning the use and emission of hazardous substances in ecolabels and green public procurement systems (referred to as product assessment systems). The mandatory labeling in France based on the “Grenelle de l’environnement” and the AgBB assessment scheme in Germany can also be accounted to the product assessment systems but have already been described in the previous chapters. They are referred to again in phrase “Harmonisation process within labelling schemes…”

Classification of the product

The requirements concerning classification of the product in accordance with 1272/2008/EG and preceding regulations are very similar in the different product assessment systems, the requirements of the European Eco-Label for indoor paints and varnishes (2009/544/EC) are quoted exemplarily:

“The product shall not be classified as very toxic, toxic, dangerous to the environment, carcinogenic, toxic for reproduction, harmful, corrosive, mutagenic or irritant (only where this is caused by the presence of ingredients labelled with R43) in accordance with Directive 1999/45/EC of the European Parliament and of the Council before or after tinting (where applicable).

Assessment and verification: The applicant shall provide a declaration of compliance with this criterion, together with a product material safety data sheet meeting the requirements of Annex II to the REACH Regulation.”

Dangerous Substances

The requirements concerning classification of the ingredients in accordance with 1272/2008/EG (Globally Harmonised System) and preceding regulations (67/548/EEC or 1999/45/EC) are very similar between the different systems, the requirements of the European Eco-Label for indoor paints and varnishes (2009/544/EC) are quoted exemplarily below.

Substances classified as dangerous for health

Ingredients (very toxic, toxic, carcinogenic, mutagenic or toxic for reproduction): No ingredient […] shall be used that at the time of application fulfill the classification criteria of any of the following risk phrases (or combinations thereof):

- R23 (toxic by inhalation),
- R24 (toxic in contact with skin),
- R25 (toxic if swallowed),
- R26 (very toxic by inhalation),
- R27 (very toxic in contact with skin),
- R28 (very toxic if swallowed),
- R33 (danger of cumulative effects),
- R39 (danger of very serious irreversible effects),
- R40 (limited evidence of carcinogenic effect),
- R42 (may cause sensitisation by inhalation),
- R45 (may cause cancer),
- R46 (may cause heritable genetic damage),
- R48 (danger of serious damage to health by prolonged exposure),
- R49 (may cause cancer by inhalation),
- R60 (may impair fertility),

- R61 (may cause harm to the unborn child),
- R62 (possible risk of impaired fertility),
- R63 (possible risk of harm to the unborn child),
- R68 (possible risk of irreversible effects),

as laid down in Council Directive 67/548/EEC or in Directive 1999/45/EC. Active ingredients used as preservatives in the formula and that are assigned any of the risk phrases R23, R24, R25, R26, R27, R28, R39 R40 or R48 (or combinations thereof) may nevertheless be used up to a limit of 0,1 % (m/m) of the total paint formulation.

Alternatively, the Globally Harmonised System (GHS) of classification may be considered (1272/2008/EG). In this case the ingredients, including those used in tinting (if applicable), classified as the following (or combinations thereof) shall not be used:

- Acute Toxicity (oral) – Category I, II, III,
- Acute Toxicity (dermal) – Category I, II, III,
- Acute Toxicity (inhalation) – Category I, II, III,
- Respiratory Sensitisation – Category I,
- Mutagenic Substances – Category I, II,
- Carcinogenic Substances – Category I, II,
- Substances Toxic for Reproduction – Category I, II,
- Specific Target Organ Systemic Toxicity (single exposure) – Category I, II,
- Specific Target Organ Systemic Toxicity (repeated exposure) – Category I, II,

[…]. Active ingredients used as preservers in the formula and that are assigned any of the following GHS categories may nevertheless be used up to a limit of 0,1 % (m/m) of the total paint formulation:

- Acute Toxicity (oral, dermal, inhalation) – I, II, III (only oral and dermal),
- Specific Target Organ Systemic Toxicity (single and/or repeated exposure) – I, II (or combinations thereof) and,
- Carcinogenicity category II,

Methyl Ethyl Ketoxime may be used in alkyd paints up to a limit of 0,3 % (m/m).

Assessment and verification: The applicant shall provide a declaration of compliance with this criterion, together with a product material safety data sheet meeting the requirements of Annex II to the REACH Regulation."

Substances classified as dangerous for the environment

No ingredient shall exceed 2 % (m/m), including those used in tinting (if applicable), that at the time of application fulfill the classification criteria of any of the following risk phrases (or combinations thereof):

- N R50 (very toxic to aquatic organisms),
- N R50/53 (very toxic to aquatic organisms, may cause long term adverse effects in the aquatic environment),
- N R51/53 (toxic to aquatic organisms, may cause long term adverse effects in the aquatic environment),
- N R52/53 (harmful to aquatic organisms, may cause long term adverse effects in the aquatic environment),

- R51 (toxic to aquatic organisms),
- R52 (harmful to aquatic organisms),
- R53 (may cause long-term adverse effects in the aquatic environment),

as laid down in Directive 67/548/EEC or Directive 1999/45/EC.

Alternatively, the Globally Harmonised System (GHS) of classification may be considered (1272/2008/EG). In this case no ingredient shall exceed 2 % (m/m), including those used in tinting (if applicable), that is assigned or may be assigned at the time of application any of the following classifications:
Aquatic Toxicity categories (and combinations thereof):

- Acute I, II, III,
- Chronic I, II, III, IV,

[…].

In either case, the sum total of all ingredients that are assigned or may be assigned at the time of application any of these risk phrases (or combinations thereof) or GHS classifications shall not exceed 4 % (m/m).
This requirement does not apply to ammonia or akyl ammonia.
This requirement does not affect the obligation to fulfill the requirement set out in criterion 6(a) above.

Assessment and verification: The applicant shall provide a declaration of compliance with this criterion, together with a list of ingredients and material safety data sheets of each ingredient meeting the requirements of Annex II to the REACH Regulation.

Specified substances

Additionally to the dangerous substances mentioned above various specific substances are often banned or limited as ingredients. Typically regulated substances are:

- Alkylphenolethoxylates (APEOs)
- Isothiazolinone compounds
- Heavy metals
- Halogenated Organic Solvents
- Phthalates

<u>VOC-Content</u>

The VOC-content in mixtures (paints, varnishes, glues,…) is limited usually in ecolabels and green public procurement systems, although the limit values vary enormously between the different systems, e.g. VOC-limits (including water) for indoor paints (walls/ceilings):
European eco-label: 15 g/l
Austrian eco-label: 500 ppm

<u>VOC-Emissions to indoor air</u>

Many product assessment systems include test chamber measurements of the emissions of building materials and corresponding limit values. The requirements are usually stricter than that of the regulation schemes in Germany or France since ecolabels want to award only the best products in the market. Table 29 shows exemplarily the natureplus' requirements on VOC-emissions from building products.

Table 29: Limits for VOC-emissions set by the international ecolabel "natureplus"

Test Parameters		Limits	Testing Method
Emissions:			Chamber Process: natureplus-Implementation regulation
Volatile Organic Compounds (VOC)		**µg/m³**	DIN ISO 16000-6, DIN EN ISO 16000-9, DIN EN ISO 16000-11
VOC (VOC, VVOC, SVOC) classified in: Regulation (EG) No. 1272/2008: Categories Carc. 1A and 1B, Muta 1A and 1B, Repr. 1A and 1B; TRGS 905: K1, K2, M1, M2, R1, R2; IARC Groups 1 & 2A; DFG MAK-List III1, III2		n.m.	3 days after loading the testing chamber
Total Volatile Organic Compounds (TVOC)		≤ 3,000	3 d after loading the testing chamber
Total Volatile Organic Compounds (TVOC)		≤ 300	28 d after loading the testing chamber
Of which:	Total bicyclic Terpenes	≤ 200	28 d after loading the testing chamber
	Total sensitising substances per MAK IV, BgVV-List Cat. A, TRGS 907	≤ 100	28 d after loading the testing chamber
	Total VOC (VOC, VVOC, SVOC) classified in:	≤ 50	28 d after loading the testing chamber
	Regulation (EG) N0. 1272/2008: Categories Carc. 2, Muta 2, Repr. 2; TRGS 905: K3, M3, R3; IARC Group 2B; DFG MAK-List III3		
	Total Aldehyde, C4-C11, acyclic, aliphatic	≤ 100	28 d after loading the testing chamber
	Styrene	≤ 10	28 d after loading the testing chamber
	Methylisothiazolinone (MIT)	n.m.	28 d after loading the testing chamber
	Benzaldehyde	≤ 20	28 d after loading the testing chamber
Total Volatile Organic Compounds (VOC) without non-identified compounds		≤ 100	28 d after loading the testing chamber
Total Semi-Volatile Organic Compounds (TSVOC)		≤ 100	28 d after loading the testing chamber
R-Value		**Value** ≤ 1.0	 28 d after loading the testing chamber
Formaldehyde		**µg/m³** ≤ 36 (2)	DIN EN 717-1, DIN ISO 16000-3 28 d after loading the testing chamber
Acetaldehyde		**µg/m³** ≤ 36 (2)	DIN ISO 16000-3 28 d after loading the testing chamber
Monomer Isocyanate(3)		**µg/m³**	
		n.m.	24 h after loading the testing chamber
Termination criteria: The emissions test can be terminated 7 days after the test chamber has been loaded if the values measured at this time are lower than 50% of the 28-day threshold limits.			

(2) 36 µg/m³ = 0.03 ppm

(3) If binding agents based upon polymer MDI (PMDI) have been employed.

Additionally to ecolabels a number of voluntary labelling schemes especially for low emitting products (e.g. EMICODE, Germany or M1, Finland) exist in Europe. The also existing mandatory systems in Germany and France have already been mentioned. Each system has its own specific requirements for testing and criteria for product evaluation. A preparatory EU expert group convened by the European Commission's Joint Research Centre (JRC) promotes and seeks consensus between the indoor material labelling schemes. The result should be a harmonised framework for indoor labelling schemes in Europe and link them to legislation: "The intention is to align the harmonised framework across various legislative mandates, such as, Construction Products Directive (89/106/EEC), Energy Performance of Buildings Directive – EPBD (2002/91/EC), EC Lead Market Initiative (COM(2007)860), Integrated Product Policy (IPP), Chemicals Policy (REACH), Green Public Procurement, Thematic Strategy on Urban Environment (COM(2004)60), Integration of Environmental Aspects into European Standardisation (COM(2004)206), etc." (ECA-IAQ, 2010)

In ECA-IAG draft report n° 27 (ECA-IAQ, 2010) a fir st step was taken in direction of a consensus achieved among the representatives of the Danish (DICL) and Finnish (M1) labelling schemes and the German (AgBB) and French (AFSSET) evaluation systems. This framework envisions

- common core criteria on testing and evaluation methodologies to be accepted by consensus and
- optional criteria to be applied locally for those substances/factors for which no consensus exists yet.

The criteria were suggested taking into consideration the results of round robin testing of products. This round robin testing was performed according to the individual schemes and the on-going work within the European standardisation body (CEN/TC 351).

The main findings in ECA-EAQ draft report n°27 are:

- Until harmonised standards become available, ISO 16000-series standards should be used for measurement with two exceptions:
  - A reference room size has already been proposed and shall be used instead of the ISO 16000-9 informative annex B.
  - Emission testing should include two chamber air sampling times (day 3 and 28)
- The evaluation criteria should cover all contaminants of concern to health and comfort and be based on scientific evidence when available.
- TVOC should not be used alone as an indicator for evaluating health effects from indoor material emissions. A common approach for TVOC definition along with an upper limit for TVOC should be established.
- If volatile compounds classified as EU carcinogens are detected after 3 days, the test can be stopped.
- The LCI-approach is currently the most feasible strategy beyond the evaluated schemes to assess the health effects of compounds from buildings materials. An expert group should be initiated to propose common European LCI-criteria. Criteria should be set also for substances not having LCI values (i.e., "non-assessable" substances).
- Sensory evaluation is considered to be an important part in the assessment of material emissions.

Table 30 gives an overview about the consensus reached for the measurement methods, the core and the optional criteria (ECA-EAQ, 2010).

Table 30: Consensus reached for the measurement methods, the core and the optional criteria (ECA-EAQ, 2010)

Requirements / Parameter	M1, Finland	DICL, Denmark	AgBB, Germany	AFSSET, France	Consensus
Measuring method / Chamber	ISO 16000 series	ISO 16000 series	ISO 16000 series	ISO 16000 series	Harmonised CEN Standard (based on ISO 16000 series)
Measuring points (days)	28	3, 10 and 28	3 and 28	3 and 28	3 and 28
Core criteria					
Single VOCs evaluated (R = Σ Ci/LCI <1))	No	comparison with irritation threshold	R < 1 165 LCIs (2010)	R < 1 164 LCIs (2009)	R < 1 Har monised list of LCIs
Carcinogens evaluated according to Concentration admitted	IARC class 1 SERa < 5 µg/m²h	IARC class 1	EU classes 1 and 2 56 listed compounds Sum < 1 µg/m³	EU classes 1 and 2 2 listed compounds < 1 µg/m³	Harmonised list of EU carcinogens classes 1 and 2 compounds to be checked
TVOC measured	SERa < 200 µg/m²h	No	1000 µg/m³	1000 µg/m³	200-1000 µg/m³
Formaldehyde measured	SERa < 50 µg/m²h	75 µg/m³ (after 60 days)	No, required for approval application	10 µg/m³ (LCI)	Value to be discussed
Optional criteria					
Compounds without LCI assessment	No	No	Sum < 100 µg/m³	Sum < 100 µg/m³	Sum < 100 µg/m³
Other compounds evaluated	Ammonia				
TSVOC measured	No	No	< 100 µg/m³	No	Await validation TC 351
Sensory evaluation	Acceptability untrained panel 15 persons	Acceptability and intensity; untrained panel 20 persons	No (Draft for intensity measurement developed)	No	Await ISO 16000-28

The next step of the force group foresees the setup of an expanded working group with representatives from labelling schemes in Europe and a wider range partners and stakeholders affected by this topic. The task of this expanded WG/committee/forum will be to finalise the details and achieve broader consensus on the harmonised framework of the European labelling scheme through open consultation. The broader consensus would enable the efficient implementation of the harmonised framework of indoor labelling schemes in building assessment systems.

11.3. Summary, conclusions and recommendations

Summary

Neither REACH nor the Construction Products Directive nor any other European Legislation or Standardisation are sufficient instruments to guarantee the absence of hazardous ingredients in or emissions from building materials into indoor air.
The existing building assessment systems go beyond legislation but cover the use of chemicals in a very different manner as one can see in the following table: in a range from the ban of certain chemicals or categories of chemicals to strict limits for VOC-emissions of building materials.

Table 31: Regulation on hazardous substances in building and product assessment systems and other related instruments on building level

	Building assessment systems					Others	
	EU Eco-Label	CSH (BRE)	BREEAM MR	LEED f. HRS	TQB Resid.	product labels	ROHS (for EEE)
Hazardous ingredients							
CMR	●		●			●	
Elements						●	
PBB&PBDE						●	●
HBCDD, DEHP, BBP, DBP						●	●
Nitrosamines						●	
HFC		●	●		●	●	
PVC					●	•	
VOC			●	● paint, adhesive	● paint, bitumen	●	
Preservatives			●			●	
Emissions from building materials to indoor air							
VOC			●		●	●	
SVOC					●	●	
Formaldehyde			●		●	●	

Recommendations for the assessment of chemicals in building materials

Parameters

The following table shows an outline of the authors' and contractors' recommendations concerning chemicals in building materials:

Table 32: Recommendations of the authors concerning the use of chemicals in building materials

Parameter		Minimum	Excellence
Hazardous ingredients / Problematic materials			
HFC (insulation materials, polyurethane foam, heat pump, ...)		banned	banned
CMR cat I & II in chemicals (varnishes, lacquer, glue,…)		banned	banned
CMR cat I & II in finished goods		avoided (e.g. scores)	banned
other substances of very high concern (vPvBs und PBTs)		banned as far as technically possible	banned
specified other toxic substances e.g. APEOs, heavy metals, halogenated organic solvents, isothiazolinone, endocrine disrupters such as phthalates		-	catalogue of banned / avoided substances e.g. Austrian GPP-standard, ecolabels
Plasticised PVC containing phthalates		banned	banned
Rigid PVC	containing cadmium or lead	banned	banned
	chlor-alkali production based on mercury or diaphragm cell	avoided (e.g. scores)	banned
	others	-	avoided (e.g. scores)
VOC / SVOC		avoided in adhesives for floors (e.g. EMICODE EC1 products)	catalogue of VOC-content-limits for different products e.g. Austrian GPP-standard, ecolabels, can be replaced by forced measurements in test chambers

Products relevant for indoor air quality

Products have to be considered, if they are

- building chemicals applied to the room covering (exterior and interior)
- building materials which are applied inside of the rooms (airtight layer and all building materials inside of it)

The following list is derived from a compilation of proposed product groups in BREEAM Multiresidential and in the Austrian Standard for Green Public Procurement:

- Wood panels (particleboard, fibreboard including MDF, OSB, cement-bonded particleboard, plywood, solid wood panel and acoustic board)
- Timber structures (glued laminated timber)
- Resilient, textile and laminated floor coverings (vinyl / linoleum, cork / rubber, Carpet)

- Wood flooring (e.g. parquet flooring, laminated wood flooring)
- Flooring adhesives
- Decorative paints and varnishes
- Wall-coverings (finished wallpapers, wall vinyls and plastic wallcoverings, wallpapers for subsequent decoration, heavy duty wall-coverings, textile wall-coverings)
- Adhesive for hanging flexible wall-coverings
- Sealings (e.g. polysiloxane sealing, liquid foil)
- Bitumen coatings and adhesives (also for outdoor use due to VOC migration)

Emissions to indoor air from building materials

Harmonised horizontal testing methods which still have to be defined by CEN/TC 351 "Construction Products - Assessment of release of dangerous substances" will not be available in the near future. Hardly any mandatory requirements on VOC-emissions from building materials to indoor air exist in Europe, except for Germany or France.
In this situation the ECA-EAQ scheme could be used as a basis for assessment.

Table 33: Evaluation scheme for the emissions from building materials

Requirements / Parameter	Minimum (modeled on ECA-EAQ)	Excellence (based on natureplus)
Measuring method / Chamber Measuring points (days)	Harmonised CEN Standard (based on ISO 16000 series) 3 and 28	Harmonised CEN Standard (based on ISO 16000 series) 3 and 28
Harmonised list of EU carcinogens classes 1 and 2 compounds	not measureable	not measureable
Single VOCs evaluated ($R = \Sigma$ Ci/LCI <1))	R < 1 Harmonised list of LCIs	benchmarks oriented on toxicology-cally derived values where possible
Compounds without LCI assessment	Sum < 100 µg/m^3	benchmarks for sum of impact categories
TVOC measured	1000 µg/m^3 (upper value)	300 µg/m^3
TSVOC measured	100 µg/m^3 (3)	100 µg/m^3
Formaldehyde measured	E1 (≤ 0.12 mg/m³) (1)	E1 (≤ 0.024 - 0.048 mg/m³) (2)
Sensory evaluation	Await ISO 16000-28	Await ISO 16000-28

(1) acc. to formaldehyde regulation in various European countries, ECA-EAQ has no value fixed yet

(2) varies between different products

(3) acc. to AGBB, ECA-EAQ has no value fixed yet

While it is still cumbersome to prescribe low-emissions products because of missing data, it will become much easier in some years since the current harmonisation work on testing methods concerning VOC-emissions from building materials (CEN TC 351, ECA-IAQ) and the mandatory labelling in Germany (AgBB) and France (AFFSET) will have a positive effect on the availability of tested products.
A remaining problem is that the standards set by different initiatives (e.g. mandatory versus voluntary labelling systems) may differ. Additionally, declared values could be indicated as “fulfilling the legal requirements” (e.g. < 0.12 mg/m³ formaldehyde concentration measured in

a test chamber) rather than indicating the actual value. Then one could not use the declaration for a voluntary scheme requiring a lower emission value (e.g. requiring a threshold of e.g. 0.048 mg/m³ formaldehyde). A shared data handling and reporting tool as suggested by ECA-IAQ (2010) can afford relief to that problem.

Miscellaneous

The on-site measurements could be done on a random basis in order to keep the costs low. This way every craftsman has to realise that his work might be assessed after completion of his work. In addition, test procedures to be used before harmonised European standards are available should be identified.

Requirements concerning dangerous substances in, and emissions from, building materials should go as far as possible. In Austria good experiences have been made with the combination of building assessment with product assessment (ecolabels, green public procurement). Detailed criteria for building products can be left to a “product manager” who is in charge of tendering and ordering proper materials. Building assessment systems are limited to requirements for indoor air quality and/or to assessing the “products’ management” or the ecolabelling process itself.

Another important step forward would be recording **information** about installed materials. The EU Eco-Label draft suggests that a list has to be set up with detailed information on the installed materials. If this list also contained information about the ingredients of materials it would be of high importance that bidders were forced to provide this information that is hard to obtain for planners or contracted co-workers in most cases.

PART III: LITERATURE AND APPENDICES

12. LITERATURE

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ISO 15686-8	Buildings and constructed assets - Service life planning - Part 8: Reference service life and service life estimation
ISO 21929	ISO/TS 21929-1 (2006): Sustainability in building construction - Sustainability indicators - Part 1: Framework for development of indicators for buildings
ISO 21930	ISO 21930 (2007): Sustainability in building construction -- Environmental declaration of building products
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13. APPENDICES: BUILDING ASSESSMENT SYSTEMS

13.1. Appendix: EU Ecolabel for new buildings (Draft) – EC

In 2008, the European Ecolabelling scheme started an Ad-hoc Working Group on a European Ecolabel for buildings. The first drafts have been prepared under the lead of the Italian Competent Body (ISPRA). In 2010, the leadership was handed over to Joint Research Centre's Institute for Prospective Technological Studies (JRC-IPTS) whose first report was drafted in October 2010 starting with the analysis of the previous draft criteria studies and the product group definition and priorisation (BOYANO&WOLF, 2010). The progress of the work can be followed through the website: http://susproc.jrc.ec.europa.eu/buildings.

The latest draft considered in the study at hand is ISPRA's third draft in May 2010 (EU ECO-LABEL, 2010). The following table illustrates the main issues up for discussion.

Table 34: EU Ecolabel (Third Draft, May 2010) - Main issues up for discussion

New Buildings - Section A - Mandatory Criteria	
Documentation	
	1. Building book 2. Maintenance plan 3. User's guide
Planning–Project–Construction	
	4. Design for disassembly, re-use and recycling 5. Social responsibility during the construction phase
Impacts on Site	
	6. Heat island
Materials	
	7. List of materials / products 8. Wood based materials 9. Wood materials 10. Long life service materials 11. Plastic materials
Energy	
	12. Energy Efficiency Heating 13. Renewable energy source
Water Consumption and Management	
	14. Rainwater use 15. Water saving systems
Waste Management	
	16. Recycling facilities
Health and well-being	
	17. Dust 18. Radon 19. Day lighting – Common areas 20. Lighting system control 21. Day lighting – Glare control

	22. Integrated indoor well- 23. Day lighting – Daylight Factor 24. Materials used for the interiors 25. VOC emissions in indoor environment
Facilities provided	
	26. Common TV antenna 27. Transport facilities 28. Cycle facilities
Fitness for use	
	29. Test of building and equipements

New Buildings . Section B- Optional Criteria	
Documentation	
	30. Other environmental certification systems
Planning–Project –Construction	
	31. Site selection 32. Experience of designers in environmental construction 33. Quality Management System 34. Building Life Cycle Assessment (LCA) 35. Environmental Management System 36. Construction and Demolition Waste
Impacts on Site	
	37. Green areas 38. Heat island
Materials	
	39. Energy embodied in materials/products 40. Use or re-use of recycled materials/products 41. Responsible sourcing of materials 42. Use of materials/products locally produced - non-structural functions 43. Use of materials/products locally produced - structural functions 44. Labelled construction products 45. CO_2 embodied in materials/products 46. Indoor and outdoor paints and varnishes, covering materials
Energy	
	47. Energy efficiency - Heating 48. Energy efficiency – Cooling and ventilation 49. Energy efficiency – Hot water
Health and well-being	
	50. Domotic systems 51. Natural ventilation
Operation and Maintenance	
	52. Internal partitions and walls 53. Piping and cabling
Facilities provided	
	54. Open spaces, green areas, common areas

13.2. Appendix: Code for Sustainable Homes (CSH)

The Code for Sustainable Homes became mandatory from May 2008 for all new self contained dwellings in England and Wales and was based on the BREEAM scheme "EcoHomes". The Technical Guide has been drafted by the BREEAM Centre at the Building Research Establishment (BRE) under contract to the Department for Communities and Local Government.

The following table illustrates the sub-issues assessed within CSH (*Source: Code for Sustainable Homes: Technical Guide May 2009, Version 2; ed. Department for Communities and Local Government, 2009 http://www.planningportal.gov.uk/uploads/code_for_sustainable_homes_techguide.pdf).*

In November 2010, the CSH was revised. The in-depth analysis of this study is based on CSH, Edition 2009.

Table 35: Sub-Issues - Code for Sustainable Homes (CSH) 2009

Code for Sustainable Homes (CSH) 2009			
Categories	**Issues**	**Points**	**Weighting, total system**
ENE Energy and Carbone Dioxide Emissions		**29**	**27,9 %**
Ene 1	Dwelling Emission Rate	15	14,4 %
Ene 2	Building Fabric	2	1,9 %
Ene 3	Internal Lighting	2	1,9 %
Ene 4	Drying Space	1	1,0 %
Ene 5	Energy Labelled White Goods	2	1,9 %
Ene 6	External Lighting	2	1,9 %
Ene 7	Low or Zero Carbon Energy Technologies	2	1,9 %
Ene 8	Cycle Storage	2	1,9 %
Ene 9	Home Office	1	1,0 %
WAT Water		**6**	**5,8 %**
Wat 1	Indoor Water Use	5	4,8 %
Wat 2	External Water Use	1	1,0 %
MAT Materials		**24**	**23,1 %**
Mat 1	Environmental Impact of Materials	15	14,4 %
Mat 2	Responsible Sourcing of Materials - Basic Building Elements	6	5,8 %
Mat 3	Responsible Sourcing of Materials - Finishing Elements	3	2,9 %
SUR Surface Water Run-off		**4**	**3,8 %**
Sur 1	Management of Surface Water Run-off from developments	2	1,9 %
Sur 2	Flood Risk	2	1,9 %
WAS Waste		**7**	**6,7 %**
Was 1	Storage of non-recycable waste and recycable household waste	4	3,8 %
Was 2	Construction Site Waste Management	2	1,9 %
Was 3	Composting	1	1,0 %

Code for Sustainable Homes (CSH) 2009			
Categories	**Issues**	**Points**	**Weighting, total system**
POL Pollution		**4**	**3,9 %**
Pol 1	Global Warming Potential of Insulants	1	1,0 %
Pol 2	NOx Emissions	3	2,9 %
HEA Health & Wellbeing		**12**	**11,5 %**
Hea 1	Daylighting	3	2,9 %
Hea 2	Sound Insulation	4	3,8 %
Hea 3	Private Space	1	1,0 %
Hea 4	Lifetime Homes	4	3,8 %
MAN Management		**9**	**8,7 %**
Man 1	Home User Guide	3	2,9 %
Man 2	Considerate Constructors Scheme	2	1,9 %
Man 3	Construction Site Impacts	2	1,9 %
Man 4	Security	2	1,9 %
ECO Ecology		**9**	**8,7 %**
Eco 1	Ecological Value of Site	1	1,0 %
Eco 2	Ecological Enhancement	1	1,0 %
Eco 3	Protection of Ecological Features	1	1,0 %
Eco 4	Change of Ecological Value of Site	4	3,8 %
Eco 5	Building Footprint	2	1,9 %
Total		**104**	**100 %**

13.3. Appendix: LEED for Homes

LEED for Homes is a voluntary rating system of the U.S Green Building Council that promotes the design and construction of high-performance green homes, including affordable housing, mass-production homes, custom designs, stand-alone single-family homes, duplexes and townhouses, suburban and urban apartments and condominiums and lofts in historic buildings.

Source: LEED for Homes, Simplified Project Check List (available under www.usgbc.org/homes) and LEED® for Homes Rating System, Version 2008 including corrections, clarifications and new exemplary performance rulings (ed. U.S. Green Building Council, January 2010)

		Max Points
Innovation and Design Process (ID)		Max
1. Integrated Project Planning	Preliminary Rating	Prereq
	Integrated Project Team	1
	Professional Credentialed with Respect to LEED for Homes	1
	Design Charrette	1
	Building Orientation for Solar Design	1
2. Durability Management Process	Durability Planning	Prereq
	Durability Management	Prereq
	Third-Party Durability Management Verification	3
3.Innovative or Regional Design	Innovation 1	1
	Innovation 2	1
	Innovation 3	1
	Innovation 4	1
		11
Location and Linkages (LL)		Max
1. LEED ND	LEED for Neighborhood Development	10
2. Site Selection	Site Selection	2
3. Preferred Locations	Edge Development	1
	Infill	2
	Previously Developed	1
4. Infrastructure	Existing Infrastructure	1
5. Community Resources/ Transit	Basic Community Resources / Transit	1
	Extensive Community Resources / Transit	2
	Outstanding Community Resources / Transit	3
6. Access to Open Space	Access to Open Space	1
		10
Sustainable Sites (SS)		Max
1. Site Stewardship	Erosion Controls During Construction	Prereq
	Minimize Disturbed Area of Site	1
2. Landscaping	No Invasive Plants	Prereq
	Basic Landscape Design	2
	Limit Conventional Turf	3
	Drought Tolerant Plants	2
	Reduce Overall Irrigation Demand by at Least 20%	6
3. Local Heat Island Effects	Reduce Local Heat Island Effects	1
4. Surface Water Management	Permeable Lot	4
	Permanent Erosion Controls	1
	Management of Run-off from Roof	2
5. Nontoxic Pest Control	Pest Control Alternatives	2
6. Compact Development	Moderate Density	2
	High Density	3
	Very High Density	4
		22

		Max Points
Water Efficiency (WE)		Max
1. Water Reuse	Rainwater Harvesting System	4
	Graywater Reuse System	1
	Use of Municipal Recycled Water System	3
2. Irrigation System	High Efficiency Irrigation System	3
	Third Party Inspection	1
	Reduce Overall Irrigation Demand by at Least 45%	4
3. Indoor Water Use	High-Efficiency Fixtures and Fittings	3
	Very High Efficiency Fixtures and Fittings	6
		15
Energy and Atmosphere (EA)		Max
1. Optimize Energy Performance	Performance of ENERGY STAR for Homes	Prereq
	Exceptional Energy Performance	34
7. Water Heating	Efficient Hot Water Distribution	2
	Pipe Insulation	1
11. Residential Refrigerant Management	Refrigerant Charge Test	Prereq
	Appropriate HVAC Refrigerants	1
		38
Materials and Resources (MR)		Max
1. Material-Efficient Framing	Framing Order Waste Factor Limit	Prereq
	Detailed Framing Documents	1
	Detailed Cut List and Lumber Order	1
	Framing Efficiencies	3
	Off-site Fabrication	4
2. Environmentally Preferable Products	FSC Certified Tropical Wood	Prereq
	Environmentally Preferable Products	8
3. Waste Management	Construction Waste Management Planning	Prereq
	Construction Waste Reduction	3
		16
Indoor Environmental Quality (EQ)		Max
1. ENERGY STAR with IAP	ENERGY STAR with Indoor Air Package	13
2. Combustion Venting	Basic Combustion Venting Measures	Prereq
	Enhanced Combustion Venting Measures	2
3. Moisture Control	Moisture Load Control	1
4. Outdoor Air Ventilation	Basic Outdoor Air Ventilation	Prereq
	Enhanced Outdoor Air Ventilation	2
	Third-Party Performance Testing	1
5. Local Exhaust	Basic Local Exhaust	Prereq
	Enhanced Local Exhaust	1
	Third-Party Performance Testing	1
6. Distribution of Space Heating and Cooling	Room-by-Room Load Calculations	Prereq
	Return Air Flow / Room by Room Controls	1
	Third-Party Performance Test / Multiple Zones	2
7. Air Filtering	Good Filters	Prereq
	Better Filters	1
	Best Filters	2
8. Contaminant Control	Indoor Contaminant Control during Construction	1
	Indoor Contaminant Control	2
	Preoccupancy Flush	1
9. Radon Protection	Radon-Resistant Construction in High-Risk Areas	Prereq
	Radon-Resistant Construction in Moderate-Risk Areas	1
10. Garage Pollutant Protection	No HVAC in Garage	Prereq
	Minimize Pollutants from Garage	2
	Exhaust Fan in Garage	1
	Detached Garage or No Garage	3
		21
Awareness and Education (AE)		Max
1. Education of the Homeowner or	Basic Operations Training	Prereq
	Enhanced Training	1
	Public Awareness	1
2. Education of Building	Education of Building Manager	1
		3

Prescriptive Approach for Energy and Atmosphere (EA) – LEED for Homes

Points cannot be earned in both the Prescriptive (below) and the Performance Approach (pg 2) of t		**Max Points**
Energy and Atmosphere (EA)		Max
2. Insulation	Basic Insulation	Prereq
	Enhanced Insulation	2
3. Air Infiltration	Reduced Envelope Leakage	Prereq
	Greatly Reduced Envelope Leakage	2
	Minimal Envelope Leakage	3
4. Windows	Good Windows	Prereq
	Enhanced Windows	2
	Exceptional Windows	3
5. Heating and Cooling Distribution Syster	Reduced Distribution Losses	Prereq
	Greatly Reduced Distribution Losses	2
	Minimal Distribution Losses	3
6. Space Heating and Cooling Equipment	Good HVAC Design and Installation	Prereq
	High-Efficiency HVAC	2
	Very High Efficiency HVAC	4
7. Water Heating	Efficient Hot Water Distribution	2
	Pipe Insulation	1
	Efficient Domestic Hot Water Equipment	3
8. Lighting	ENERGY STAR Lights	Prereq
	Improved Lighting	2
	Advanced Lighting Package	3
9. Appliances	High-Efficiency Appliances	2
	Water-Efficient Clothes Washer	1
10. Renewable Energy	Renewable Energy System	10
11. Residential Refrigerant Management	Refrigerant Charge Test	Prereq
	Appropriate HVAC Refrigerants	1
		38

Table 36: Categories and Sub-Categories - LEED® for Homes Rating System, Version 2008 including corrections, clarifications and new exemplary performance rulings (ed. U.S. Green Building Council, January 2010)

13.4. Appendix: LEnSE

Sustainability issues as described in Oliver Kornadt / Karl Wallasch (LEnSE Porject partners), Report of Comparison LEnSE vs. Total Quality (TQ) (Interim Report of LEnSE, Methodology Development towards a Label for Environmental, Social and Economic Buildings, 2008:

ENVIRONMENTAL		**400**
Climate Change	Building – depletion of non renewable primary energy	150
	Transport – depletion of non renewable primary energy	
	Use of renewable primary energy	
	Destruction of the stratospheric ozone layer	
	Local tropospheric ozone layer	
Biodiversity	Minimise point sources of eutrophication	100
	Land of low ecological value	
	Mitigation impact on existing site ecology	
	Enhance native plant/animal species	
	Habitat management/action plant	
Resource use and Waste	Depletion/use of renewable/non renewable resources (other than primary energy)	100
	Responsible sourcing of materials	
	Non hazardous waste disposal	
	Hazardous waste disposal	
	Use of freshwater resources	
	Re-use of previously developed sites	
	Development footprint	
	Contaminated land, bioremediation and soil reuse	
Environm. Man. Geophys. Risk	Certified Environmental Management System	50
	Minimizing regional specific climatalogical risk	
	Minimizing regional specific geophysical risk	

SOCIAL		**240**
Occupants' Well Being	Lighting comfort (artificial & natural)	75
	Thermal comfort	
	Ventilation comfort	
	Acoustic comfort	
	Occupant satisfaction	
	Internal user amenities	
	Outdoor space	
	Materials/substance exclusion	
	Indoor air quality	

	Avoiding mould from structural work	
	Quality of drinking water	
	Building safety assessment	
Accessibility	Key amenities – provision and proximity	30
	Public Transport accessibilty	
	Provision of safe and adequate pedestrian route ways	
	Provision of safe and adequate cycle lanes and cyclist facilities	
	Provision of car pooling facilities	
Security	Site security and spatial arrangement	65
	Building security	
Social and Cultural Value	Community impact consultation	70
	Social cost benefit analysis	
	Socially responsible and ethical procurement of goods/services	
	Considerate constructors	
	External ‘neighbourhood’ impacts	
	Design quality	

ECONOMIC		**160**
Financ. Manag.	Function analysis	50
	Risk & value management	
Whole Life Value	WLC appraisal – strategic level	60
	WLC appraisal – component level	
	Option appraisal	
	Exchange value	
	Added value	
	Building adaptability	
	Design for maintainable buildings / ease of maintenance	
Exter-nalities	Local employment opportunities/use of local services	50
	Specification/use of locally produced materials	
	Branding and external expression	

Table 37: Sustainability issues - LEnSE

13.5. Appendix SBTool 07

Elements of the SBTool system

SBT07-A is used by regional third-party organizations to establish scope, eligible occupancy types, and locally valid weights, benchmarks and standards;
SBT07-B allows designers to provide information about the site and project characteristics;
SBT07-C is used to carry out self-assessments that are based on the data entered in the A and B files. Parameters included within the system cover sustainable building issues within the three major areas of environment, social and economic sectors
A distinguishing feature of SBTool is that it is designed as a generic framework, and requires a thirdparty to adjust it to suit the unique conditions applicable to certain building types in various regions. This means that an assessment carried out using the system has little validity unless such a calibration feature is first carried out. Third party organizations are expected to adjust default weights, benchmarks and emission values throughout the system.
The development of the residential component in SBTool07 was funded by Canada Mortgage and Housing Corporation (CMHC) under the terms of the External Research Program.

Example

Issues of "SBT07 A Tiny DsnN1 (Settings) file" (ed. by iiSBE, Nils Larsson, available under http://www.iisbe.org/iisbe/sbc2k8/sbc2k8-download_f.htm)

This file currently contains Generic User-selected benchmarks and weights for Design Phase assessment for a location in Ottawa, Canada, suited to the following parameters:
New Apartment, no additional occupancies.

A	**Site Selection, Project Planning and Development**
A1	Site Selection
A1.1	Pre-development ecological value or sensitivity of land.
A1.2	Pre-development agricultural value of land.
A1.3	Vulnerability of land to flooding.
A1.4	Potential for development to contaminate nearby bodies of water.
A1.5	Pre-development contamination status of land.
A1.6	Proximity of site to public transportation.
A1.7	Distance between site and centres of employment or residential occupancies.
A1.8	Proximity to commercial and cultural facilities.
A1.9	Proximity to public recreation areas and facilities.
A2	Project Planning
A2.1	Feasibility of use of renewables.
A2.2	Use of Integrated Design Process.
A2.3	Potential environmental impact of development or re-development.
A2.4	Provision of surface water management system.
A2.5	Availability of potable water treatment system.
A2.6	Availability of a split grey / potable water system.

A2.7	Collection and recycling of solid wastes in the community or project.
A2.8	Composting and re-use of sludge in the community or project.
A2.9	Site orientation to maximize passive solar potential.
A3	Urban Design and Site Development
A3.1	Development density.
A3.2	Provision of mixed uses within the project.
A3.3	Encouragement of walking.
A3.4	Support for bicycle use.
A3.5	Policies governing use of private vehicles.
A3.6	Provision of project green space.
A3.7	Use of native plantings.
A3.8	Provision of trees with shading potential.
A3.9	Development or maintenance of wildlife corridors.
B	**Energy and Resource Consumption**
B1	Total Life Cycle Non-Renewable Energy
B1.1	Annualized non-renewable primary energy embodied in construction materials.
B1.2	Annual non-renewable primary energy used for facility operations
B2	Electrical peak demand for facility operations
B3	Renewable Energy
B3.1	Use of off-site energy that is generated from renewable sources.
B3.2	Provision of on-site renewable energy systems.
B4	Materials
B4.1	Re-use of suitable existing structure(s).
B4.2	Minimal use of finishing materials.
B4.3	Minimal use of virgin materials.
B4.4	Use of durable materials.
B4.5	Re-use of salvaged materials.
B4.6	Use of recycled materials from off-site sources.
B4.7	Use of bio-based products obtained from sustainable sources.
B4.8	Use of cement supplementing materials in concrete.
B4.9	Use of materials that are locally produced.
B4.10	Design for disassembly, re-use or recycling.
B5	Potable Water
B5.1	Use of potable water for site irrigation.
B5.2	Use of potable water for occupancy needs.
B5.3	N.A.
C	**Environmental Loadings**
C1	Greenhouse Gas Emissions
C1.1	Annualized GHG emissions embodied in construction materials.
C1.2	Annual GHG emissions from all energy used for facility operations.
C1.3	N.A.
C2	Other Atmospheric Emissions
C2.1	Emissions of ozone-depleting substances during facility operations.
C2.2	Emissions of acidifying emissions during facility operations.
C2.3	Emissions leading to photo-oxidants during facility operations.

C3	Solid Wastes
C3.1	Solid waste resulting from the construction and demolition process.
C3.2	Solid waste resulting from facility operations.
C4	Rainwater, Stormwater and Wastewater
C4.1	Liquid effluents from facility operations sent off the site.
C4.2	Retention of rainwater for later re-use.
C4.3	Untreated stormwater retained on the site.
C4.4	N.A.
C5	Impacts on Site
C5.1	Impact of construction process on natural features of the site.
C5.2	Impact of construction process or landscaping on soil erosion.
C5.3	Changes in biodiversity on the site.
C5.4	Adverse wind conditions at grade around tall buildings.
C5.5	Minimizing danger of hazardous waste on site.
C6	Other Local and Regional Impacts
C6.1	Impact on access to daylight or solar energy potential of adjacent property
C6.2	Cumulative thermal changes to lake water or sub-surface aquifers.
C6.3	Heat Island Effect - landscaping and paved areas.
C6.4	Heat Island Effect - roofing.
C6.5	Atmospheric light pollution.
C6.6	N.A.
C6.7	N.A.
D	**Indoor Environmental Quality**
D1	Indoor Air Quality
D1.1	Protection of materials during construction phase.
D1.2	Removal, before occupancy, of pollutants emitted by new interior finish materials.
D1.3	Off-gassing of pollutants from interior finish materials.
D1.4	Pollutant migration between occupancies.
D1.5	Pollutants generated by facility maintenance.
D1.6	Pollutants generated by occupant activities
D1.7	CO2 concentrations in indoor air.
D1.8	IAQ monitoring during project operations.
D2	Ventilation
D2.1	Effectiveness of ventilation in naturally ventilated occupancies.
D2.2	Air quality and ventilation in mechanically ventilated occupancies.
D2.3	Air movement in mechanically ventilated occupancies.
D2.4	N.A.
D3	Air Temperature and Relative Humidity
D3.1	Air temperature and relative humidity in mechanically cooled occupancies.
D3.2	Air temperature in naturally ventilated occupancies.
D4	Daylighting and Illumination
D4.1	Daylighting in primary occupancy areas.
D4.2	N.A.
D4.3	N.A.
D5	Noise and Acoustics
D5.1	Noise attenuation through the exterior envelope.

D5.2	Transmission of facility equipment noise to primary occupancies.
D5.3	Noise attenuation between primary occupancy areas.
D5.4	N.A.
D6	N.A.
E	**Service Quality**
E1	Safety and Security During Operations
E1.1	N.A.
E1.2	N.A.
E1.3	N.A.
E1.4	N.A.
E1.5	N.A.
E1.6	Maintenance of core building functions during power outages.
E1.7	N.A.
E1.8	N.A.
E2	Functionality and efficiency
E2.1	N.A.
E2.2	N.A.
E2.3	N.A.
E2.4	N.A.
E2.5	Spatial efficiency.
E2.6	Volumetric efficiency.
E3	Controllability
E3.1	Provision and operation of an effective facility management control system.
E3.2	Capability for partial operation of facility technical systems.
E3.3	N.A.
E3.4	Degree of personal control of technical systems by occupants.
E4	Flexibility and Adaptability
E4.1	Ability to modify facility technical systems.
E4.2	Adaptability constraints imposed by structure.
E4.3	Adaptability constraints imposed by floor-to-floor heights.
E4.4	Adaptability constraints imposed by building envelope and technical systems.
E4.5	Adaptability to future changes in type of energy supply.
E5	Commissioning of facility systems
E6	Maintenance of Operating Performance
E6.1	Maintenance of building envelope performance.
E6.2	Use of durable materials
E6.3	Development and implementation of a maintenance management plan.
E6.4	On-going monitoring and verification of performance.
E6.5	Retention of as-built drawings and documentation.
E6.6	Provision and maintenance of a building log.
E6.7	Performance incentives in leases or sales agreements.
E6.8	Skills and knowledge of operating staff.
F	**Social and Economic aspects**
F1	Social Aspects
F1.1	Minimization of construction accidents.
F1.2	Access for physically handicapped persons.

F1.3	Access to direct sunlight from living areas of dwelling units.
F1.4	Access to private open space from dwelling units.
F1.5	Visual privacy from the exterior in principal areas of dwelling units.
F1.6	N.A.
F1.7	Social utility of primary building function
F2	Cost and Economics
F2.1	Minimization of life-cycle cost.
F2.2	Minimization of construction cost.
F2.3	Minimization of operating and maintenance cost.
F2.4	Affordability of residential rental or cost levels.
F2.5	Support of Local Economy.
F2.6	N.A.
G	**Cultural and Perceptual Aspects**
G1	Culture & Heritage
G1.1	Relationship of design with existing streetscapes.
G1.2	Compatibility of urban design with local cultural values.
G1.3	Maintenance of heritage value of existing facility.
G2	N.A.
G2.1	N.A.
G2.2	N.A.
G2.3	N.A.

Total active low-level parameters = 113
N.A. Not Assessed

Table 38: Issues of “SBT07 A Tiny DsnN1 (Settings) file”

13.6. Appendix: DGNB (German Sustainable Building Certificate)

The following overview refers to the scheme “New Construction Office and Administration (Version 2009)”.
Source: DGNB (ed.): German Sustainable Building Certificate: Structure – Application – Criteria. Stuttgart, 2nd English Edition, March 2009

Ecological Quality

01 Global Warming Potential
02 Ozone Depletion Potential
03 Photochemical Ozone Creation Potential
04 Acidification Potential
05 Eutrophication Potential
06 Risks to the Regional Environment
08 Other Impacts on the Global Environment
09 Microclimate
10 Non-renewable Primary Energy Demands
11 Total Primary Energy Demands and Proportion of Renewable Primary Energy
14 Potable Water Consumption and Sewage Generation
15 Surface Area Usage

Economical Quality

16 Building-related Life Cycle Costs
17 Value Stability

Socio-cultural and Functional Quality

18 Thermal Comfort in the Winter
19 Thermal Comfort in the Summer
20 Indoor Hygiene
21 Acoustical Comfort
22 Visual Comfort
23 Influences by Users
24 Roof Design
25 Safety and Risks of Failure
26 Barrier free Accessibility
27 Area Efficiency
28 Feasibility of Conversion
29 Accessibility
30 Bicycle Comfort
31 Assurance of the Quality of the Design and for Urban Development for Competition
32 Art within Architecture

Technical Quality

33 Fire Protection

34 Noise Protection

35 Energetic and Moisture Proofing Quality of the Building's Shell

40 Ease of Cleaning and Maintenance of the Structure

42 Ease of Deconstruction, Recycling and Dismantling

Process Quality

43 Quality of the Project's Preparation

44 Integral Planning

45 Optimization and Complexity of the Approach to Planning

46 Evidence of Sustainability Considerations during Bid Invitation and Awarding

47 Establishment of Preconditions for Optimized Use and Operation

48 Construction Site, Construction Phase

49 Quality of Executing Companies, Pre-qualifications

50 Quality Assurance of the Construction Activities

51 Systematic Commissioning

Quality of the Location

Is presented separately, and is not included in the overall grade of the object.

56 Risks at the Microlocation

57 Circumstances at the Microlocation

58 Image and Condition of the Location and Neighbourhood

59 Connection to Transportation

60 Vicinity to Usage-specific Facilities

61 Adjoining Media, Infrastructure Development

13.7. Appendix: TQB Criteria in Detail and TQB Building Certificate

A			Site and Facilities: up to 200 credits
A	1.		Infrastructure
A	1.	1.	Access to public transport
A	1.	2.	Local supply
A	1.	3.	Social infrastructure
A	1.	4.	Infrastructure for recreation
A	2.		Safety and Sustainability of Site
A	2.	1.	Risks of natural hazards
A	2.	2.	Land use, preservation of biodiversity,
A	2.	3.	Magnetic fields by low frequency electro-magnetic fields
A	2.	4.	Low-frequency pulsed high-frequency fields
A	3.		Facilities
A	3.	1.	Safe access routes (internal/external), biking facilities
A	3.	2.	Site facilities and amenities of the flats
A	3.	3.	Dedicated free spaces of flats (gardens, balconies, terraces)
A	3.	4.	Protection against burglary
A	4.		Barrier Free Building
A	4.	1	Barrier free accessibility
A	4.	2	Barrier free dwelling units

B			Economic and Technical Performance: up to 200 credits
B	1.		Economic Efficiency
B	1.	1.	Life cycle cost assessments
B	1.	2.	Integrative planning
B	1.	3.	Operation and maintenance
B	2.		Construction Site Management
B	2.	1.	Logistics and transport management
B	2.	2.	Waste management
B	3.		Durability and Adaptability
B	3.	1.	Durability and adaptability of the construction concept
B	3.	2.	Flexibility of building services
B	4.		Fire protection
B	4.	1.	Construction elements
B	4.	2	Fire detection elements
B	4.	3	Fire extinguishing systems

C			Energy and Water: up to 200 credits
C	1.		Energy demand
C	1.	1	Heating demand
C	1.	2	Final energy demand
C	1.	3	Airtightness of the building
C	1.	4	Avoidance of thermal bridges
C	1.	0	optional (C.1.1 to C.1.4): passive house
C	2.		Energy supply
C	2.	1	Primary energy demand or alternatively C2.1a-C.2.1e
C	*2.*	*1a*	*Share of renewable energies*
C	*2.*	*1b*	*Energy efficient hot water preparation*
C	*2.*	*1c*	*Photovoltaics*
C	*2.*	*1d*	*Energy efficient ventilation system*
C	*2.*	*1e*	*Energy efficient lighting system*
C	2.	2	CO2-Emissions
C	3.		Water
C	3.	1	Individual cost control
C	3.	2	Use of rainwater/greywater
C	3.	3	Water efficiency of sanitary facilities
C	3.	4	Quality of cold and hot water

D			Health and Comfort: up to 200 credits
D	1.		Thermal comfort
D	1.	1	Thermal comfort in winter
D	1.	2	Thermal comfort in summer
D	1.	3	Building automation and influences by users
D	2.		Indoor air quality
D	2.	1	Ventilation systems
D	2.	2	Low emitting materials (coatings, flooring, wooden materials, adhesives)
D	2.	3	Moisture protection
D	3.		Sound insulation
D	3.	1	Ambient noise level (exterior)
D	3.	2	Good acoustic planning
D	3.	3	Airborne sound insulation values (separating walls)
D	3.	4	Airborne sound insulation values (separating floors)
D	3.	5	Impact sound insulation values (separating floors)
D	3.	6	Interior ambient noise level (night)
D	4.		Daylighting
D	4.	1	(Point) Daylight factor in living rooms
D	4.	2	Sun hours in wintertime in living rooms

E			Resource efficiency: up to 200 points
E	1.		Avoidance of critical materials
E	1.	1	HFC: insulation, foams, cooling solvents
E	1.	2	PVC: water pipes, ventilation ducts, power installations, flooring,…
E	1.	3	VOC (except interior fittings): bitumen coatings, adhesives
E	2.		Regional, recycled / re-used and eco-labelled products
E	2.	1	Regional products and construction materials
E	2.	2	Recycled or re-used materials
E	2.	3	Eco-labelled products
E	3.		Ecoefficiency of the building (life cycle view)
E	3.	1	Ecological index OI3 (PE non renewable, GWP, AP)
E	4.		Waste Disposal
E	4.	1	Disposal index

Table 39: TQB Criteria in Detail