Mandate

Under the terms of a contract with SB Alliance, N. Larsson of iiSBE was commissioned to carry out the tasks described below:

1. Undertake an initial international review of existing sustainable building performance indicators and benchmarks, and sustainable building assessment schemes (HQE, BREEAM, LEnSE, Protocollo ITACA /SBC Offices, AQUA, PromisE). This is a completion of initial work undertaken in a separate CSTB contract;

2. Map key indicators, and the metrics used in all the various systems. Identify system boundaries and parameters that are common to these systems. The very first expected outcome is the definition of a 'simple' matrix (Excel spreadsheet) which maps the indicators used by different schemes so the areas of commonality and gaps can be quickly identified - starting with the 'common' ones and determining what differences there are for these in methodological approaches used - and seek to standardise them if possible.

3. Map these against current CENTC350 structure and note note apparent gaps in coverage;

This document, and the attached spreadsheet, describes the findings of this work.

Existing systems

BREEAM Office, United Kingdom

The Building Research Establishment Environmental Assessment Method (BREEAM) is the starting point for the development of subsequent systems. It has been revised several times, and versions now exist for Offices (reviewed here), Schools, Retail, Courts, Industrial, Multi-residential and EcoHomes. BREEAM Bespoke provides custom services for application outside the UK.

BREEAM is now a well-developed system that relies on independent assessors to carry our project assessments.

The system is suited to UK conditions. As the manual state: *Assessments using UK BREEAM schemes can also be carried out in the Republic of Ireland, but it must be recognised that BREEAM is tailored to the UK's construction sector. No concessions are made in the schemes where the Republic of Ireland building standards and design and procurement practices differ from those in the UK.*

This BREEAM scheme can be used to assess the environmental impacts arising as a result of an individual building development (including external site areas) at the following stages:

1. Design Stage (DS) - leading to an Interim BREEAM Certificate

2. Post-Construction Stage (PCS) – leading to a Final BREEAM Certificate

There are a number of elements that determine the BREEAM rating; these are as follows:

- BREEAM rating benchmarks
- BREEAM environmental weightings
- Minimum BREEAM standards
- BREEAM credits for Innovation

The results categories are determined by the number of points awarded, as per the table at right:

Table 1: BREEAM 2008 rating benchmarks

BREEAM Rating	% score
UNCLASSIFIED	<30
PASS	≥30
GOOD	≥45
V GOOD	≥55
EXCELLENT	≥70
OUTSTANDING*	≥85

The 9 major categories of issues are weighted according to the table below,with a distinction being made between new construction that may include fit-up, compared to fit-up only:

Table 2: BREEAM 2008 environmental weightings

BREEAM Section	Weighting (%) New builds, extensions & major refurbishments	Weighting (%) Building fit-out only (where applicable to scheme)
Management	12	13
Health & Wellbeing	15	17
Energy	19	21
Transport	8	9
Water	6	7
Materials	12.5	14
Waste	7.5	8
Land Use & Ecology	10	N/A
Pollution	10	11

The system provides some threshold or minimum requirement values, as shown below:

Table 3: Minimum performance standards

Minimum Standards for BREEAM 'Very Good' rating	Achieved?
Man 1 - Commissioning	✓
Hea 4 - High frequency lighting	✓
Hea 12 - Microbial contamination	✓
Ene 2 Sub-metering of substantial energy uses	✓
Wat 1 - Water consumption	✓
Wat 2 - Water meter	✓
LE 4 - Mitigating ecological impact	✓

The individual information sheets for criteria are well developed with respect to guidance and reference to standards.

HQE, France

Two French organizations, CSTB and Qualitel, use the basic HQE (Haute Qualité Environmentale) system, but in different ways and for different sectors. The figure shows that different organizations are involved in different sectors. However, they all use various versions of the HQE system, which provides some consistency to the results. The following figure provides a good overview of the situation:

Table 4: Certification in France

Scope	Non-Residential Buildings	Multi-unit Residential Buildings	Detached Houses Builders
Certification Name	**NF Bâtiments Tertiaires - Démarche HQE®**	**1. Habitat et Environnement 2. Patrimoine Habitat et Envt**	**NF Maison Individuelle - Démarche HQE®**
Status	**Official since february 2005 for offices and schools**	**1. Official since 2003 2. Official since 2006**	**Official since may 2006**
Certifying Body	Certivéa (CSTB)*	Cerqual / Cerqual Patrimoine (QUALITEL)	CEQUAMI * (CSTB-QUALITEL)
Future	**Other types of buildings (hotels, etc.) and operation phase (2008)**	**NF Logements – Démarche HQE® (end 2007)**	**Other types of actors : ie architects**

The focus of this study is on commercial buildings, which are certified by Certivéa, a CSTB subsidiary. About 200 non-residential projects have been certified to date, providing the system with a considerable track record.

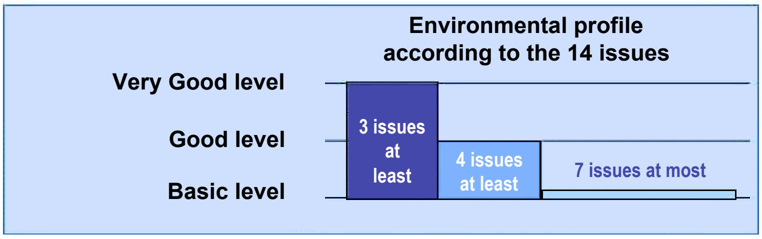
The system covers new (or restructured) offices and schools. Three phases are covered : brief, design, construction, and audits are carried out at each of three phases : end of brief phase, end of design, and end of construction.

The basic HQE system provides methods of scoring of up to 14 issues, but does not provide a single result for overall building performance. The HQE parameters cover a broad range of site, construction process, operational, user comfort and user health sub-issues, but does not extend to socio-economic issues. Considerable emphasis is placed on the quality of the process and inclusion of relevant local issues.

Assessments are based on the following principles:

- Tree structure of 14 issues of concern of HQE approach
- Priorisation of the 14 issues (profile) according to the context
- Three levels of performance : Basic, Good, Very Good. There are minimum numbers of Good or Very Good scores to be reached, and Basic scores are limited to a maximum number, which is also varied by criterion type.
- Mix of quantitative and qualitative evaluations
- Some indicators have to be calculated (methods are not unique)
  (ex: % of valorized construction waste, primary energy consumption, CO_2 emissions, daylight factor, indoor temperature in summer…)
- Respect of a « minimum profile »

Figure 5: Minimum performance levels required in HQE

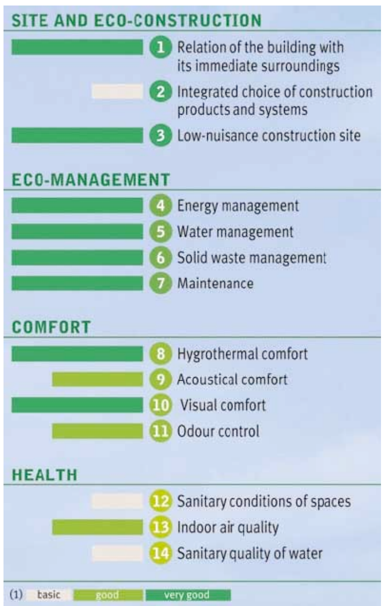


Requirement: Energy issue must be Good or Very Good

- Basic: Regulation level or normal practice
- Good: Good practice, better than Basic
- Very Good: Best practice, comparable to the best projects in the country

The figure at right shows the graphic results of an assessment, indicating again that the 14 issue areas are not meant to be aggregated into a single score. This avoids the problem of blending disparate issue areas, but it in fact assumes that each issue area is of equal importance. It also is very difficult to retain a mental image of all 14 issue area results if one wants some sort of overall understanding of the building's performance.

Figure 6: Example of results



AQUA system, Brazil

The Brazilian system closely follows the HQE approach, except that some lower-level parameters are added or changed.

DGNB System

The German system is a result of a long-term work of many experts of different fields. Everything is still in a state of development but a beta version will be at the end of the summer (handbook and also software).

The DGNB system is focused only on the building, thereby excluding site area outside the building footprint. Another unique characteristic of the DGNB system is that it excludes energy-using systems that may not be part of the base building, e.g. lighting and equipment loads are not included. Weights for the main issues were set by a round table of experts, e.g. by consensus. Assessment boundary is limited to the building footprint.

There are three main issue areas (Ecological, Economic and Socio-economic and Functional Quality), with Technical and Process Quality issues as cross-cutting elements.

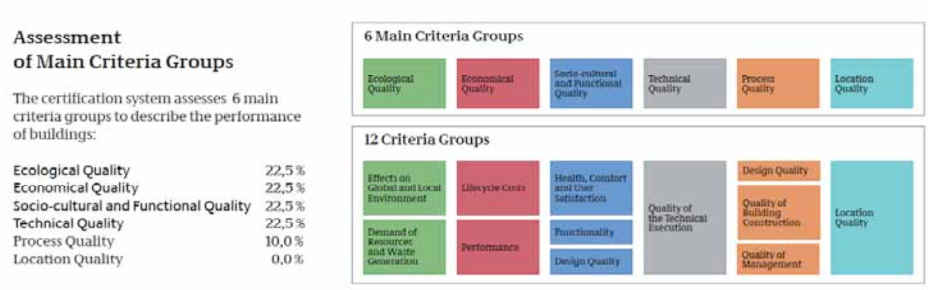
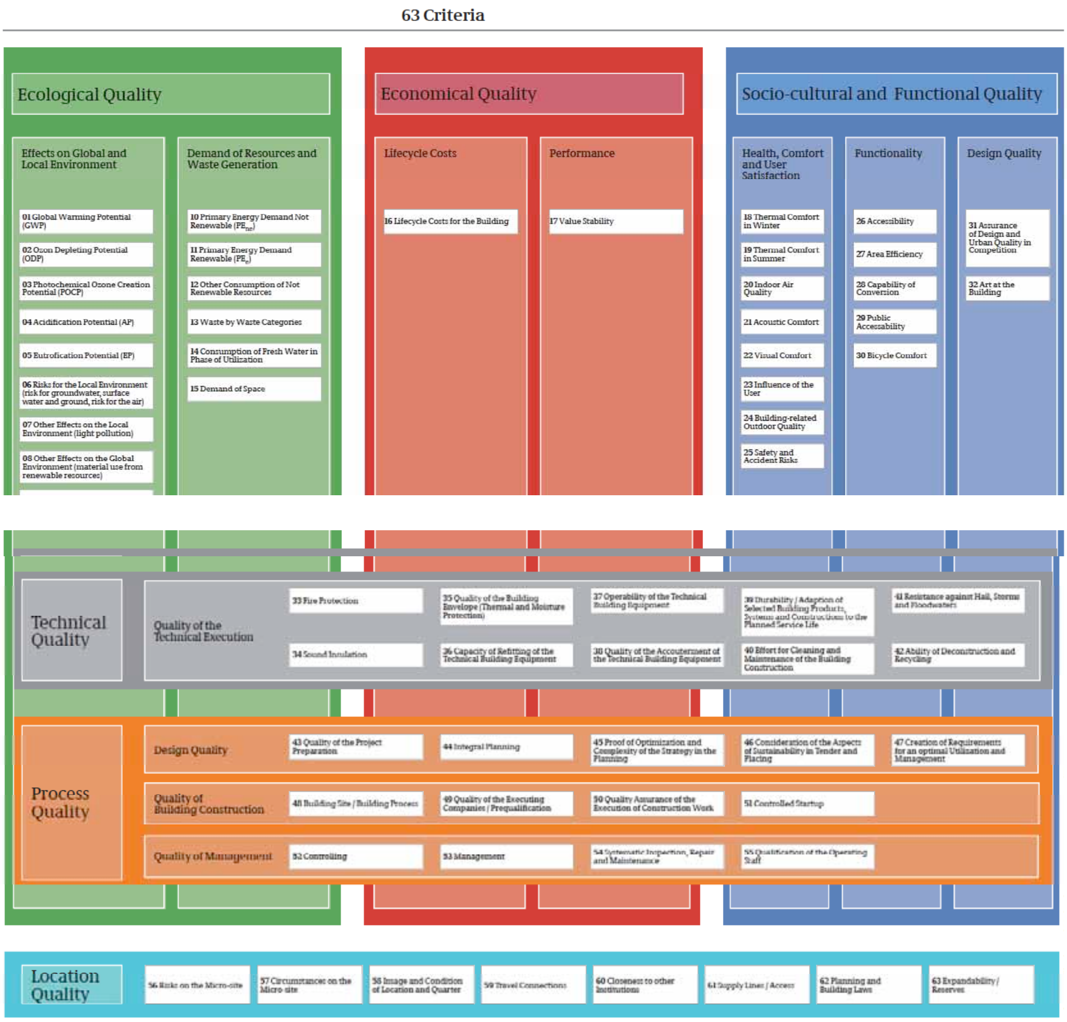
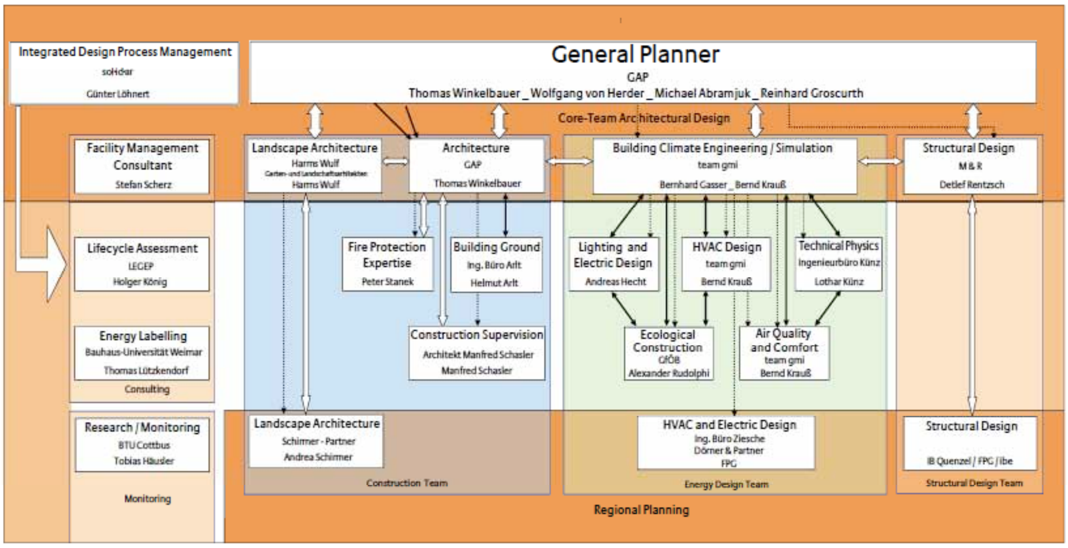


Figure 7: Overview of DGNB system



One of the interesting features of the DGNB scheme is the inclusion of process information in the form of a diagram, as below:

Figure 8: DGNB system process chart



Italy: SBC Uffici 1.1

Protocollo SBC

Protocollo SBC is a rating system based on the SBMethod of iiSBE, developed by iiSBE Italia and ITC CNR (National Research Council).

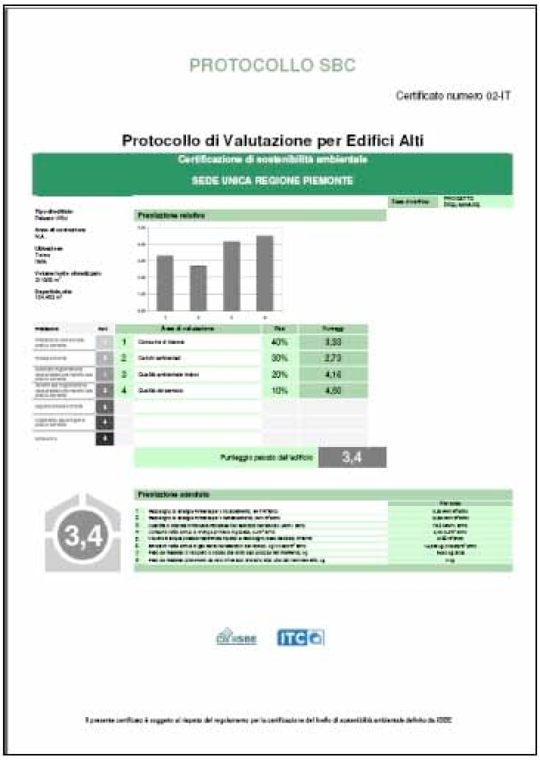
From SBMethod, Protocollo SBC adopts the hierarchic structure (Issues, Categories and Criteria), the performance scale (ranging from -1 to +5), the weighting system and the aggregation method. The final score of the assessment express the sustainability level of the building with regard to the local industrial practice.

The criteria composing the system have been selected from the master list contained in SBTool with some additions made on the base of local regulations and technical standards.

The Protocollo SBC can be applied to buildings in the "design" and "as built" phases. The assessment is carried out by the design team and verified by qualified assessors.

In the rating system all the criteria are organised in reference cards containing all the necessary information to carry out the assessment:

Figure 9: SBC Uffici results chart



Each card covers the following items: objective, weight of the criterion, performance indicator and unit of measure, performance scale, assessment method, indicator's value, score, target score; requested data; requested technical documents; benchmarking; reference standards and laws.

At the end of the certification process a certificate is issued with the results of the assessment in relative (performance scale from -1 to 5) and absolute (for instance: kWh/m2 year of primary energy consumption) values.

Figure 10: SBC Uffici worksheet

CRITERIO D.4.1	Progetto	(codice commessa)	SBT UFFICI 1.1

Illuminazione naturale negli ambienti principali

AREA DI VALUTAZIONE	CATEGORIA
D. Qualità ambientale interna	D.4 Illuminazione naturale e artificiale

ESIGENZA	PESO DEL CRITERIO	
Assicurare adeguati livelli d'illuminazione naturale in tutti gli spazi primari occupati.	nella categoria	nel sistema completo
	6.8%	2.7%

INDICATORE DI PRESTAZIONE	UNITA' DI MISURA
Fattore medio di luce diurna, definito come il rapporto tra l'illuminamento naturale medio dell'ambiente e quello esterno ricevuto, nelle identiche condizioni di tempo e di luogo, dall'intera volta celeste su una superficie orizzontale esposta all'aperto, senza irraggiamento diretto del sole.	%

SCALA DI PRESTAZIONE

	%	PUNTI
NEGATIVO	< 2,0	-1
SUFFICIENTE	2.0	0
BUONO	3.5	3
OTTIMO	4.5	5

METODO E STRUMENTI DI VERIFICA

Per il calcolo dell'indicatore di prestazione e relativo punteggio, si proceda come segue:
- Calcolare i fattori di ombreggiamento medi (Fov, Ffin, Fhor), solo relativamente ad ostacoli fissi, come descritto nella serie UNI TS 11300;
- Calcolare il fattore di luce diurna in assenza di schermatura mobile (ma tenendo in considerazione gli aggetti e gli elementi di ombreggiamento fissi), per ciascun tipo di vetro e di locale, secondo la procedura descritta nello standard UNI EN ISO 10840 (Appendice A); la metodologia prevede l'applicazione di un'unica formula in cui inserire i dati di input:

FLDm = [Af*Fov*Ffin*Fhor*t*e / Atot*(1-rm)]*R
dove:
Af = area della superficie vetrata totale (telaio escluso) del locale, [m_]
Fov = fattore di ombreggiatura relativo ad aggetti orizzontali per ciascuna esposizione, [-];
Ffin = fattore di ombreggiatura relativo ad aggetti verticali per ciascuna esposizione, [-];
Fhor = fattore ombreggiatura relativo ad ostruzioni esterne per ciascuna esposizione, [-];
t = fattore di trasmissione luminosa relativo alla superficie vetrata del locale, [-];
e = fattore finestra: posizione della volta celeste vista dal baricentro della finestra, [-];
Atot = area totale delle superfici che delimitano l'ambiente, [m_];
rm = fattore medio di riflessione luminosa delle superfici che delimitano l'ambiente, [-];
R = fattore di riduzione del fattore finestra, [-].

- Calcolare il fattore di luce diurna relativo all'edificio come media aritmetica dei fattori calcolati per ciascuna tipologia di ambiente;
- Inserire il valore calcolato all'interno della cella corrispondente al "VALORE INDICATORE DI PRESTAZIONE" della presente scheda.

VALORE INDICATORE DI PRESTAZIONE		%
PUNTEGGIO		
TARGET		

NOTE (da compilare dal tecnico unicamente in fase di prevalutazione)

DATI DI INPUT	Locale 1	Locale 2	Locale 3	Locale 4	Locale 5	VALORE	UNITA' DI MISURA
						-	-
FLDm						-	-
Area di pavimento						-	m_
Af						-	m_
t						-	-
Atot						-	m_
rm						-	-
R							-

DOCUMENTAZIONE	NOME DOCUMENTO
Relazione tecnica con il dettaglio delle misurazioni e del calcolo del Fattore medio di Luce Diurna.	
Altri documenti:	

BENCHMARKING

I livelli di benchmark per il FLDm sono stati definiti sulla base delle indicazioni riportate nella Circolare Ministeriale n° 3151 del 22/5/67 e nelle norme UNI EN 12464 - 1 e prEN 15251.
Livello 0: valore di FLDm raccomandato per attività da ufficio, considerando un illuminamento esterno pari a 5000 lux.(Circolare Ministeriale n° 3151 del 22/5/67)
Livello 5: valore di FLDm che garantisce il 50% dell'illuminamento medio minimo previsto per gli uffici - 500lux (UNI EN 12464 - 1 e prEN 15251), considerando un illuminamento esterno pari a 5000 lux.(Circolare Ministeriale n° 3151 del 22/5/67)

RIFERIMENTI LEGISLATIVI

-

RIFERIMENTI NORMATIVI

UNI TS 11300 - "Prestazioni energetiche degli edifici "
UNI EN ISO 10840 - "Luce e illuminazione, Locali scolastici, Criteri generali per l'illuminazione artificiale e naturale"
UNI EN 12464 - 1 - "Illuminazione dei posti di lavoro - Parte 1
prEN 15251 - "Criteria for indoor environment including thermal, indoor air quality (Ventilation), light and noise"

LEnSE

LEnSE is a research project funded by the EC and led by BBRI, ARMINES, BRE and others. The system is the first to integrate social and economic variables into its structure. It also has an innovative weighting system that pre-sets 800 points as core weights, then permits countries using it to assign 200 more points in any category to reflect regional priorities. This is a very useful feature, but note that it does not quite solve the issue of how to ensure that the weights are developed in a way that is logical and objective.

Figure 11: LEnSE weighting overview

Category	EU wide category weighting	Country specific category weighting			
		UK	Total	France	Total
Climate change	150	+ 50	200	+ 30	180
Biodiversity	100	+ 30	130	+ 50	150
Resource use	100	+ 15	115	0	100
Env. & Geophysical risk	50	0	50	+ 20	70
Occupant wellbeing	75	+ 25	100	+ 40	115
Security	30	+ 20	50	+ 10	40
Social and cultural value	65	0	65	0	65
Accessibility	70	+ 40	110	0	70
Financing and management	50	0	50	+ 30	80
Whole life value	60	+ 20	80	+ 15	75
Externalities	50	0	50	+ 5	55
Total	800	200	1000	200	1000

Figure 12: LEnSE assessment methods

Issue	scale	Assessment method(s)
Preserve raw material resources	G, E, N, L	■ Exhaust of abiotic resources, CML 2001 ■ % recycled, renewable, reused materials, ECO-BAU (6.2) ■ Eco-devis, SIA 112/1(3.1.1)
Save drink water resources	G, E, N, L	■ Life cycle inventory data bases ■ drink water use ■ % rain water and water reuse
Improve visual comfort	I	■ daylight factor, SIA 112/1 (1.4.2), software DIAL-Europe ver. 3 (ESTIA), ECO-Bau
Improve acoustics comfort	S, I	■ SIA 112/1 (1.4.6) (reduce noise and vibration indoor and outdoor)
Reduce life cycle cost of a new building	S,I	■ Construction (Swiss elements cost calculation standard) ■ land cost ■ operation (CEN TC 228) ■ maintenance (CEN TC228, preventing maintenance, Management and maintenance plans and schedules to minimise cost and optimise endurance) ■ renovation (Ready flexibility and adaptability for reuse) ■ end of life (dismantling, recycling, disposal) ■ Balance of capital (construction) to revenue (running and refurbishment) costs.

LEnSE has extensive proposals for dealing with polluted and remediated sites, deals with radioactive waste and has made many innovative suggestions for the type of parameters to be included, relevant benchmarks and how supporting documentation is to be provided.

LEnSE also provides a useful listing of assessment methods to go with each major assessment parameter.

PromisE, Finland

The Finnish PromisE rating system has been under development for some time, but further work is suspended until the nature of SB Alliance work becomes clarified. VTT is therefore anxious to see rapid progress in the SBA work. Schematic features from the existing version are shown in the spreadsheet.

Description of the spreadsheet

General features of the spreadsheet

The spreadsheet file *(SBA system comparison)* describes the systems under study by establishing a matrix of the system parameters on the Y axis, and relating this to various aspects and features on the X axis. The spreadsheet can be viewed at various levels of detail in both axes.

The systems covered include the following:

- BREEAM Offices 2008 2.0
- HQE for non-residential, 2008
- Aqua 2008 (Brazil) for non-residential
- DGNB 2008 (Germany)
- SBT Uffici 1.1, 2007 (Italy)
- LEnSE
- PromisE

Full details were available for BREEAM, HQE, DGNB, SBT Uffici and LEnSE. However, the AQUA system is only available in Portugese and the SBT Uffici is in Italian, so some guesswork was necessary for these systems.

Other features of the spreadsheet include the following:

- In Column A, single letter codes mark the individual system that each parameter belongs to
- In column B, codes indicate unique features of various systems
- Columns G and H indicate whether the system is applicable to New and/or Renovation projects
- Columns I to M show the applicable main occupancies. Note that some ancillary occupancies (e.g. food service in an office building) are not shown here.
- Columns N to U show applicable phases of the lifecycle. This has been completed primarily on the basis of indicating which phases are most relevant for for gathering information relevant to the parameter in question.
- Columns V and W indicate whether the system parameters can be adapted to suit varying context (such as special site conditions, availability of existing structures, certain materials, etc.), or to suit special building features (e.g is the building naturally ventilated or mechanically cooled etc.).
- Column X indicates whether a threshold performance value or minimum must be achieved to satisfy the parameter.
- Column Y indicates that weights are applicable to new buildings, while Column Z is for fit-outs only.
- Columns AA to AV are for the modified CEN TC 350 values as discussed below.

Impact categories adapted from CEN TC350

It should be noted that the CEN TC350 categories (columns AB to AV) are modified from the CEN TC350 originals. There are two main reasons for this: one is that there is only a draft version of the TC350 categories available and the social and economic categories of that standard remain to be completed. A second reason is that an analysis of the draft categories show that there is some confusion in CEN between what is a Loading or Quality and what is an Impact. The analysis below provides more detail.

Environmental indicators (CEN N063, June 2008), as per the CEN Document

Output Indicators for environmental impacts

- acidification of land and water resources;
- climate change;
- destruction of the stratospheric ozone layer;
- eutrophication;
- formation of ground-level ozone.

Input Indicators for material and energy flow

- Use of non-renewable resources other than primary energy;
- use of renewable resources other than primary energy;
- use of non-renewable primary energy;
- use of renewable primary energy;
- use of freshwater resources
- use of secondary raw materials

Output indicators for waste and secondary materials and energy

- materials for recycling
- materials for energy recovery.
- materials for re-use
- secondary raw materials
- non-hazardous waste to disposal;
- hazardous waste to disposal (other than nuclear waste)
- nuclear waste to disposal
- exported energy

Comments on CEN TC350 Indicators

Output Indicators for environmental impacts

- acidification of land and water resources;
- climate change;
- destruction of the stratospheric ozone layer;
- eutrophication;
- formation of ground-level ozone.

The Output Indicators at left are all indicators of impacts

Input Indicators for material and energy flow

- Use of non-renewable resources other than primary energy;
- use of renewable resources other than primary energy;
- use of non-renewable primary energy;
- use of renewable primary energy;
- use of freshwater resources
- use of secondary raw materials

The Input Indicators, on the other hand, could be phrased as resource depletion impacts, but are not. As currently framed, they are loadings that are related to unnamed impact categories - except for renewable resources which do reduce use of non-renewable resources, but are of no importance by themselves.

Output indicators for waste and secondary materials and energy *(comments below)*

- materials for recycling *reduces use of virgin materials, but of no intrinsic importance*
- materials for energy recovery. *Similar - can reduce use of non-renewable energy*
- materials for re-use *reduces use of virgin materials, but of no intrinsic importance*
- secondary raw materials *not defined in the glossary - not sure what it means*
- non-hazardous waste to disposal; *a loading related to depletion of land used for waste*
- hazardous waste to disposal (other than nuclear waste) *linked to health impacts*
- nuclear waste to disposal *linked to health impacts*
- exported energy *important, but not sure yet how to handle*

In this last group, only the last 4 are relevant as loadings. The first 3 reduce loadings of the relevant parameters and are therefore of interest, but only as explanatory variables.

Finally, an analysis of the CEN draft documents indicate that there are no social or economic indicators agreed upon at this time.

Conclusions and revised set of Impact Indicators

As a result of the analysis of CEN indicators, the impact categories below have been used for this analysis of assessment systems. Some have been dropped in accordance with the comments previously made, and one (wastewater disposal and treatment) has been added.

Ecological systems

Climate change
Destruction of the stratospheric ozone layer
Acidification of land and water resources
Eutrophication of water bodies
Photo-chemical ozone creation (POCP)
Changes in biodiversity and other ecological systems

Resources

Depletion of non-renewable primary energy
Depletion of non-renewable resources other than primary energy
Depletion of non-renewable freshwater resources
Depletion of land resources with ecological or agricultural value
Exhaustion of solid waste sites suitable for non-hazardous waste

Waste

Pollution of water bodies by wastewater, other than eutrophication
Hazards from disposal of non-radioactive hazardous waste
Hazards from disposal or storage of radioactive waste

Health, society and culture

Ability of users with functional impairments to use the facility
Personal safety and security of users
Health, well-being and productivity for users of facility
Health, security and well-being of off-site population
Changes to social or cultural systems

Economy

Financial risk or benefits for investors
Housing affordability or commercial retail viability
Changes in economic system (employment, economic stimulus)

Analysis of systems according to spreadsheet information

Scope of assessment

The spreadsheet includes three active spreadsheets: *SysCompare, KeyParameters* and *DetailsEn&Water*.

SysCompare shows some of the obvious issues related to scope - new v. renovation, occupancy type and applicable phase of the life cycle. There are other issues related to scope, including the following:

Green or sustainable or whole building assessment:

Most of the systems reviewed deal primarily with environmental issues, but some (SBT Uffici and LEnSE) include social and economic assessment parameters that make a start, at least, in qualifying them as "sustainable building" assessment systems. It should not be forgotten that users n China, HK and Korea have raised the question of why earthquake resistance performance is not included. Then there are potential issue areas related to security against natural events such as flooding, or dealing with power outages, or even resistance against terrorist attacks. The inclusion of such parameters has been discussed during the development of some existing systems, but the suggestions have been rejected by those who argue that such issues are dealt with by regulations, and who wish to keep the focus on core sustainability issues. Nevertheless, some users see logic in including all issues that are pertinent to the real world of design and development in one system, or at least having the potential of including all issues. DGNB, for example, includes fire safety in its system and both DGNB and BREEAM consider flooding. During the next phase, this issue should be explicitly dealt with.

Physical boundaries of assessment:

Most systems extend their reach to urban region and even further (local, regional and global). However, there are different ways of approaching this issue: the CASBEE system (not reviewed here) limits explicit assessment activities to within the site boundary, and the DGNB system focuses on the building footprint.

Project-related parameters v. impact categories and concerns

An overview of the systems on the spreadsheet indicate that their structures seem to be the result between a struggle to represent project aspects on the one hand, and impact concerns on the other. All the systems contain a mix of the two types of parameters, although LEnSE is almost purely structured according to theoretical sustainability impact categories (Environmental, Social, Economic).

Parameters in common

An attempt was made to identify what parameters might be used by all or most systems, thereby indicating that the system developers have found these parameters to be of relevance and/or importance. Unfortunately, as the *KeyParameters* worksheet shows, many systems certainly use many similar criteria, but there is a range of variation in the phrasing and even definition of these which makes clear findings difficult to identify.

Detailed review of approaches to energy and atmospheric emissions:

In the Energy and atmospheric emissions category, it will be seen that BREEAM includes an appraisal of various features that are considered to lead to good energy performance, including building fabric, sub-metering, zero carbon technologies, energy efficient lifts and escalators. It is interesting to note that EE lighting is not included in this section of BREEAM. Certivéa / HQE goes directly to the assessment of primary non-renewable energy and "pollution" control, as does Aqua. DGNB adopts a classical approach of ignoring building features or strategies, and focuses on measurable performance. This is the closest to being compatible with impact categories. SBT Uffici follows a similar approach and so does LEnSE except, oddly enough, providing no coverage of GHG emissions. PromisE covers only heat consumption but does cover target-setting.

It is curious that, in an area as well developed as energy and atmospheric emissions, that considerable variation exists in the breadth of coverage and the specific parameters used, exemplified by the BREEAM approach of focusing on features and measures (and assuming that this will lead to high performance), as against predicting (through simulation) or measuring (in operations) various aspects of real performance[1].

Figure 13: Parameters related to energy and emissions from 7 rating systems

		Energy and atmospheric emissions	
B		Evidence of an improvement in the energy efficiency of the building's fabric and services and therefore achieves lower building operational related CO2 emissions.	BREEAM includes an appraisal of various features that are considered to lead to good energy performance, including building fabric, sub-metering, zero carbon technologies, energy efficient lifts and escalators. It is interesting to note that EE lighting is not included in this section of BREEAM.
B		Evidence of direct sub-metering of energy uses within the building.	
B		Evidence that sub-metering of energy consumption by tenancy/building function area is installed within the building (in high energy load and tenancy areas).	
B		Evidence that a feasibility study considering local (on-site and/or near site) low or zero carbon (LZC) technologies has been carried out and the results implemented.	
B		Evidence that the first credit has been achieved and there is a 10% reduction in the building's CO2 emissions as a result of the installation of a feasible local LZC technology.	
B		Evidence that the first credit has been achieved and there is a 15% reduction in the building's CO2 emissions as a result of the installation of a feasible local LZC technology.	
B		Up to two credits are available with evidence of the installation of energy-efficient lift(s).	
B		Evidence that escalators reduce unnecessary operation when there is no passenger demand.	
H		Non-renewable primary energy saving	Certivéa / HQE focuses more directly on the simulation or measurements of primary non-renewable energy and control of emissions, as does Aqua.
H		Pollution control	
A		Redução do consumo de energia por meio da concepção arquitetônica	
A		Redução do consumo de energia primária e dos poluentes associados	
D		Global warming potential (GWP)	DGNB adopts a classical approach of ignoring building features or strategies, and focuses on simulated or measurable performance. This is the closest to being compatible with impact categories.
D		Ozone depletion potential (ODP)	
D		Photochemical ozone creation (POCP)	
D		Acidification potential (AP)	
D		Primary energy demand, non-renewable (PEnr)	
D		Primary energy demand, renewable (PEr)	
S		Fabbisogno annuo di energia primaria per la climatizzazione invernale	SBT Uffici follows a similar approach, including both embodied and operational primary energy consumption of non-renewable fuels.
S		Fabbisogno annuo di energia primaria per il raffrescamento	
S		Emissioni effetto serra prodotte annualmente per l'esercizio dell'edificio	
S		Emissione di sostanze acidificanti prodotte annualmente	
S		Emissioni responsabili della formazione di fotossidanti prodotte annualmente	
L		Building - depletion of nonrenewable primary energy	So does LEnSE except, oddly enough, providing no coverage of GHG emissions.
L	♦	Transport - depletion of nonrenewable primary energy	
L		Destruction of the stratospheric ozone layer	
L		Local tropospheric ozoneformation	
P	♦	Setting of requirements for energy consumption	PromisE covers only heat consumption but does covers target-setting
P		Heat consumption	
P		Environmental impact of building products	
P		Environmental impact from energy use	

1: The system codes are: B = BREEAM, H = Certivéa HQE, A = Aqua, D = DGNB, S = SBC Uffici, L = LEnSE and P = PromisE

The *KeyParameters* worksheet shows other instances of variation in approach to similar problems (example below of daylighting and lighting).

Figure 14: Parameters related to daylighting, glare and lighting from 7 rating systems

	Daylighting, glare and lighting	
B	Evidence that, in all relevant building areas, lighting is appropriately zoned and occupant controllable.	Although the criteria refer to features and measures, they are supported by various detailed technical performance standards and requirements such as DF for certain percent of area, uniformity, room proportions and reflectances etc. Various physical conditions are also considered.
B	Evidence that at least 80% of floor area in each occupied space is adequately daylit.	
B	Evidence that an occupant-controlled shading system (e.g. internal or external blinds) is fitted in relevant building areas.	
B ♦	Evidence that high frequency ballasts are installed on all fluorescent and compact fluorescent lamps.	
B	Evidence that all internal and external lighting, where relevant, is specified in accordance with the appropriate maintained illuminance levels (in lux) recommended by CIBSE	
B	Evidence that, in all relevant building areas, lighting is appropriately zoned and occupant controllable.	
B	Energy-efficient external lighting is specified and all light fittings are controlled for the presence of daylight.	
H	Optimisation of natural light comfort	The term "comfortable" is defined by various DF, Lux levels and uniformity indices for occupancy sub-types.
H	Availability of comfortable artificial lighting	
H	Availability of artificial lighting of outside areas	
A	Garantia de iluminância natural ótima evitando seus inconvenientes (ofuscamento)	
A	Iluminação artificial confortável	
D	Visual comfort	Well defined in a 9-pg doc.
S	Illuminazione naturale negli ambienti principali	Methods, standards and performance thresholds are well defined.
S	Abbagliamento (glare)	
S	Livelli di illuminamento e qualità della luce artificiale	
L	Lighting comfort (artificial & natural)	Include. Lux & DF req'mnts
P	Intensity and uniformity	Does not cover daylighting
P	Prevention of reflections and glare	

Unique parameters

A first look indicates that some systems feature parameters that are relatively unique; e.g. they are not found in other systems. These are marked in Column B of the spreadsheet by a turquoise diamond shape. A count by system gives the following result:

23	BREEAM
5	HQE
5	AQUA
24	DGNB
5	SBC Uffici
14	LEnSE
11	PromisE

BREEAM and DGNB are more-or-less tied for the system with the most unique parameters, and LEnSE, HQE, AQUA and PromisE have the fewest. This is not intended to imply that BREEAM or DGNB are necessarily better systems, only that it is capable of assessing certain issues that are not included in other systems. This might be seen as an advantage; on the other hand, it may be preferable to have a more compact system that is quicker to apply.

One impact category for which all systems appear to lack relevant assessment criteria is the need to ensure access and use of buildings by persons with mobility or other sensory parameters.

Links between parameters and impact categories

It must be noted that the matching of specific parameters with impact categories is only feasible in an approximate sense. For example, energy consumption is linked to climate change in a fairly direct way, via GHG emissions that occur as a result of the energy use. But indoor air quality and ventilation are also connected to GHG via a more complex route - fan energy to electrical consumption to GHG emissions. These correlations should therefore be treated with some caution.

The Certivéa (HQE) system provides a useful introduction to the presentation of each major criterion, in the form of a cross-reference to other related performance target areas.

Weighting of parameters

All systems feature weighting of parameters. This includes HQE and AQUA which, even if they are presented as not having weights, are implicitly weighted on an even basis. LEnSE is the most interesting in this regard, in its use of core (Europe-wide) weights, supplemented by national or regional weightings. Weighting is not explored in detail in this study.

Possible future development

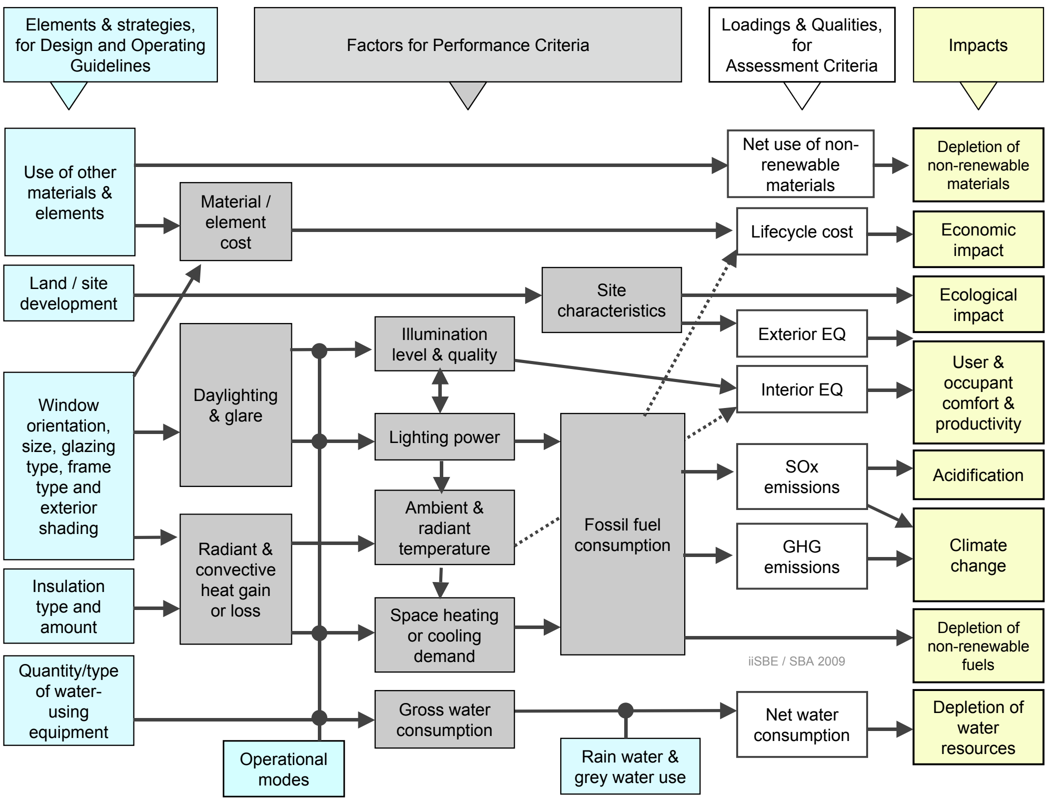
Key parameters proposed as a core starting set

After consideration of the performance parameters used by the different systems for office buildings, and also the CEN impact categories, we suggest that the following parameters may represent a good core starting set, that might be augmented at a later point:

- Use of valuable land and effects on ecological systems, predicted or actual
- Measures to promote and use of efficient forms of transport, predicted or actual
- Lifecycle greenhouse gas emissions, embodied + predicted or actual operating
- Use of non-renewable fuel resources, predicted or actual
- Use of non-renewable material resources, predicted or actual
- Potable and total non-renewable water consumption, predicted or actual
- Liquid waste, predicted or actual
- Solid waste, predicted or actual
- Daylighting (DF), glare and lighting illuminance, predicted or actual
- Indoor air quality and ventilation, predicted or actual
- Key service quality factors - adaptability, security, efficiency, amenity quality - predicted or actual
- Economic performance relative to market, predicted or actual

Design Strategies and Measures v. Loadings and Impacts

Our preliminary analysis of the system structures indicates that they would probably all benefit from a more clear separation between project-oriented parameters and those that represent either Loadings or Qualities of Service, or else Impacts. The diagram below illustrates this issue.



Most of the existing systems mix the two different types of information and this leads to systems which attempt to serve two functions at once: to guide developers and designers in their attempts to design for high performance, and to measure and assess building performance in an objective way as possible. There is a practical consideration here as well, since information related to design guidance tends to be voluminous and complex, while assessment can be focused on a much smaller number of key parameters. Therefore, we believe that next steps will involve a fairly clean separation between these two quite different functions.

A different approach to structure

The following three figures illustrate the difference in volume of parameters involved, with respect to energy and water. Please note that there are a large number of design strategies or measures that are pertinent to a much smaller number of Loadings or Impact categories. The three figures also show a suggestion for how various actions, including types of assessment, could be related to the information available at various phases.

These figures illustrate an approach not currently followed: that information about design strategies, technologies and measures could be limited to information provision, without being part of a scoring system.

Possible approach to SB Alliance structure - example

To expand the spreadsheet use buttons at far left

Click on box

Design

Click on box

5-Mar

	Design strategies or elements
Energy and Emissions	Orient to maximize solar gain in heating season and to minimize in cooling season
	Number, location and size of windows to balance daylight w.heat loss or gain
	High performance glazing to minimize thermal transmission
	Exterior shading located in walls exposed to high solar gain and designed to maximize solar cutoff during cooling season but to minimize during heating season.
	Maximize daylighting effectiveness through amount and location of glazed opening, glazing characteristics and interior reflective surfaces
	Maximize use of renewable energy sources to minimize use of non-renewable sources.
	Maximize efficiency of HVAC equipment that uses non-renewable fuels
	Maximize efficiency of building conveying systems, motors, pumps etc.
	Digital building management system with feedback from key systems.
	Through lease instruments, ensure that tenants use only EE equipment
	Train operating staff and occupants
Water	Use water-conserving fixtures
	Use grey water for irrigation and toilet purposes
	Retain rain water for use as grey water
	Retain and treat storm water for use in irrigation
	Use green roof for storm water capture
	Monitor leaks
	Train operating staff and occupants

Designer's checklist, not scored

External loads & demands	Performance summary	Specific Performance Factors
Exterior heat and humidity during hot season; cold weather & low humidity & winds during cold season;	Indoor temperature maintained at XX +/- YY deg.C for xx/24 hours;	Space heating
	Relative humidity maintained within limits X to Y;	Mechanical space cooling
Orientation affecting solar gain and therefore heat gain or loss.	Ventilation rate maintained in specific locations;	Mechanical space ventilation
Demand by occupants for domestic hot water (DHW)	Provision of XX Lpp DHW at 55 degC. On 24 hr. basis	Domestic hot water
Demand for electric power by artificial lighting systems, building mechanical and conveying equipment, also by occupant equipment.	Provision of power for lighting and equipment to a level of X kW/m2	Power for interior lighting and equipment
		Power for exterior lighting and equipment
Demand for potable water by occupants;	Provision of water for all building-related uses	Provision of water for occupants sanitary fixtures
Demand for clean water by mechanical systems;		Provision of water for external uses
Demand for water by exterior landscaped systems		Provision of water for building systems use

First assessment, carried out during Design Phase

Loadings 1	Loadings 2
Non-renewable fuels used on site for heating or cooling	Non-renewable primary energy used for operations on site
Delivered electrical power for operations generated from non-renewable sources	
Renewable fuels used on site for heating or cooling	Renewable fuel and electric power used for operations
Delivered electrical power for operations generated from renewable sources	
Electrical power for operations generated on-site from renewable sources	
Gross consumption of water	A. Gross consumption of potable water
	B. Recyclable sanitary waste water
	C. Retention of recyclable storm and rain water

Loadings 3	Loadings summary
Consumption of non-renewable fuels	
GHG primary emissions from non-renewable fuels	GHG primary emissions
GHG primary emissions from **renewable** fuels	
GHG emissions generated by energy used for pumping and treating potable water and wastewater sent off-site	
Net consumption of potable water A - (B + C)	Net consumption of potable water

Impact Categories	Units and comments
Depletion of non-renewable fuels	Based on simulation results using an hour-by-hour energy simulation program Units used: Energy consumption: KwH/m2 per year and Tonnes or kg./m2 * yr, by fuel or TOE/m2 * yr Primary emissionse: eCO2 per m2 * year,based on CO2, SO2, Nox and Methane; Primary energy is delivered electrical power multiplied by primary energy factor plus fuels combusted on site. Generating fuel mix affects primary energy factor; Adjust for actual v. theoretical occupancy;
Climate Change	
Depletion of water resources	Based on estimates of water consumption using typical consumption figures for the region for comparable occupancy types and occupancy densities. Units are litres or m3 of water from all sources used per occupant (or per m2) per year for site, building systems and occupancy uses. For area measure, normalize according to occupancy;

Possible approach to SB Alliance structure - example

To expand the spreadsheet use buttons at far left

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Construction

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5-Mar

	Design strategies or elements
Energy and Emissions	Orient to maximize solar gain in heating season and to minimize in cooling season
	Number, location and size of windows to balance daylight w.heat loss or gain
	High performance glazing to minimize thermal transmission
	Exterior shading located in walls exposed to high solar gain and designed to maximize solar cutoff during cooling season but to minimize during heating season.
	Maximize daylighting effectiveness through amount and location of glazed opening, glazing characteristics and interior reflective surfaces
	Maximize use of renewable energy sources to minimize use of non-renewable sources.
	Maximize efficiency of HVAC equipment that uses non-renewable fuels
	Maximize efficiency of building conveying systems, motors, pumps etc.
	Digital building management system with feedback from key systems.
	Through lease instruments, ensure that tenants use only EE equipment
	Train operating staff and occupants
Water	Use water-conserving fixtures
	Use grey water for irrigation and toilet purposes
	Retain rain water for use as grey water
	Retain and treat storm water for use in irrigation
	Use green roof for storm water capture
	Monitor leaks
	Train operating staff and occupants

External loads & demands	Performance summary	Specific Performance Factors
Exterior heat and humidity during hot season; cold weather & low humidity & winds during cold season; Orientation affecting solar gain and therefore heat gain or loss.	Indoor temperature maintained at XX +/- YY deg.C for xx/24 hours; Relative humidity maintained within limits X to Y; Ventilation rate maintained in specific locations;	Space heating Mechanical space cooling Mechanical space ventilation
Demand by occupants for domestic hot water (DHW)	Provision of XX Lpp DHW at 55 degC. On 24 hr. basis	Domestic hot water
Demand for electric power by artificial lighting systems, building mechanical and conveying equipment, also by occupant equipment.	Provision of power for lighting and equipment to a level of X kW/m2	Power for interior lighting and equipment Power for exterior lighting and equipment
Demand for potable water by occupants; Demand for clean water by mechanical systems; Demand for water by exterior landscaped systems	Provision of water for all building-related uses	Provision of water for occupants sanitary fixtures Provision of water for external uses Provision of water for building systems use

Loadings 1	Loadings 2
Non-renewable fuels used on site for heating or cooling	Non-renewable primary energy used for operations on site
Delivered electrical power for operations generated from non-renewable sources	
Renewable fuels used on site for heating or cooling	Renewable fuel and electric power used for operations
Delivered electrical power for operations generated from renewable sources	
Electrical power for operations generated on-site from renewable sources	
Gross consumption of water	A. Gross consumption of potable water
	B. Recyclable sanitary waste water
	C. Retention of recyclable storm and rain water

Loadings 3	Loadings summary	Impact Categories
	Consumption of non-renewable fuels	Depletion of non-renewable fuels
GHG primary emissions from non-renewable fuels	GHG primary emissions	Climate Change
GHG primary emissions from renewable fuels		
GHG emissions generated by energy used for pumping and treating potable water and wastewater sent off-site		
Net consumption of potable water A - (B + C)	Net consumption of potable water	Depletion of water resources

Second assessment, carried out before occupancy

Units and comments
Based on metered energy use monitored for at least 12 months and carried out at least two years after occupancy Units used: Energy consumption: KwH/m2 per year and Tonnes or kg./m2 * yr, by fuel or TOE/m2 * yr Primary emissionse: eCO2 per m2 * year,based on CO2, SO2, Nox and Methane; Primary energy is delivered electrical power multiplied by primary energy factor plus fuels combusted on site. Generating fuel mix affects primary energy factor; Adjust for actual v. theoretical occupancy;
Based on metered gross water use monitored for at least 12 months and carried out at least two years after occupancy Units are litres or m3 of water from all sources used per occupant (or per m2) per year for site, building systems and occupancy uses. For area measure, normalize according to occupancy;

Possible approach to SB Alliance structure - example

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Operations

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5-Mar

	Design strategies or elements
Energy and Emissions	Orient to maximize solar gain in heating season and to minimize in cooling season
	Number, location and size of windows to balance daylight w.heat loss or gain
	High performance glazing to minimize thermal transmission
	Exterior shading located in walls exposed to high solar gain and designed to maximize solar cutoff during cooling season but to minimize during heating season.
	Maximize daylighting effectiveness through amount and location of glazed opening, glazing characteristics and interior reflective surfaces
	Maximize use of renewable energy sources to minimize use of non-renewable sources.
	Maximize efficiency of HVAC equipment that uses non-renewable fuels
	Maximize efficiency of building conveying systems, motors, pumps etc.
	Digital building management system with feedback from key systems.
	Through lease instruments, ensure that tenants use only EE equipment
	Train operating staff and occupants
Water	Use water-conserving fixtures
	Use grey water for irrigation and toilet purposes
	Retain rain water for use as grey water
	Retain and treat storm water for use in irrigation
	Use green roof for storm water capture
	Monitor leaks
	Train operating staff and occupants

External loads & demands	Performance summary	Specific Performance Factors
Exterior heat and humidity during hot season; cold weather & low humidity & winds during cold season;	Indoor temperature maintained at XX +/- YY deg.C for xx/24 hours;	Space heating
	Relative humidity maintained within limits X to Y;	Mechanical space cooling
Orientation affecting solar gain and therefore heat gain or loss.	Ventilation rate maintained in specific locations;	Mechanical space ventilation
Demand by occupants for domestic hot water (DHW)	Provision of XX Lpp DHW at 55 degC. On 24 hr. basis	Domestic hot water
Demand for electric power by artificial lighting systems, building mechanical and conveying equipment, also by occupant equipment.	Provision of power for lighting and equipment to a level of X kW/m2	Power for interior lighting and equipment
		Power for exterior lighting and equipment
Demand for potable water by occupants;	Provision of water for all building-related uses	Provision of water for occupants sanitary fixtures
Demand for clean water by mechanical systems;		Provision of water for external uses
Demand for water by exterior landscaped systems		Provision of water for building systems use

Loadings 1	Loadings 2
Non-renewable fuels used on site for heating or cooling	Non-renewable primary energy used for operations on site
Delivered electrical power for operations generated from non-renewable sources	
Renewable fuels used on site for heating or cooling	Renewable fuel and electric power used for operations
Delivered electrical power for operations generated from renewable sources	
Electrical power for operations generated on-site from renewable sources	
Gross consumption of water	A. Gross consumption of potable water
	B. Recyclable sanitary waste water
	C. Retention of recyclable storm and rain water

Loadings 3	Loadings summary
Consumption of non-renewable fuels	
GHG primary emissions from non-renewable fuels	GHG primary emissions
GHG primary emissions from renewable fuels	
GHG emissions generated by energy used for pumping and treating potable water and wastewater sent off-site	
Net consumption of potable water A - (B + C)	Net consumption of potable water
	Final assessment

Impact Categories	Units and comments
Depletion of non-renewable fuels	Based on metered energy use monitored for at least 12 months and carried out at least two years after occupancy Units used: Energy consumption: KwH/m2 per year and Tonnes or kg./m2 * yr, by fuel or TOE/m2 * yr Primary emissionse: eCO2 per m2 * year,based on CO2, SO2, Nox and Methane;
Climate Change	Primary energy is delivered electrical power multiplied by primary energy factor plus fuels combusted on site. Generating fuel mix affects primary energy factor; Adjust for actual v. theoretical occupancy;
Depletion of water resources	Based on metered gross water use monitored for at least 12 months and carried out at least two years after occupancy Units are litres or m3 of water from all sources used per occupant (or per m2) per year for site, building systems and occupancy uses. For area measure, normalize according to occupancy;