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THE PAPER COMPARES ESD RATING SCHEMES IN IARU COUNTRIES.

Comparison of Building Rating Schemes

Sustainable development seeks to meet the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987, p 43), and is an important underlying influence in developing environmental building rating schemes. In particular, sustainable development aims to balance improvements of lifestyle and wellbeing while preserving natural resources and ecosystems. All building rating schemes discussed have contributed in some way to the sustainable development. Yet the degree to which they focus on the environmental effects of a building on particularly when measured in terms of a building's life-cycle, vary considerably.

Building rating schemes in each IARU member country are comparable to one another. All EBRS's have been compared with each other according to the criteria used in BREEAM: management, health and wellbeing, energy, transport, water, materials, land use, and pollution. Furthermore, each rating scheme has been re-weighted so that each criterion and requirement can be represented as a percentage (Annex 1-7). The rating schemes for China, Denmark and Switzerland could not be compared using this method of analysis as there was insufficient data on the weighting of each criterion. In these cases, qualitative comparisons with the other EBRS's have been made. All comparisons are for guidelines relating to office-type buildings, except LEED which is for multiple-buildings and on-campus buildings.[1] Mandatory building regulations generally fall far short of environmental assessment methods and are usually inline with the minium score possible and are therefore not discussed further in the context of this report.

The flow of energy is often considered the most important parameter (Canada Mortgage and Housing Corporation 2004). It is also one of the easiest parameters to measure, and, because simple measurements can be taken during building operation, simple post-construction tools for reducing energy use can be employed. It is for these reasons that energy ratings for building use, such as First Rate (Australia), BV95 (Denmark) and Energy 10 (United States) herald the inception of environmental assessment tools. However, to fully assess the environmental impact of a building, a much more detailed analysis is required. Some of the important aspects of sustainable

[1] LEED for multiple-buildings and on-campus buildings has the same weighting for each criterion as LEED-NC (new constructions).

development in relation to buildings are discussed below within reference to selected building rating systems in IARU member countries presented above.

Energy use is consistently a major focus of all rating schemes. Energy is generally weighted at between 15 to 36 % of the overall building rating (Figure 1). This difference can often be attributed to geo-political factors. For example, in Australia (Green Star), where electricity produced from coal is cheap and abundant, energy is only weighted at 18 % while Singapore (Green Mark), which is reliant on imported fossil fuels, place a heavy importance on energy efficiency (36 %). Switzerland also places a heavy importance on reducing energy use. MINERGI (Switzerland) focuses heavily on reducing energy consumption, particularly by reducing heat loss from buildings by restricting air flow and with insulation 200-300 mm thick.

While sub-metering of energy use is common, only Engerimarke (Denmark) uses this information to re-evaluate a buildings rating depending on use. BREEAM, however, does recognize the need to disseminate energy use and savings data to occupants on a regular basis. The lack of monitoring of the use of a building is surprising given that energy use and CO_2 emissions from using a building are more than 10 times higher than the combined energy (embodied and use) and CO_2 emissions for materials and construction (Canada Mortgage and Housing Corporation (2004).

The Indoor Environment Quality (IEQ) (Health and Wellbeing in BREEAM) is extensively addressed for all EBRS's. Weighted values range between 12 % for Green Mark to 26 % for CASBEE (Figure 1). The common features addressed include ventilation and air quality, use of daylight, selecting low emission materials, temperature and lighting control, and noise pollution. LEED does not address noise, while CASBEE does in some detail. Generally, human comfort levels are well understood and defined, and are usually irrespective of country location. Thus, IEQ is well suited to rating schemes which employ simple addition of weighted criteria (eg. Noise levels below 45 dB or temperature levels at 22^{o}C).

Water efficiency is consistently found as an independent category within all rating systems. Minimizing water use for irrigation and landscaping, waste water generation reduction and utilization of grey-water or collecting rainwater are commonly recommended. Weighted values for the water criteria range between 3% for CASBEE to 18 % for Green Mark. The variation in weighting of these categories can generally be attributed to geopolitical factors. In Australia, where water scarcity due to low precipitation is commonplace, and in Singapore, where fears over water supply remain politically important, water is weighted at 12 % and 18 % respectively, significantly higher than for other countries (Figure 1). The degree to which water is considered important (i.e. as measured by its relative weighting) will remain specific to each country, and possibly even specific to certain regions within each country.

The difficulties associated even with finding commonalities on water issues highlight the problem with comparing rating systems between countries, but also suggests an approach for resolving these issues. Because so many elements of EBRS's are site- and country-specific, comparing criteria (e.g. water use, energy consumption, CO_2 emissions) is not only unproductive, but any decision based on such comparisons will not necessarily contribute to sustainable development. Instead, each university should aim to reduce their use (e.g. of water) relative to current use, and to the environmental consequences of such use. In the case of water, focus should be on reductions in water use across all countries proportional to current usage levels (e.g. 30 %). While such a policy will lead to disparities in the total reduced amount in each university, it should contribute evenly (on a global sense) to sustainable development. Furthermore, it is likely to be much easier to implement such a policy for each university rather than trying to develop and all-encompassing (e.g. water) policy for all universities.

Transport related issues, such as proximity to major public transport nodes, cycle facilities and walking access is a common area of interest in EBRS's. Both BREEAM (13%) and Green Star (9%) place considerable importance on transport facilities. CASBEE on the other hand, does not consider transport at all and Green Mark assigns it only 1 % of the overall points (Figure 1). This disparity is probably due to the discretion of EBRS policy makers. The link between transport and building development is quite weak, and it is usually considered in a category of its own in ESD frameworks. However, its inclusion in some EBRS does highlight the importance of considering the way in which a building is used over its lifetime, and the effect that such uses could have on the environment.

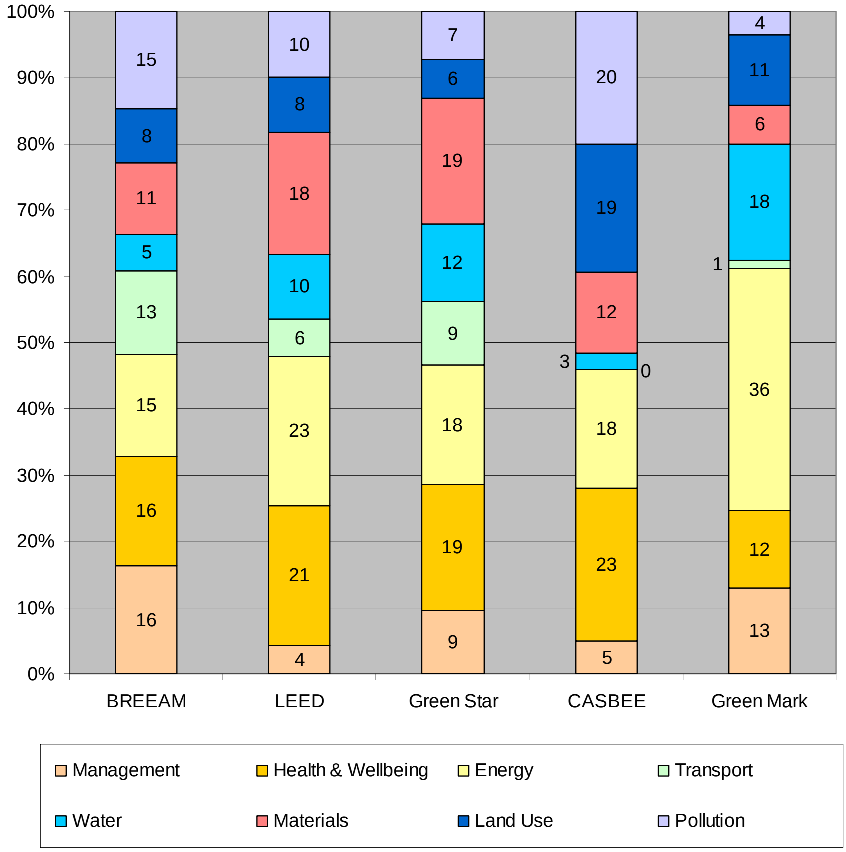


Figure 1. Normalised weightings for EBRS for selected IARU countries

Reductions in atmospheric pollution are a strong focus of all the EBRS, however there are considerable differences in the metrics used to quantify pollution and the methods for reducing the pollution associated with buildings. The most common requirements for reducing pollutants are for CO_2 and refrigerants (often explicitly CFCs). Light pollution is considered by LEED, Green Mark and Green Star, while noise pollution is considered by CASBEE and Green Mark. Only Green Star and CASBEE consider airborne pathogens (Legionella). Other measured pollutants include the greenhouse warming potential (GWP) of materials used in construction, nitric oxides (BREEAM), heat island effects (LEED and CASBEE), environmental tobacco smoke (ETS) (BREEAM and LEED) and vibrations (CASBEE). EACB measures a number of other pollutants including ash and radioactive pollution.

The importance of air pollution in each rating systems varies considerably. The category of pollution (Figure 1) also includes other pollutants such as 'flooding potential' (BREEAM) and 'reduced flow to sewer' (Green Star). CASBEE and

BREEAM both place a large importance on pollutants (20% and 15% respectively) while Green Mark weights pollution at only 4%.

While BREEAM, and to a lesser extant LEED, have been widely used as the basis for EBRS's throughout the world, most rating schemes in IARU member countries have been developed independently, making comparisons between them difficult. Switzerland focuses on energy consumption reduction while Denmark relies heavily on BEAT as a life-cycle analysis tool for the materials used in construction, as well as considerable emphasis on indoor environmental quality (IEQ). Japan (CASBEE) on the other hand, like China (GOBAS), has taken a considerably different approach. By scoring a building both by its quality and also by the effect it has on the environment quite separately, CASBEE has modelled its rating system more closely to the definition of sustainable development suggested above (i.e. improving lifestyle while preserving natural resources). As Cole (publish date unknown) suggests, CASBEE is one of the first assessment tools which is moving ahead of the 'first generation' of assessment tools such as BREEAM and LEED, which use simple addition of weighted performance scores and characterise a building as a "product", and instead, measure the environmental implications associated with providing a set of "services." For the purposes of this discussion, this distinction is important, as a rating system which considers a building for the services it provides is better able to describe university facilities, which contain a multitude of building types, from laboratories to residential halls. Such a rating system also allows for simpler comparison between buildings in different countries, largely independently of their location.

Particularities in each IARU member country make the use of single EBRS almost impossible. In particular, while only the first generation in EBRS's exist, where points are allocated for meeting certain criteria, comparisons between countries will remain fruitless because criteria may not be suited to some countries. BREEAM, for example cannot be used in its current form to accurately assess most other IARU member countries – it must be modified. While BREEAM was used as the basis for Green Star in Australia, less than half the original requirements were used (Annex 9). Even the similar requirements had to be modified to better describe the Australian landscape. The same can also been seen with HK-BEAM (criteria not presented). Even within Australia, weightings in Green Star categories are modified by 5% so that building can be better represented despite natural variations in the environment in different parts of the country.

Life-cycle analysis (LCA) tools (e.g. BEAT in EACB) generally consider pollutants in much more detail than EBRS's, however, they add a level of complexity to building rating. For example, the Boustead Model for Life Cycle Inventory Calculations tool (Australia) includes air pollutants such as dust, carbon monoxide, carbon dioxide, sulphur oxides, nitric oxides, hydrocarbons, methane, hydrogen sulphide, chlorine and lead just to name a few, whereas Green Star (Australia) only considers ozone depleting, refrigerants and *legionella*. EBRS's which contain LCA elements, such as

EACB, are able to provide much more detailed evaluations of the effects of a building on the environment. However, while it is not within the scope of this report, it is worth mentioning that the complexity of LCA may make it prohibitively difficult as a current tool for building analysis. Furthermore, the pollution from certain materials may change considerably over time, for example due to changes in manufacturing techniques or the proximity of material source location.

The difficulties associated with comparing different kinds of pollution in different buildings remains a problem for building evaluators (Dinesen 2001). EACB attempts to overcome this drawback of LCA by normalizing each environmental effect to 'person-equivalents/kg/yr'. However, different production methods, sources of energy, distance transport, etc can lead to hugely different embodied energy in similar products produced in different locations.

While it may be difficult to compare metrics from LCA tools in different countries, considering the life-cycle of a building is an important element of EDS which has been partially overlooked. This is particularly evident in the apparent disregard for the environmental consequences of how a building is used; generally the rating of a building is not reflected by the amount of resources (e.g. energy) which it uses.

Finally, it is worth mentioning the Sustainable Building Tool (SBTool, formally GBTool) which was developed specifically as a global rating tool. SBTool is the software implementation (publicly available excel spreadsheet[2]) of the Green Building Challenge (GBC) assessment method that has been under development since 1996 (SBTool 2007). It is managed by the International Initiative for a Sustainable Built Environment (iiSBE):[3]

> 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. (SBTool 2007).

This tool is primarily focused towards countries or regions where no rating tools currently exist, and using this tool may simply duplicate existing rating schemes. However, it may also provide an excellent reference should the IARU wish to develop its own environmental building rating scheme.

Conclusions

Environmental building rating schemes (EBRS) provide a method of evaluating buildings under a sustainable development framework. The development of EBRS's

[2] Tools available for download at http://greenbuilding.ca/down/sbc2008/SBTool/
[3] http://www.iisbe.org/

in IARU member countries has been largely independent, and as a consequence there is a considerable disparity between weighted criteria. In this report, EBRS's were compared by normalizing requirements of each EBRS and comparing them with the 8 main criteria of BREEAM: management, health and wellbeing (IEQ), energy, transport, water, materials, land use, and pollution. While most rating schemes considered elements of these 8 categories to varying degrees, due to geopolitical and environmental variations between IARU member countries, it is not possible to compare the weightings of these criteria between countries.

EBRS's which involve the simple addition of weighted criteria such as BREEAM, LEED or Green Star are unlikely to accurately evaluate university buildings due to the range of building types. The flexibility which CASBEE offers, however, provides a system of evaluation which can be adapted to different building types. CASBEE is conceptually different from BREEAM-like evaluation methods because it considers a weighting for both the environmental load of a building and the quality of the building. Such a methodology is more complex but much more adaptable.

Life-cycle analysis is an important tool for sustainable development, but it has very little use in EBRS presumably due to the complexity in using it. It will, however, have to become an important tool for attaining sustainable development. Given that only a small amount of energy is used in the materials and construction of a building compared with its use, it is surprising that so little importance has been placed on the way in which the building is later used. Energimarke (Denmark) is a notable example of a continual assessment rating based on actual consumption.

REFERENCES:

1. Bauwens, Hoogelander, Jensen, Loncour, Marcos, Sager, Tchang, Thomsen, Voskens, Wittchen and Zegers (2005) Energy Certification Schemes and Impact Test Preparation Report no.: IMPACT 2005:1, EC contract: EIE/04/161/S07.38659

2. Bowe C., (2004) Guide to green buildings, Adelaide review, available at http://www.adelaidereview.com.au/archives/2004_08/issuesandopinion_story2.shtml

3. Building & Construction Authority (2006a) *BCA Green Mark Scheme*, available at http://www.bca.gov.sg/GreenMark/green_mark_buildings.html

4. Building & Construction Authority (2006b) *Bca Green Mark Assessment Criteria,* available at http://www.bca.gov.sg/GreenMark/green_mark_criteria.html

5. Building Authority (1995) *Code of Practice for Overall Thermal Transfer Value in Buildings*, Hong Kong Building Authority

6. Bunz K., Henze G., and Tiller D. (2006) *Survey of Sustainable Building Design Practices in North America, Europe, and Asia*, Journal of Architectural Engineering Vol. 33, p. 33

7. Canada Mortgage and Housing Corporation (2004) Energy-Related Environmental Impact of Buildings, Canada, available at http://www.greenbuilding.ca/annex31/pdf/B_environmental.pdf

8. China Ecological Residential Technology Assessment Manual (2002) China construction industry publishing house - 中国生态住宅技术评估手册 中国建筑工业出版社 [2002] available for purchase at http://product.dangdang.com/product.aspx?product_id=9146004

9. China Housing Industry Associations, *Programs*, unknown publication date, available at http://bj.chinahouse.info/EN/index/Programs.asp

10. Chunming H., (2007) *Construction department: The strengthened standard impels the building energy conservation*, available at http://www.cin.gov.cn/bzde/bzdt/200707/t20070702_115008.htm

11. Crown (2006) Code for Sustainable Homes, available at http://www.planningportal.gov.uk/england/professionals/en/1115314116927.html

12. DCLG - Department for Communities and Local Government (2006) *Code for Sustainable Homes A step-change in sustainable home building practice*, Communities and Local Government Publications, UK, available at http://www.planningportal.gov.uk/uploads/code_for_sust_homes.pdf

13. Dinesen, Hansen and Treldal (2001), Miljødeklarering og -klassificering af Bygninger, Forslag til fremgangsmåde, og Byg Dokumentation 014 Statens Byggeforskningsinstitut 2001

14. Directive 2002/91/EC (2002) On the Energy Performance of Buildings, The European Parliament and of the Council, available at http://eur-lex.europa.eu/LexUriServ/site/en/oj/2003/l_001/l_00120030104en00650071.pdf

15. Hansen K., and Dammann S., (2002) Survey on Danish Environmental Indicators in the Building Sector, Danish Building and Urban Research DRAFT February 2002

16. He Huiyu, H., (2007) *The building can effect marking - let the energy conservation "be clear"*, Ministry of Construction of the People Republic of China, Press release http://www.cin.gov.cn/jskj/jsdt/200703/t20070327_103805.htm (Chinese)

17. Hui, S., (2000), *Building energy efficiency standards in Hong Kong and mainland China,* In Proc. of the 2000 ACEEE Summer Study on Energy Efficiency in Buildings, 20-25 August 2000, Pacific Grove, California.

18. iiSBE (2006) *GBTool Overview*, available at http://greenbuilding.ca/gbc2k/gbtool/gbtool-main.htm

19. Japan Sustainable Building Consortium (2007) *CASBEE*, available at http://www.ibec.or.jp/CASBEE/english/overviewE.htm (English version)

20. Langer K., and Watson R., (2004) *The Greening of China's Building Industry*, The China Business Review, available at http://www.chinacleanenergy.org/docs/greenbuildings/Greening%20of%20Chinas%20Bldg%20Industry.pdf

21. Langer K., and Watson R., (2005) *Bringing LEED to China*, Environmental Design and Construction, Vol. Nov 2005, available at http://www.emsi-green.com/content/China%20Business%20Reprint.pdf

22. Langer K., and Watson R., (2007) The Greening of China's Building Industry available at www.chinabusinessreview.com/public/0411/langer.html

23. Ministry of Environment and Energy Danish Energy Agency (1996) Act to Promote Energy and Water Savings in Buildings No. 485, Unofficial translation of: Lov om fremme af energi-og vandbesparelser i bygninger. Translation: MM Sprogservice DK / Margaret Malone. June 1998, available athttp://www.ens.dk/graphics/Publikationer/Laws/actsav.html#IndexMark2_1_1

24. Murakami S., Iwamura K., Ikaga T., and Endo J. (2002), *Comprehensive Assessment System for Building Environmental Efficiency CASBEE*, Proc., Japan-Canada Int. Workshop, Japan Sustainable Building Consortium, Keio, Japan.

25. People's Daily Online (2005) *China puts energy-efficient, land-saving building development on government agenda*, available at http://english.people.com.cn/200503/12/eng20050312_176564.html

26. Reed B., (1997) Speaker at Session *18: Green Building Evaluation Tools, Environmentally Preferable Purchasing*, US Environmental Protection Agency, available at http://www.epa.gov/epp/pubs/symp/symp18.htm

27. SBTool (2007) International Initiative for a Sustainable Built Environment, tools available for download at http://www.iisbe.org/iisbe/sbc2k8/sbc2k8-download_f.htm

28. SFOE - Swiss Federal Office of Energy (Bundesamt für Energie BFE) (2007) Building Standards, http://www.bfe.admin.ch/energie/00567/00569/00600/index.html?lang=en

29. Turner J., (2003) *Inventory of Environmental and Energy Projects in China*, China Environment Series, Iss. 61 available at http://www.wilsoncenter.org/topics/pubs/INTERNATIONALNGOSEPT13.pdf

30. Wang, Bai, Yu, Zhang and Zhu (2004) *Regulatory standards related to building energy conservation and indoor-air-quality during rapid urbanization in China*, Energy and Buildings, Vol. 36, Iss. 12, pp. 1299-1308

31. Wentzel, Henrik; Hauschild, Michael; Alting and Leo (1997), Environmental Assessment of Products, Chapman & Hall, London

32. Yang, D., (2005) *Can LEED Be Adopted In China?*, available at http://www.sigbac.com/eng/news/ReadNews.asp?NewsID=362

33. Yi, J., Zhu, X., Qin, Y., (2006) Green Olympics Assessment System Architectural Overview, available at http://www.topenergy.org/show.php?newsid=5137

34. Yien, Fu Hai (2007) Greening The Built Environment, available at http://stars.nhb.gov.sg/stars/public/viewHTML.jsp?pdfno=20070320998

35. Zachary G., (1997) *Water pressure: Nations scramble to defuse fights over supplies* Wall Street Journal, December 4, p. A17

36. Zimmerman, A., Aho, I., Bordass, W., Geissler, S. and Jaaniste, R. (2002) Proposed framework for Environmental Assessment of existing buildings, in Proceedings of International Conference of Sustainable Building 2002, 23-25 September, Oslo, Norway, p. 86.

37. Zhao Jinping, (unknown publication date), *Brief introduction of China Academy of Building Research*, available at http://www.cn-greenlights.gov.cn/english/3E1_4.htm

ANNEX 1: BREEAM ASSESSMENT CRITERIA

Values for each criterion in BREEAM have been re-weighted as a percentage of the overall score, and are here presented below. BREEAM *Design and Procurement* and BREEAM *Operations and Management* for offices have been combined in the table below.

Category/Requirement	**Percentage Score**
1 Management	**16.4**
Building Regulations	1.8
Best Practices	1.8
Monitoring Implementation	2.7
Recycled Construction Timber	0.9
Tennant Information	0.9
Company Policy on Environment	2.0
Environmental Purchasing Policy	2.0
EMS	2.0
Operations and Management Manual	2.0
2 Health and Wellbeing	**16.4**
80% Adequately Day lit	1.2
Desks Location	1.2
Window Antiglare	1.2
Ballasts	1.2
Illuminance Levels	1.2
Independent Lighting Control	1.2
Openable Windows	1.2
Air Intake	1.2
Fresh Air	1.2
Thermal Comfort	0.6
Local Temperature Control	1.2
Legionella	1.2
Noise	0.6
Smoking	0.5
Clean Carpets	0.5
Occupant Feedback	0.5
Occupant Satisfaction Recording	0.5
3 Energy	**15.5**
CO2 Emissions	9.7
Electricity Component Metering	0.8
Sub-Metering	0.8
Automated External Lighting	0.8
Preventive Maintenance Procedures	1.4
Energy Policy	0.7
Reduction in CO2 Emissions	1.0
Occupant Feedback	0.3
4 Transport	**12.6**

Public Transport	1.5
Transport Node	7.6
Bicycle Facilities	2.3
User Travel Plans	0.8
Travel Survey	0.3
5 Water	**5.5**
Above Regulation	2.3
Water Metering	0.8
Leak Detection	0.8
Leak Detection Shut Off	0.8
O&M For All Sanitary Fittings	0.3
Water Monitoring	0.6
6 Materials	**10.9**
A' rating per *Green Guide to Specs.*	1.8
Occupants Carpet Selection	0.5
50% of façade is reuse façade	0.5
80% reuse of existing structures	0.5
Recycled Building Materials	0.5
Materials Responsibly Sourcesd	1.4
Recyclable Materials Storage	2.3
Hazardous Material Information	1.8
Recycling Office Consumables	1.8
7 Land Use	**8.2**
Use Industrial Site	0.8
Decontaminated Land	0.8
Low Ecological Value Land	0.8
Animal Conservation	1.6
Species Protection	2.5
Above Mandatory Requirements	1.6
8 Pollution	**14.7**
Refrigerants	1.1
Refrigerant leak detection	2.3
Insulation Pollution	0.5
Nitric Oxides	3.4
Flooding	1.7
Pollution Treatment Area	1.1
Renewable Energy	3.4
Obtrusive Lights	1.1
Total	**100.0**
Pass:	25

Good:	41
Very Good:	57
Excellent	74

ANNEX 2: LEED ASSESSMENT CRITERIA

Values for each criterion in LEED have been re-weighted as a percentage of the overall score, and are here presented below. 'C' represents compulsory conditions that were not used in the weighting.

Category/Requirement	Percentage Score
Sustainable Sites	**20.3**
Erosion and Sedimentation Control	C
Site Selection	1.4
Urban Redevelopment	1.4
Brownfield Redevelopment	1.4
Alternative Transportation	5.8
Reduced Site Disturbance	2.9
Stormwater Management	2.9
Reduced Heat Island Effect	2.9
Light Pollution Reduction	1.4
Water Efficiency	**7.2**
Water Efficient Landscaping	2.9
Innovative Wastewater Technologies	1.4
Water Use Reduction	2.9
Energy and Atmosphere	**24.6**
Fundamental Building Systems Commissioning	C
Minimum Energy Performance	C
CFC Reduction in HVAC&R Equipment	C
Optimize Energy Performance	14.5
Renewable Energy	4.3
Additional Commissioning	1.4
Ozone Protection	1.4
Measurement and Verification	1.4
Green Power	1.4
Materials and Resources	**18.8**
Storage and Collection of Recyclables	C
Building Reuse	4.3
Construction Waste Management	2.9
Resource Reuse	2.9
Recycled Content	2.9
Local/Regional Materials	2.9
Rapidly Renewable Materials	1.4
Certified Wood	1.4
Indoor Environmental Quality	**21.7**
Minimum IAQ Performance	C
Environmental Tobacco Smoke (ETS) Control	C
Carbon Dioxide (CO2) Monitoring	1.4
Ventilation Efficiency	1.4

Construction IAQ Management Plan	2.9
Low-Emitting Materials	5.8
Indoor Chemical and Pollutant Source Control	1.4
Controllability of Systems	2.9
Thermal Comfort	2.9
Day-lighting and Views	2.9
Innovation and Accredited Professional	**7.2**
Innovations in Design	5.8
LEED Existing Building Accredited Professional	1.4
Certified	38
Silver	48
Gold	57
Platinum	75

ANNEX 3: GREEN STAR ASSESSMENT CRITERIA

Values for each criterion in GREEN STAR have been re-weighted as a percentage of the overall score, and are here presented below. 'C' represents compulsory conditions that were not used in the weighting.

Category/Requirement	Percentage Score
Management	**9.2**
Green Star Accredited Professional	1.4
Commissioning - Clauses	1.4
Commissioning - Building Tuning	0.7
Commissioning - Commissioning Agent	0.7
Building Users' Guide	0.7
Environmental Management	1.4
Waste Management	1.4
Learning Resource	0.7
Maintainability	0.7
Indoor Environment Quality	**18.3**
Ventilation Rates	2.1
Air Change Effectiveness	1.4
Carbon Dioxide and VOC Monitoring and Control	0.7
Daylight	2.8
Daylight Glare Control	0.7
High Frequency Ballasts	0.7
Electric Lighting Levels	0.7
External Views	0.7
Thermal Comfort	2.1
Hazardous materials	0.7
Internal Noise Levels	1.4
Volatile Organic Compounds	2.8
Formaldehyde Minimisation	0.7
Mould Prevention	0.7
Energy	**17.6**
Ene-Conditional Requirement	C
Energy Improvement	10.6
Electrical Sub-metering	0.7
Peak Energy Demand Reduction	1.4
Stairs	0.7
Unoccupied Areas	0.7
Lighting Zoning and Control	0.7
Efficient External Lighting	0.7
Car Park Ventilation	1.4
Centralised Energy Systems	0.7
Transport	**9.2**
Car Park Minimisation	1.4
Fuel Efficient Transport	0.7

Cyclist Facilities	2.8
Commuting Mass Transport	3.5
Pedestrian Routes	0.7
Water	**11.3**
Occupant Amenity Potable Water Efficiency	3.5
Water Meters	0.7
Landscape Irrigation Water Efficiency	2.1
Heat Rejection Water Consumption	2.8
Fire System Water Consumption	0.7
Portable Water Use in Laboratories	1.4
Materials	**17.6**
Recycling Waste Storage	0.7
Reuse of Façade	1.4
Reuse of Structure	2.1
Recycled Content of Concrete	2.1
Recycled Content of Steel	1.4
PVC Minimisation	1.4
Sustainable Timber	1.4
Flooring	2.1
Joinery	1.4
Loose Furniture	2.1
Recycled-Content & Reuse Products and Materials	0.7
Disassembly/Deconstruction	0.7
Land Use & Ecology	**5.6**
Ecological Value of Site	
Reuse of Land	0.7
Reclaimed Contaminated Land	1.4
Change of Ecological Value	2.8
Topsoil and Fill Removal from Site	0.7
Emissions	**7.7**
Ozone Depletion Potential	0.7
Refrigerant GWP	1.4
Refrigerant Leak Detection and Recovery	0.7
Watercourse Pollution	2.1
Reduced Flow to Sewer	1.4
Light Pollution	0.7
Legionella	0.7
Innovation	**3.5**
One Star	10

Two Star	20
Three Star	30
Four Star	45
Five Star	60
Six Star	75

ANNEX 4: CASBEE ASSESSMENT CRITERIA

Values for each criterion in CASBEE have been re-weighted as a percentage of the overall score, and are here presented below. The right-hand column indicates which category of BREEAM each requirement was allocated to. '--' indicates criterion which could not be allocated to a BREEAM category.

Q Building Environmental Quality & Performance	**Percentage Score**	**BREEAM Category Allocation**
Q-1 Indoor Environment	**20.0**	
Background noise	0.6	2
Equipment noise	0.6	2
Sound Insulation of Openings	0.7	2
Sound Insulation of Partition Walls	0.5	2
Sound Absorption	0.6	2
Room Temperature Setting	1.1	2
Variable Loads & Following-up Control	0.0	2
Perimeter Performance	0.7	2
Zoned Control	1.1	2
Temperature & Humidity Control	0.4	2
Individual Control	0.0	2
Allowance for After-hours Air Conditioning	0.4	2
Monitoring Systems	0.0	2
Humidity Control	1.4	2
Type of Air Conditioning	2.1	2
Daylight Factor	0.9	2
Openings by Orientation	0.0	2
Daylight Devices	0.6	2
Glare from light fixtures	0.6	2
Daylight control	0.9	2
Illuminance Level	0.5	2
Uniformity Ratio of Illuminance	0.2	2
Lighting Controllability	1.3	2
Chemical Pollutants	0.6	8
Mineral Fiber	0.6	2
Mites, Mold etc.	0.6	2
Legionella	0.6	2
Ventilation Rate	0.4	2
Natural Ventilation Performance	0.4	2
Consideration for Outside Air Intake	0.4	2
Air Supply Planning	0.4	2
CO_2 Monitoring	0.5	2
Control of Smoking	0.5	2
Q-2 Quality of Service	**15.0**	
Provision of Space & Storage	1.2	--
Adaptation of Building Structure & Services to IT	1.2	--

Innovation		
Barrier-free Planning	1.2	2
Perceived Spaciousness & Access to View	0.8	--
Space for refreshment	0.8	--
Décor Planning	0.8	6
Earthquake-resistance	1.8	8
Seismic Isolation & Vibration Damping Systems	0.4	8
Necessary Refurbishment Interval for Exterior Finishes	0.5	--
Necessary Renewal Interval for Main Interior Finishes	0.2	--
Necessary Renewal Interval for Plumbing & Wiring Materials	0.5	--
Necessary Renewal Interval for Major Equipment & Services	0.5	--
HVAC System	0.2	--
Water Supply & Drainage	0.2	--
Electrical Equipment	0.2	--
Support method of machines & ducts	0.2	--
Communications & IT equipment	0.2	--
Allowance for Story Height	0.8	--
Adaptability of Floor Layout	0.5	--
Floor Load Margin	1.3	--
Ease of Air Conditioning Duct Renewal	0.3	--
Ease of water supply & drain pipe renewal	0.3	--
Ease of Electrical Wiring Renewal	0.2	--
Ease of Communications Cable Renewal	0.2	--
Ease of Equipment Renewal	0.4	--
Provision of backup space	0.4	--
Q-3 Outdoor Environment on Site	**15.0**	
Preservation & Creation of Biotope	4.5	7
Townscape & Landscape	6.0	7
Attention to Local Character & Improvement of Comfort	2.3	7
Improvement of the Thermal Environment on Site	2.3	7
LR Reduction of Building Environmental Loadings		
LR-1 Energy	**20.0**	
Building Thermal Load	6.0	3
Natural Energy Utilization	4.0	3
HVAC System	2.7	3
Ventilation System	0.9	3
Lighting System	1.8	3
Hot Water Supply System	0.3	3

Elevators	0.3	3
Monitoring	2.0	**1**
Operational Management System	2.0	**1**
LR-2 Resources & Materials	**15.0**	
Water Saving	0.9	5
Rainwater Use Systems	0.9	5
Gray Water Reuse System	0.5	5
Reuse Efficiency of Materials Used in Structure	3.0	6
Reuse Efficiency of Non-structural Materials	1.5	6
Timber from Sustainable Forestry	0.5	**1**
Materials with Low Health Risks	1.1	6
Reuse of Existing Building Structure etc.	2.3	6
Predicted Volume of Recyclable Materials	2.3	6
Fire Retardant	0.8	8
Insulation Materials	0.8	8
Refrigerants	0.8	8
LR-3 Off-site Environment	**15.0**	
Air Pollution	2.3	8
Noise & Vibration	1.1	8
Odours	1.1	8
Wind Damage & Sunlight Obstruction	2.3	7
Light Pollution	1.5	8
Heat Island Effect	4.5	8
Load on Local Infrastructure	2.3	8

ANNEX 5: GREEN MARK ASSESSMENT CRITERIA

Values for each criterion in GREEN MARK have been re-weighted as a percentage of the overall score, and are presented below.

Category/Requirement	**Percentage Score**
Part 1: Energy Efficiency	
Building Envelope Design	10
Energy Efficiency Index	5
Electrical Sub-metering	2
Energy Efficient Features	12
Efficient Lighting Control	2
Green Plot Ratio	4
Total	**35**
Part 2: Water Efficiency	
Water Efficient Fittings	6
Water Usage and Leak Detection	3
Water Efficient Irrigation and Landscaping	4
Water Consumption of Cooling Tower	2
Total	**15**
Part 3: Site & Project Management	
Conservation & Restoration	3
CONQUAS	2
Public Transport Accessibility	1
Environmental Management System	5
Environment Friendly Materials	5
Buildable Design	1
Building Maintenance and Operation	3
Total	**20**
Part 4: Indoor Environmental Quality and Environmental Protection	
CO and CO2 Monitoring	2
High Frequency Ballasts	2
Luminance Level	2
Thermal Comfort	2
Noise Level	2
Indoor Air Pollutants	2
Refrigerants	3
Total	**15**
Part 5: Innovation	
Innovation	
Total	**15**

Certified	50
Gold	70
Gold Plus	80
Platinum	85

ANNEX 6: EACB ASSESSMENT CRITERIA

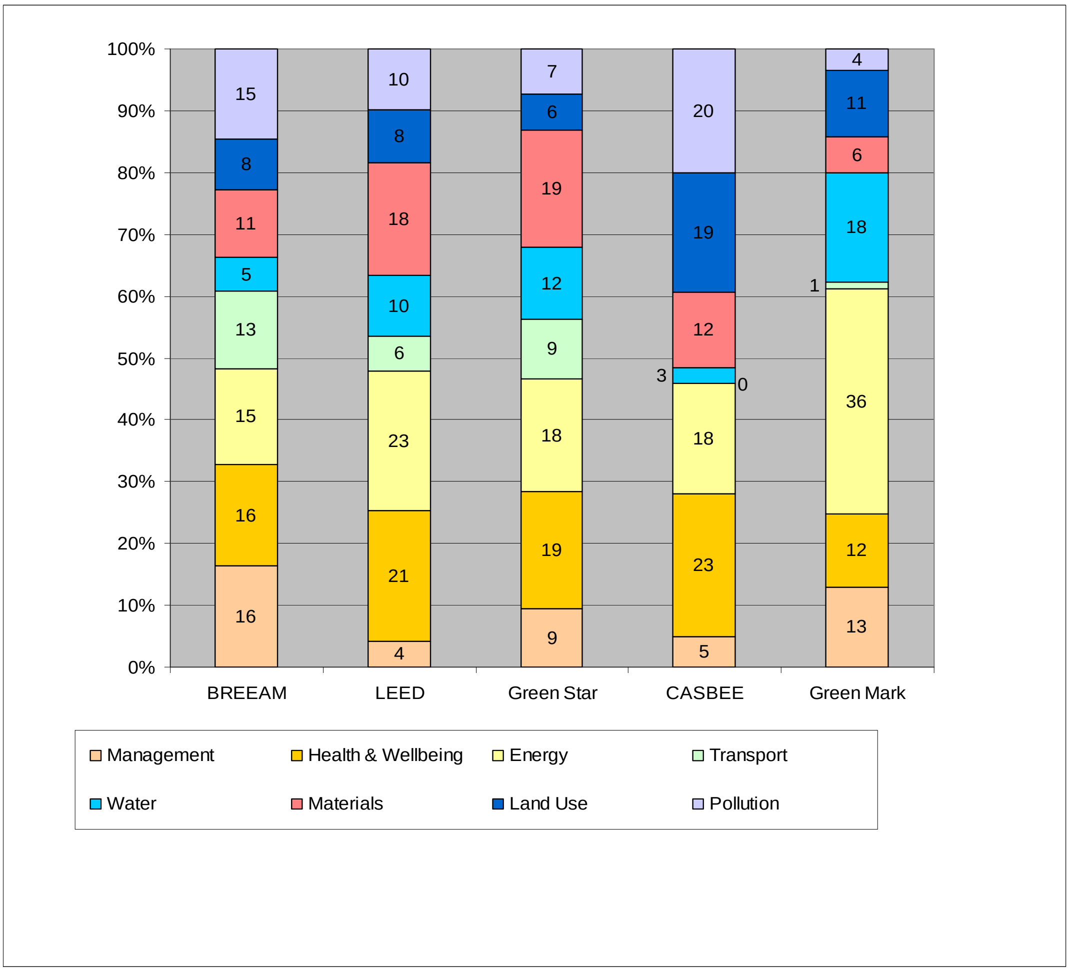
Level 1	**Level 2**	**Level 3**
Energy Consumption		
Material Consumption		
Waste	Volume Waste	
	Slag and Ashes	
	Hazardous Waste	
Contributions to global climate change	Global Warming	
	Ozone Depletion	
Contribution to Air Pollution	Acidification	
	Photochemical Ozone Formation	
Indoor Climate	Air Quality	Offgasing
		Dust
		Ventilation
		Moisture Resistance
	Thermal Climate	Low Temperature
		High Temperature
		Draught
		Heat Radiation to Cold
		Surfaces
		Individual Climate Control
	Daylight, View, Artificial light	Daylight Conditions
		View
		Solar Shading
		Artificial Lighting
	Noise and Acoustics	Transmitted Noise from Outside
		Transmitted Noise from Other Rooms
		Noise from Installations
		Reverberations time
Other Indicators	Hazardous Substances	
	Water Consumption	
	Operation of the Building	
	Localization of the Building (Transport)	
	Own Choice	

ANNEX 7: GOBAS

Q1	**Quality of Site** Fire Prevention Air Quality
Q2	**Quality of Facilities and Service** Public Facilities Transport Facilities Suitability of Building
Q3	**Outdoor Physical Environment** Sound Light Heat Wind Water To Make Greener (plants)
L1	**Necessity to Carry out project** Importance of Project Control Scale of Control Availability of Temporary Facilities
L2	**Effects on the environment** Effect of Land Usage Reduce Damage to the Ecosystem Effect on Physical Environment Effects on Municipal Facilities
L3	**Energy Consumption** Quantity of Energy Used Effect on Air Quality
L4	**Materials** Recycle Existing Building Materials Building Materials Solid Waste Handling
L5	**Water Consumption** Quantity of Water Used Recycled Water Use

ANNEX 8: CRITERIA CAPARISON BETWEEN SELECTED EBRS

	BREEAM	LEED	Green Star	CASBEE	Green Mark
Management	16	4	9	5	13
Health and Wellbeing	16	21	19	23	12
Energy	15	23	18	18	36
Transport	13	6	9	0	1
Water	5	10	12	3	18
Materials	11	18	19	12	6
Land Use	8	8	6	19	11
Pollution	15	10	7	20	4
Rating 1	25	38	10	--	50
Rating 2	41	48	20	--	70
Rating 3	57	57	30	--	80
Rating 4	74	75	45	--	85
Rating 5			60	--	
Rating 6			75	--	



ANNEX 9: COMPARISON OF BREEAM AND GREEN STAR

Side-by-side comparison of BREEAM and GREEN STAR from Annex 1 and 3. Highlighted cells in GREEN STAR correspond with requirements in BREEAM.

BREEAM	%		GREEN STAR	%
1 Management	**16.4**		**Management**	**9.2**
Building Regulations	1.8		Green Star Accredited Professional	1.4
Best Practices	1.8		Commissioning - Clauses	1.4
Monitoring Implementation	2.7		Commissioning - Building Tuning	0.7
Recycled Construction Timber	0.9		Commissioning - Commissioning Agent	0.7
Tennant Information	0.9		Building Users' Guide	0.7
Company Policy on Environment	2.0		Environmental Management	1.4
Environmental Purchasing Policy	2.0		Waste Management	1.4
EMS	2.0		Learning Resource	0.7
Operations and Management Manual	2.0		Maintainability	0.7
2 Health and Wellbeing	**16.4**		**Indoor Environment Quality**	**18.3**
80% Adequately Day-lit	1.2		Ventilation Rates	2.1
Desks Location	1.2		Air Change Effectiveness	1.4
Window Antiglare	1.2		Carbon Dioxide and VOC Monitoring and Control	0.7
Ballasts	1.2		Daylight	2.8
Illuminance Levels	1.2		Daylight Glare Control	0.7
Independent Lighting Control	1.2		High Frequency Ballasts	0.7
Openable Windows	1.2		Electric Lighting Levels	0.7
Air Intake	1.2		External Views	0.7
Fresh Air	1.2		Thermal Comfort	2.1
Thermal Comfort	0.6		Hazardous materials	0.7
Local Temperature Control	1.2		Internal Noise Levels	1.4
Legionella	1.2		Volatile Organic Compounds	2.8
Noise	0.6		Formaldehyde Minimisation	0.7
Smoking	0.5		Mould Prevention	0.7
Clean Carpets	0.5			
Occupant Feedback	0.5			
Occupant Satisfaction Recording	0.5			
3 Energy	**15.5**		**Energy**	**17.6**
CO2 Emissions	9.7		Ene-Conditional Requirement	
Electricity Component Metering	0.8		Energy Improvement	10.6
Sub-Metering	0.8		Electrical Sub-metering	0.7
Automated External Lighting	0.8		Peak Energy Demand Reduction	1.4
Preventive Maintenance Procedures	1.4		Stairs	0.7
Energy Policy	0.7		Unoccupied Areas	0.7
Reduction in CO2 Emissions	1.0		Lighting Zoning and Control	0.7
Occupant Feedback	0.3		Efficient External Lighting	0.7
			Car Park Ventilation	1.4
			Centralised Energy Systems	0.7
4 Transport	**12.6**		**Transport**	**9.2**

Public Transport	1.5	Car Park Minimisation	1.4
Transport Node	7.6	Fuel Efficient Transport	0.7
Bicycle Facilities	2.3	Cyclist Facilities	2.8
User Travel Plans	0.8	Commuting Mass Transport	3.5
Travel Survey	0.3	Pedestrian Routes	0.7
5 Water	**5.5**	**Water**	**11.3**
Above Regulation	2.3	Occupant Amenity Potable Water Efficiency	3.5
Water Metering	0.8	Water Meters	0.7
Leak Detection	0.8	Landscape Irrigation Water Efficiency	2.1
Leak Detection Shut Off	0.8	Heat Rejection Water Consumption	2.8
O&M For All Sanitary Fittings	0.3	Fire System Water Consumption	0.7
Water Monitoring	0.6	Portable Water Use in Laboratories	1.4
6 Materials	**10.9**	**Materials**	**17.6**
A' rating per *Green Guide to Specs.*	1.8	Recycling Waste Storage	0.7
Occupants Carpet Selection	0.5	Reuse of Façade	1.4
50% of façade is reuse façade	0.5	Reuse of Structure	2.1
80% reuse of existing structures	0.5	Recycled Content of Concrete	2.1
Recycled Building Materials	0.5	Recycled Content of Steel	1.4
Materials Responsibly Sourced	1.4	PVC Minimisation	1.4
Recyclable Materials Storage	2.3	Sustainable Timber	1.4
Hazardous Material Information	1.8	Flooring	2.1
Recycling Office Consumables	1.8	Joinery	1.4
		Loose Furniture	2.1
		Recycled-Content & Reuse Products and Materials	0.7
		Disassembly/Deconstruction	0.7
7 Land Use	**8.2**	**Land Use & Ecology**	**5.6**
Use Industrial Site	0.8	Ecological Value of Site	
Decontaminated Land	0.8	Reuse of Land	0.7
Low Ecological Value Land	0.8	Reclaimed Contaminated Land	1.4
Animal Conservation	1.6	Change of Ecological Value	2.8
Species Protection	2.5	Topsoil and Fill Removal from Site	0.7
Above Mandatory Requirements	1.6		
8 Pollution	**14.7**	**Emissions**	**7.7**
Refrigerants	1.1	Ozone Depletion Potential	0.7
Refrigerant leak detection	2.3	Refrigerant GWP	1.4
Insulation Pollution	0.5	Refrigerant Leak Detection and Recovery	0.7
Nitric Oxides	3.4	Watercourse Pollution	2.1
Flooding	1.7	Reduced Flow to Sewer	1.4
Pollution Treatment Area	1.1	Light Pollution	0.7
Renewable Energy	3.4	Legionella	0.7
Obtrusive Lights	1.1		
		Innovation	**3.5**
Pass:	25	**One Star**	10

Good:	41		**Two Star**	20
Very Good:	57		**Three Star**	30
Excellent	74		**Four Star**	45
			Five Star	60
			Six Star	75