

Sustainable Campuses

Wednesday 19 September

- 1130 **Transfer from Tokyo Dome Hotel (Assemble in foyer)**
- 1145 Transfer from Forest Hongo Hotel (Assemble in foyer)
- 1200 – 1320 *Lunch (Gakushi Club Annex, Room 8, Second floor)*
- 1320 Guests to walk to Sanjo Conference Hall
- 1330 – 1530 **Sustainable Campuses – Session 1**
(Second floor meeting room, **Sanjo Conference Hall**)
1. Welcome – **Professor Ian Chubb** *
 2. Identifying appropriate sustainability measures (metrics) *
 3. Comparing Ecologically Sustainable Design (ESD) building standards in IARU member countries to identify common elements *
 4. Developing a (global) standard - integrating metrics, building guidelines and sustainability principles, for **IARU** *
- 1530 – 1600 *Afternoon Tea*
- 1600 – 1800 **Sustainable Campuses - Session 2**
(Second floor meeting room, **Sanjo Conference Hall**)
5. Integrating education and campus management in the context of campus sustainability *
 6. Interns for sustainable campuses – proposed exchange program *
 7. General discussion on the process leading up the meeting of IARU Presidents at Yale in April 2008
 8. Closing Summary
- 1815 **Bus transfer from Tokyo Dome Hotel to dinner venue for delegates not attending Sustainable Campus sessions (Assemble in foyer)**
- 1900 – 2100 *Dinner – Japanese (On-campus at Kaitoku-kan)*
- 2100 Transfer to Hotels

** Document/s included*

Participants

Chair

Professor Ian Chubb (ANU)

Full list of participants

The University of Tokyo

Professor Keisuke Hanaki
Department of Urban Engineering
Graduate School of Engineering

Professor Kiichi Fujiwara
Graduate School for Law and Politics

Mr Norihiko Shimizu
Head, International Affairs Department

The Australian National University

Professor Lawrence Cram
Deputy Vice-Chancellor

Associate Professor Richard Baker
Deputy Dean
College of Science

Mr Bart Meehan
Associate Director
Business and Site Services

Dr David Carpenter
Environmental Manager

ETH Zurich

Dr Margrit Leuthold
Office of Planning and Logistics

National University of Singapore

Professor Barry Halliwell
Deputy President (Research and Technology)

Professor Michael Saunders
Director
NUS Environmental Research Institute (NERI)

Ms Lina Goh
Senior Engineer
Campus Sustainability Unit
Office of Estate & Development

Ms Lily Wong
Project Coordinator
NUS Campus Sustainability Committee
Environmental Stewardship

University of Cambridge

Professor Michael Gregory
Head of the Manufacturing and Management
Division of the University Department of
Engineering

University of Copenhagen

Professor Lykke Friis
Pro-rector

Dr John E. Andersen
Director
International Office

Mr Hans Halvorsen
Manager
Campus Programme

University of Oxford

Dr Heather Bell
Director of International Strategy

Yale University

Mr Don Filer
Director
Office of International Affairs

Dr Jane Edwards
Associate Dean for International Affairs

Dr Julie Newman
Director Office of Sustainability

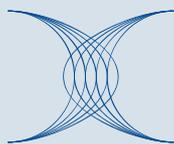
Dr William Whobrey
Director
Yale Summer Session

Ms Caroline Howe
2007 ANU/YALE Sustainability Internship
Program participant

IARU Secretariat

Mr Iain Watt
Director

Ms Amelia Whitelaw
Co-ordinator



Invitation to Sustainable Campus Side Events

In addition to the official workshop on sustainable campuses on the afternoon of Wednesday 19 September, the University of Tokyo will organize two side events. We welcome your participation.

1. Student Forum (Morning - Wednesday 19 September)

Informal discussion with students of the University of Tokyo who have initiated sustainable campus related activities.

09:00 Transfer from hotel (Tokyo Dome Hotel and Forest Hongo Hotel)

09:30 - 11:30 Student Forum at meeting room of IR3S (Integrated Research System of Sustainability Sciences) located on the 4th Floor of Administration Building No. 2.

Following this event, participants will rejoin the official IARU Senior Officers Meeting program (Lunch at 12:00pm, followed by Sustainable Campuses Session 1).

2. Campus tour (Thursday, September 20)

Visit the University of Tokyo's Facility Department on both the main (Hongo) campus and Kashiwa campus.

07:45 Transfer from Tokyo Dome Hotel by bus

08:15 Arrival at Sanjo Kaikan, Hongo Campus

09:00 Move to Facility Department in Administration Building No. 2

09:10-10:30 Introduction of UT Facility Management and discussion
(Japanese - English translation provided)

10:30-11:30 Campus walking tour.

11:30-12:40 Transfer to Kashiwa Campus by train

Lunch at Kashiwa Campus

14:00 - 14:45 Discussion with Professor Hidetoshi Ohno (Architecture) about environmentally conscious buildings/campus

15:00- 15:45 Kashiwa Campus tour

17:00 Return to main campus or hotel by train.

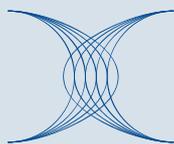
Note: Those who will be departing Tokyo on an evening flight (eg. QF360 at 21:30) on 20 September can leave luggage at Sanjo Kaikan in the morning and pick it up on return to the main campus.

Delegates able to participate in these events should contact:

Mr. Yuji Togami (togami@ir3s.u-tokyo.ac.jp) or Ms. Ai Hiramatsu (ai@ir3s.u-tokyo.ac.jp).

Please Cc Ms Amelia Whitelaw (amelia.whitelaw@anu.edu.au)

Organizer: Keisuke Hanaki



IARU Sustainability Discussion Paper

At the IARU meeting held in Zurich in April 2007, working parties were set up to look at the following issues, as the first step in developing sustainability targets for IARU members:

- Identification of the sustainability metrics currently being used by Universities
- Comparison of ESD standards being used in the countries of member institutions
- Development of a framework for a "global sustainability" standard that can be adopted by Universities.

Section 1 of this paper provides a brief status of the work undertaken for dot points 1 and 2; Section 2 provides some proposals for the development of the framework noted at dot point 3.

SECTION 1

Current metrics

Work was undertaken by Cambridge, UC- Berkeley, Yale and ANU.

Attachment 1 details a short questionnaire used to identify the current metrics being collected by IARU members. A copy has been sent to representatives at all Universities, but responses have only been received from Yale, Oxford, University of Tokyo, UC-Berkley, NUS, Cambridge, and ANU to date. The responses from these Universities are included in the table presented in Attachment 1.

Separate reviews of web based documentation, suggests that the majority of the Universities do collect sustainability metrics, though not all in the form of carbon inventories or detailed sustainability indexes.

Attachment 2 is a copy of the more detailed questionnaire developed by Cambridge as part of this process. Attachment 3 is a questionnaire developed by Yale. Both would be effective tools in developing a carbon inventory and sustainability index.

A review of available information for most IARU members, shows that they do collect metrics across key environmental areas, including GHG emissions (most have or are preparing carbon inventories that show emission production from energy, travel, construction etc), water consumption and waste generation. The review showed that only ANU had a formal process for quantifying environmental risk - that is, risks associated with non compliance against relevant legislation/standards, as well as, broader risks to the environment through poor practices.

ESD Standards

Attachment 4 is a paper prepared by ANU (through its ANUgreen internship program). This paper is a comparative overview of Environmental Building Rating Schemes (EBRS's) in IARU member countries. In summary, it identifies that all countries, with the exception of China, have national standards. China is in the process of developing nationwide standards, and has developed standards for the Olympics. Some developers in China voluntarily apply LEED standards (i.e. the American standard) to their buildings.

The rating methodology underlying these standards varies, with the weightings applied to each rating criteria reflecting national priorities. However, each standard strives to achieve the same basic outcome of national and international best practice in the sustainable design of buildings/campuses.

There appear to be ways of mapping between criteria in LEED (USA), BREAM (UK), CASBEE (Japan) and GREENSTAR (Australia) - and with modification, an agreed standard could also be found in the European standards.

SECTION 2

Development of a sustainability standard and targets for IARU

Attachment 5, prepared by ANU and Yale, provides a comparative assessment of global sustainability standards. This paper states that while most Universities collect data they may use or interpret it different ways to support their sustainability targets. The paper recommends that IARU members should complete a qualitative survey that shows where each University stands in terms of policy, inventories, plans and funding for sustainability. This would include the development of a sustainability index (inventory) that details greenhouse emission production, waste production, and water consumption.

Attachment 6 also prepared by ANU and Yale provides an analysis of greenhouse calculators (to determine GHG produced from energy etc) used around the world. The paper states that the use of existing online emissions calculators is the most efficient way of determining the environmental impact of respective University operations. However, in comparing results for “institutions around the world, the computation method for deriving the emissions is primarily dependent upon the characteristics of the country's (and sometimes the local region's), energy supply”. (To expand, in the UK and Europe, the major sources of power are hydro and nuclear, which have low GHG emissions, whereas in other IARU countries there is a greater dependence on fossil fuel in energy production with the consequent environmental impact). It is difficult to identify greenhouse calculators for all countries represented in the IARU. This does not mean that they do not exist. They were simply not easily accessible or translatable from web based information. Generally speaking, most IARU members would be using internationally verifiable calculators for identifying the volume of greenhouse emissions produced by key activities.

Given the research completed, it is clear that direct comparison between IARU members for greenhouse emissions is not possible. Hence, it would not be possible to establish metrics that ranked performance overall, or provided valid comparisons between specific operations on campus (for example, the environmental footprint of buildings). Having said that, once greenhouse emissions have been calculated (using an agreed regional/international calculator), a tonne of

GHG released into the environment will be the same regardless of regional context. Similarly, a litre or gallon of water consumed or a tonne of waste produced will be the same at all Universities.

This allows the IARU member to establish absolute targets for improving environmental performance and demonstrate a leadership role to government and the broader community.

Given this the following broad proposals are put forward for discussion at the IARU Senior Officers meeting to be held in Tokyo on 19th September 2007.

Proposal 1

Review the amended Principles of Sustainability agreed at the IARU Presidents' Meeting held in March 2007 and establish procedures for implementing the actions identified.

Proposal 2

Establish a sustainability index which measures each University's environmental performance. Noting the differences between Universities, including staff/student populations, age, energy sources, prior investment in energy and water conservation etc, the recommendation is that the focus be on those activities that have substantial and measurable environmental impact. The following format is proposed:

Environmental issues to be measured in the Index (which will be developed using modified versions of the questionnaires designed by Cambridge and Yale)

1. Greenhouse emissions arising from the following activities:
 - Energy use (electricity, gas, purchased steam/hot water)
 - Air Miles
 - Fuel Consumption (LPG, Petrol, and Diesel consumption from university controlled vehicle fleet)
 - Waste Disposal to landfill
 - HFC's, PFC's and Sulphur Hexafluoride

Greenhouse gases arising from the aforementioned activities should be should be measured as Tonnes of Carbon Dioxide Equivalents (TCO₂^e)

2. Waste disposal including: general waste to landfill, radioactive, chemical and biological waste
3. Recycling programs including: E- waste, paper, cardboard, metal, glass, aluminium, building materials
4. Potable Water Consumption
5. Biodiversity – specific projects aimed at improving/increasing campus biodiversity
6. Environmental Risk

Environmental risk measures both the compliance with relevant legislation/standards and the broader risk to the environment of operational activities. The intent is to set a measure of existing risks and reduce it to acceptable level of residual risk. We have not been able to determine if other IARU members have a tool for measuring environmental risk. However, the ANU has

used the CERAM methodology for several years. This has also been used by several government departments and large municipal councils. The methodology was developed as part of PhD research undertaken in the Fenner School for Environment and Society. See URL for information: <http://cres.anu.edu.au/~swildriv/ceram/>¹.

Areas of University operations to be measured in the Index

The main focus of University environmental management performance should be activities over which the institute has direct management control. Hence, performance should be measured in academic and administrative support areas. University or private commercial activities should be excluded, as should Student Residential Halls, where the consumption of energy, water etc is more aligned with the domestic use patterns in people's homes. The index should also not attempt to measure private travel (commuting by vehicle, air travel etc) by the campus community. (Note that as part of the broader environmental program established by the IARU, members may want to commit to initiatives that promote greater awareness of the impact of individual behaviour on the environment)

Proposal 3

Establishment of sustainability targets

Given the difficulties already identified in making direct comparisons between IARU members' environmental performance, the most effective way of achieving tangible environment benefits is to set absolute targets for improvement. With that in mind, the following targets are *suggested*. Based on the information provided by IARU members, these targets are considered achievable within the timeframes suggested and would establish the IARU as a genuine leader in the area of campus sustainability. (Note that the tertiary sector world wide has a significant environmental impact and that by taking the lead, IARU may encourage other Universities, as well as the broader community, to set similar targets.

Greenhouse emissions

Short term target: Reduce absolute GHG emissions by 10,000 tonnes per University per annum by 31 December 2010 - a total saving of 100,000 tonnes pa. This will be measured against annual GHG emissions levels for the calendar year 2007. IARU members can chose to reduce GHG against any area identified in their Sustainability index (for example, some may chose to lower the emissions from energy use, while others may off set emissions from travel).

Medium term target: Reduce absolute GHG emissions by 20,000 per University per annum by 31 December 2015 - a total saving of 200,000 tonnes pa. This will be measured against the annual GHG emission levels for the calendar year 2015.

Long term target: 10% below 1990 levels of GHG emissions by 2020.

(These targets do not prescribe how the savings can be made. In some cases, Universities may choose to reduce or offset energy consumption, while others may focus on travel, food miles, waste etc. It is important to ensure that the IARU establishes what it considers valid emission reduction strategies. For example Universities might only include 'Green' energy that is accredited by national regulatory

bodies, and offsetting products that are recognised as national/international best practice as defined in national codes of best practice).

Potable Water consumption

Medium term target: Reduce absolute potable water consumption by 20% by 1 January 2012 (as measured against annual water consumption for 2007)

Longer term target: Reduce potable water consumption by 50% by 2017 (as measured against annual water consumption for 2016)

Recycling

Target: 100% of all e-waste to be recycled or reused by 31 December 2012; reductions in waste to landfill by 70% (according to the base level year of 2008) by 2012

Building Design

Target: IARU members would agree to designing all new buildings to an agreed ESD standard, where one exists. Each University would use its own national standard and would make best endeavours to design and operate using *national best practice*. Accreditation against the design guidelines would be optional, but the design and building operation should still meet the relevant standard identified in the respective national ESD standards.

(Regardless of ESD goals, the building design would still need to meet the necessary academic/functional requirements. Life cycle costing of the building would need to demonstrate that both economic [return on investment] and environmental benefits are achievable).

Proposal 4

Reporting

Each IARU member will prepare an annual report detailing performance against the agreed targets, for presentation at the annual meetings of IARU Presidents. The metrics will be combined and a performance report for the IARU will be published on the IARU website. (This report will not breakdown performance by individual members). Case studies of innovative sustainability projects established by IARU members will be published on the website as appropriate.

The reports will be reviewed at the annual senior officers meeting before presentation to Presidents.

The first report to be reviewed in the senior officers meeting in 2008 and presented to the IARU Presidents' Meeting in 2009.

Endnote

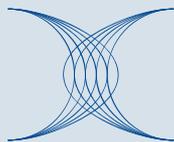
- 1 Quantification of environmental risk can be consistent across contexts, and a robust, comparative analysis of ‘per cent residual environmental risk’ could readily be achieved for all IARU universities. This is a more cost-effective and practical approach than ISO 14001 certification.

The ANU uses the semi-quantitative Comparative Environmental Risk Assessment Method (CERAM) to assess its inherent and residual environmental risk on an annual basis. The method converts qualitative measures of inherent and residual environmental risk into a quantitative result, using a logarithmic scale in a risk management matrix. This approach has its intellectual origins in contemporary environmental protection laws which are broadly consistent across most IARU countries. CERAM takes account of the quality of the receiving environment, as well as the nature and scale of activities.

Statistical analysis of CERAM results have shown that different assessors may return different results for the absolute value of inherent and residual risks. Calibration guides have been developed to overcome this problem, and a tailored guide is already available for research institutions. In addition, the statistic of ‘per cent residual risk’ is extremely robust between contexts, and could readily provide a valuable benchmark between institutions.

CERAM’s great benefit is its speedy, rigorous identification of priorities for action. CERAM assessments make it is easy to plan and justify an effective pollution prevention program and to track results.

ISO14001 is a generic, standard approach, which can incorporate methods such as CERAM. However ISO14001 is expensive, and does not necessarily highlight priorities. The ANU has adopted an approach that is broadly consistent with ISO14001, but has not required expensive external certification. The ANU Environmental Policy identifies priorities and targets, and has provided sufficient benchmarking to produce an initial set of environmental management results, unburdened by administrative inertia



Attachment 1: IARU Survey Responses

What information relevant to sustainability/environmental performance do you currently collect and how? (This should include information on greenhouse emissions from operations, official travel, University fleet; as well as, water consumption)

The Australian National University

We collect information on the following:

- Energy and water consumption
- Gas consumption
- Greenhouse emissions production – including greenhouse emissions from research activities
- University Fleet transport miles
- University air travel (though this is not complete – some areas do not book using the central administrative service)
- Waste to landfill and recycling volumes
- Biodiversity/ecological health of landscape
- Material consumption (eg. paper, furniture etc)
- Food purchases in Halls of Residence
- Public transport use
- Bike transport use
- Private commute to campus
- Environmental risk (we measure risks against legislative requirements and best practice activities to reduce pollution in water ways, landscape and air)

University of Cambridge

We collect information on the following:

- Consumption and associated CO₂ equivalent emissions from Electricity, Gas, Oil, Water (metered consumption and calculated emissions using conversion factors)
- Waste to landfill and incineration (estimated tonnages)
- Recycled waste - paper, cardboard, glass, plastic and redundant IT equipment (estimated tonnages)
- Number of buildings designed and constructed to BREEAM (Building Research Establishment Environmental Assessment Method - similar to US LEED)
- Information on commuting from an annual travel to work survey
- Information from a one-off Academic Air Travel survey

University of California, Berkeley

Cal CAP Feasibility Study: We collected most (if not all) of this information when we determined our greenhouse emissions. The categories we have collected include:

- Steam (co-generation and auxiliary boilers)
- Purchased electricity
- Air travel
- Faculty and staff auto commute
- Natural gas
- Student commute
- Fugitive emissions - refrigeration
- Water consumption
- Solid waste
- Campus fleet

Additional information on emissions related to procurement were inventoried but are not presently being reported

UCB Campus Sustainability Assessment (2005) collected information and metrics for the following areas:

- Energy: greenhouse gas (GHG) emissions from UCB's energy consumption: carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O), all expressed in CO₂ equivalent units (CO₂e).
- Water
- Built Environment: The degree to which we are establishing green building practices in our campus policies.
- Transportation – modal split
- Purchasing & Waste – diversion and recycling rates
- Land Use – impervious surface area and water quality in Strawberry Creek; irrigation; pest management and chemical use;
- Food - procurement (origin) healthful ingredients, organics, food waste treatment (compost/ disposal), education and communication
- Health & Wellbeing
 - degree to which green custodial products and cleaning strategies are used
 - Efforts to ensure healthy indoor air for campus community.
 - Effectiveness of efforts to promote a safe working environment for its employees, including training accessibility on ergonomic safety and monitoring of progress.
- Academics & Culture - explores the number of courses related to sustainability offered at UCB, campus sustainability organizations and town gown relations,

A 2 year update is proposed and being developed by the Campus Chancellor's Advisory Committee on Sustainability (CACS)

Campus tracks environmental mitigation performance for construction projects in several areas, including stormwater runoff, air quality, and noise. We are now beginning to track construction waste.

Every two years campus measures commute patterns for faculty, staff, students

Each major construction and renovation project performance is tracked according to the UCB Green Building Baseline and/or LEED.

University of Copenhagen (KU)

KU do collect information on consumption of: electricity, water, gas in pipeline, heating in pipelines (KU is not producing electricity or energy for warming/cooling the buildings and have no waste to landfill), waste to landfill and recycling (detailed on types and volumes) and some material consumption.

KU do not collect or calculate informations on: greenhouse emissions production, transportation (travels and commute), food production/consumption.

National University of Singapore

We currently collate data on water, energy, waste, recyclables

University of Oxford

Building & process related gas, electricity oil and water consumption. GHG emissions calculated from energy use.

Five yearly staff travel survey provides indication of travel patterns.

No data on official travel and is readily available.

The University own 108 vehicles.

The University has several waste contractors for general waste. The main waste contractor provides data on waste and recycling collections for the departments that use this contractor. The trend towards recycling is that the University departments are increasing their recycling. However, the University does not have a monitoring system for overall waste tonnages produced, recycled and landfilled.

The Waste Management Officer's role includes changing behavioural attitudes to recycling and waste minimisation, through communication campaigns and distributing recycling information throughout the University. Changing behaviour is a gradual process, but one that is catching on, particularly now that it is cheaper to recycle than send waste to landfill (due to increases in the UK Landfill Tax).

Travel related achievements include - a reduction in staff travelling to and from work by car from 46% in 1997 to 28% in 2002 to 23% in 2007 achieved through the implementation of a car parking permit scheme based on an assessment of need and the introduction of various alternative travel initiatives including a bus pass scheme, train pass scheme, season ticket loan scheme, bicycle salary sacrifice scheme, mobile bicycle repair service, free cycle training, cycle registration scheme, departmental pedestrian and cycling facilities improvement fund, car share scheme.

See figures above for 50% reduction in the percentage of staff travelling to and from work by car. The same period, 1997 to 2007, has seen an increase in the following modes of travel to work:

- bus up from 11% to 20%
- walking up from 7% to 13%
- train up from 2% to 6%
- Park and Ride up from 2% to 5%

Note also that students are not permitted to own cars in Oxford. Staff travel around Oxford is mainly by bike or on foot.

The University of Tokyo

Collected information:

- 1) Greenhouse gas emission (report obligated by local government)
- 2) Water consumption
- 3) Solid waste disposal
- 4) Chemical compounds discharge (according to national regulation, PRTR Pollutant Release and Transfer Register)

Official travel, fleet resource consumption are not evaluated.

Yale University

Yale Sustainability Indicators FY 2004-2006: Executive summary

Resource Consumption

- Water Consumption
- Paper Consumption
 - Percent recycled
- Secondary Energy Consumption
- Final Energy Consumption
 - Electricity
 - Heat (steam)
 - Cooling (chilled water)
 - Transportation
- Transportation Fuel
- Biodiesel Consumption

Energy

- GHG Emissions
- NOx Emissions
- SOx Emissions
- Particulate Emissions (PM10)

Waste Production

- Municipal Solid Waste
 - Percent recycled
- Hazardous Waste
- Universal waste

Other Metrics

- Pesticides
- Organic and/or Local Food
- Parking Spaces
- Biking Spaces
- Commuting Distance
- Basic Statistics
 - Building Space
 - LEED Certified Space
 - Population

Can these data be separated into different operations activities, that is, can they show separate environmental footprints for teaching, research, residential, catering, commercial and administration?

The Australian National University

Yes – we break down greenhouse emissions, water consumption, waste/recycling by area. We are currently working on a methodology we hope to have in place later this year that uses this information to assess environmental impact per square metre across buildings (with particular emphasis on benchmarking like buildings/operations)

University of Cambridge

The data available relates to academic and administration only, i.e. non-residential. Residential accommodation for students is in one of the 31 Cambridge Colleges which are independent institutions and are therefore responsible for their own activities

It would not be possible to break the information down further into teaching, research, catering, commercial or administration.

University of California, Berkeley

This is possible, although we have not used these categories to characterize our inventory.

The easiest one to separate is probably resources use such as energy and water since it is localized by building and many (but not all) buildings have a dominant use i.e. research labs, classrooms, administrative offices.

University of Copenhagen (KU)

KU is able to separate collected data in geographic/campus areas. KU is not able at the moment to show separate collected data for activities (teaching, research, administration etc.)

National University of Singapore

We are categorising certain data such as water and energy per faculty/admin department/hostel basis. However, waste and recyclables are collected by vendors and data separation cannot be carried out to this level of detail.

University of Oxford

Oxford has data on use of net internal areas for each building so could provide data on teaching, research etc. but the separate areas are not sub-metered and energy consumption would have to be apportioned on a percentage area basis.

The University of Tokyo

As the university hospital is a large consumer inside the campus, its consumption is evaluated separately. Energy and water consumption is evaluated for each of the building, but they are not categorized into activity. Residential activity is negligible

Yale University

Because the metrics are collected building by building, the energy usage data can be broken down based on the utility of the building, and GHG emissions can be calculated separately for different operations activities. The general set of metrics are difficult to break down for teaching/research/residential other than the energy use of the various buildings.

What is the primary source of greenhouse emissions?

The Australian National University

Energy (electricity), followed by air travel

University of California, Berkeley

- The two largest sources of GHG emissions, responsible for approximately 70% of the total emissions, are purchased electricity and steam (from the cogeneration plant owned by Delta Power).
- Air travel and faculty-staff-student auto commute is 2nd largest source of GHG emissions, at approximately 22% of the total emissions

National University of Singapore

Energy

University of Oxford

Combustion of natural gas for heating and hot water.

Use of grid electricity (depends if you accept that green electricity is carbon emission free or not)

The University of Tokyo

Almost all GHG is CO₂ from energy consumption in the form of electricity (78%), city gas (19%) and oil (3%)

Which activities are the primary consumer of potable water?

The Australian National University

Management of landscape, followed by research activities (particularly in chemistry and earth sciences).

University of California, Berkeley

Buildings (primarily research) followed by irrigation and steam production.

National University of Singapore

The highest consumer group is the Prince George's Park Hostel, with a GFA of 87,403 sqm.

University of Oxford

Two thirds of water for laboratory use and one third for domestic use.

The University of Tokyo

Hospital, office and laboratory use.

What is the primary source of electricity (eg. fossil fuel, hydro, gas, nuclear etc)?

Do you use internationally variable conversion factors in calculating your greenhouse emissions and, if so, what are they?

The Australian National University

Primary source of energy in Australia is fossil fuel – with a consequent high level of CO₂ emissions. We currently have 80% black (fossil fuel) energy and 20% green energy.

These formulas are used to calculate the green emissions from various sources. Our formulas are set by the Australian Greenhouse Office (AGO) and measure as follows:

- energy from electricity consumption (kWh)
- energy from gas consumption (GJ)
- energy from fuel consumption (LPG, unleaded, diesel)
- Methane emissions arising from waste disposal
- Sulphur Hexafluoride emissions from particle accelerator at RSPHYSE

We use emission factors to calculate the Tonnes of CO₂ equivalent produced as a result of the above. These figures are updated by the AGO, last years factors were as follows:

Emissions Source

Electricity(kWh) – 1.054

Natural Gas (GJ) – 0.068

LPG - non-transport (Tonnes) – 2.9

LPG (k/l) – 1.6

Petrol (unleaded/leaded) (k/l) – 2.5

Automotive Diesel Oil (ADO) (k/l) – 2.7

Industrial diesel fuel – 2.8

CNG (Kgs/M3) – 2.4

Coal (Tonnes) -

Comingled – 1.2

Paper & Cardboard – 2.8

Textiles – 3.9

Wood/straw – 2.1

Garden – 1.2

Food – 1.5

Medical Waste – 0.5

Municipal wastewater -

Industrial wastewater -

SF₆ (Tonnes) – 23 900

University of Cambridge

The current electricity supply contract is for 97% hydro supplied via the grid.

The following conversion factors are provided by the UK Department of Environment Farming and Rural Affairs (DEFRA) - last updated in July 2005

Fuel Type	Units	kg CO₂ per unit
Grid Electricity	kWh	x 0.43
Natural Gas	kWh	x 0.19
	therms	x 5.43
Gas Oil	tonnes	3190
	kWh	0.25
	litres	2.69
Diesel	tonnes	3164
	kWh	0.25
	litre	2.63
Petrol	tonnes	3135
	kWh	0.24
	litres	2.30
Fuel Oil	tonnes	3223
	kWh	0.27
Coal	tonnes	2548
	kWh	0.32
LPG	tonnes	0.214
	kWh	6.27
	litres	1.49
Renewables	kWh	0.0

Transport

Small petrol car - >1.4 litres

miles kilometres

0.26 0.16

Medium petrol car -1.4 - 2.1 litres

miles kilometres

0.30 0.19

Large petrol car - - 2.1 litres

miles kilometres

0.35 0.22

Average petrol car

miles kilometres

0.29 0.18

Small diesel car - >2.0 litres

miles kilometres

0.26 0.16

Large diesel car - <2.0 litres

miles kilometres

0.31 0.19

Average diesel car

miles - kilometres

27.27 0.17

Rail person / kms 0.04

Air - Long Haul person / kms 0.11

Air - Short Haul person / kms 0.15

University of California, Berkeley

Steam: 95% of steam (by wt) consumed by UCB is produced by Delta Cogen. Plant, with remaining 5% from the Plant's auxiliary boilers.

Electricity: see PG&E provider power content, below:

POWER CONTENT LABEL		
Energy Resources	PG&E 2006 Power Mix* (Projected)	2004 CA Power Mix** (For Comparison)
Eligible Renewable	13%	4%
Biomass and waste	5%	0%
Geothermal	2%	3%
Small hydroelectric	4%	1%
Solar	0%	0%
Wind	2%	<1%
Coal	3%	29%
Large Hydroelectric	19%	20%
Natural Gas	42%	45%
Nuclear	23%	2%
Other	<1%	0%
TOTAL	100%	100%

* At least 95% of PG&E's POWER MIX is provided by the California Department of Water Resources or from PG&E-owned resources, or specifically purchased from individual suppliers.

** Percentages are estimated annually by the California Energy Commission based on the electricity sold to California consumers during the previous year.

For specific information about this electricity product, contact Pacific Gas and Electric Company. For General Information about the Power Content Label, contact the California Energy Commission at 1.800.555.7794 or www.energy.ca.gov/consumer.

Conversion factors used based on California Climate Action Registry (CCAR) protocol, Cal CAP report:
<http://sustainability.berkeley.edu/calcap/inventory.html>

University of Copenhagen (KU)

KU receive all energy (electricity and water to warming up buildings) from DONG (Danish Oil and NatureGas company). KU believe that DONG is able to give information about the mix of sources the company use (water, wind, oil, naturegas, coal etc.)

KU do not yet calculate greenhouse emissions

National University of Singapore

We obtain our electricity from the Grid, supplied mainly by Senoko Power Plant, which uses a combination of natural gas, diesel and oil. The main supply comes from natural gas (more than 70%).

There isn't any conversion factor we can use in Singapore. We are using the formulae in a spreadsheet taken from this website: <http://www.ghgprotocol.org/templates/GHG5/layout.asp?type=p&MenuId=OTAx>

University of Oxford

The University purchases electricity generated by large scale hydro-electric scheme and is classed as "carbon emission free".

Figures are from UK Government published in the Building Regulations Part L2A.

Natural gas	=	0.194 kg CO ₂ /kWh
Oil	=	0.265 kg CO ₂ /kWh
Electricity	=	0.422 kg CO ₂ /kWh

The University of Tokyo

The university purchases electricity from Tokyo Electric Power Company (TEPCO). Due to nuclear power and natural gas, carbon intensity of TEPCO electricity is rather low, 0.34 kg CO₂/kWh in 2006.

National government and local government provides calculation basis, which is compatible with UNFCCC method

Yale University

59% is purchased electricity from the United Illuminating Company, Connecticut, sources are various, including gas, oil, coal, nuclear

41% is generated at Yale by two power plants burning natural gas, zero emissions electricity from the fuel cell and solar array is negligible (< 0.5 %)

Purchased electricity: emissions factor for New England region is 0.469 MTCE / MWh (US national average is 0.671 MTCE / MWh)

On campus power generation from two powerplants: calibrated emissions factor of 0.251 MTCE / MWh for the medical school and 0.326 MTCE / MWh for central campus

On campus fuel cell and solar array: zero emissions

Transportation, carbon sinks and other emissions have not been included in the inventory to date, the focus is on the powerplants and purchased electricity which in 2002 made up 86% of total proportion of GHG emissions on campus. In 2007, a transportation survey will be conducted enabling Yale to include commuter transportation.

What activities/system replacement/redesign have they undertaken to reduce energy consumption and water consumption over the past 30 years? (The latter will help to determine where each institution sits in terms of opportunities to further improve performance)

The Australian National University

We can break this down in more detail – but in summary, we have been undertaking various upgrades of systems over the past 15 years to improve energy and water efficiency. There are still significant amounts of larger scale plant that will be progressively replaced and as a consequence, we will have improvements in environmental efficiency. We have not introduced any large scale alternative energy generation plant on campus (Solar PV or co gen). We are looking at these issues but the cost is likely to be prohibitive.

University of Cambridge

Work to reduce energy use within the University has been on-going since the oil crisis of the mid 1970s.

As part of the UK Higher Education Carbon Management (HECM) programme, an Implementation Plan has been developed, which aims to cut emissions from University buildings by 10% over the next 5 years through a range of emission reduction measures. These measures will eventually be largely self-financing as operational cost savings resulting from energy efficiency improvements start to be realised.

In 2004 the University adopted a policy for the Design and Construction of Environmentally Sustainable Buildings, which includes a target for all new large buildings (over 1,000 m²) to achieve a BREEAM rating of Excellent with a minimum of ‘very Good’.

Ongoing water conservation initiatives have resulted in a 53% reduction in metered water usage since 1988 against a building stock increase of 25.5%

University of California, Berkeley

Energy: UCB electricity use increased by approximately 7.7% over the past seven years. This increase in electricity use is largely due to campus expansion and construction. Per gross square foot of building area, electricity consumption has increased by 3.4% over the same span.

Energy audits & retrofits –UC Berkeley has completed three generations of large scale energy audits and lighting retrofits in most of our state-funded buildings since 1986. The first of these retrofits resulted in a 25%-40% decrease in lighting energy use. Typical energy utilization

for lighting has been cut from two to three Watts per square foot (W/sqft) to 1.5 W/sqft. The University continues to increase its energy efficiency through additional improvements, and as a result, more than 10 million kWh per year and about \$1 million per year are currently saved due to facility energy upgrades.

Green Building Policy and Clean Energy Standard July 2003, rev. March 2007. UC Berkeley integrated principles of energy efficiency and sustainability into capital projects. As a result, all new buildings surpass the California Energy Code “Title 24” efficiency standard by at least 20% and major renovations surpass by 10%. Campus is also taking more seriously the opportunity to procure and/or develop renewable power.

Provide energy usage feedback and education – Campus Physical Plant has developed a student intern program that promotes energy conservation in campus buildings. A project is underway to provide real time energy use feedback to building occupants to aid in management and conservation efforts.

Lighting audits and retrofits continue in order to maximize energy efficiency. Lighting upgrades underway for 40 campus classrooms.

Increase use of improved technology in all new building and renovation projects: occupancy sensors, wireless lighting controls.

Monitor-based commissioning (MBCx) – Install real-time energy meters and sub meters so that facilities personnel can track building energy use and effectively monitor and diagnose the performance of significant energy-using equipment. Of the 40 largest energy use buildings, 20 have or will undergo MBCx process within the next 4 years.

Fund energy efficiency projects. Ongoing funding for energy efficiency projects has been allocated.

Water: From 1979 to 2003, overall water consumption decreased by 17% while campus gross-square footage increased by 19%. However, recently, water consumption increased by 20% and per capita water consumption rose 11.5% from 1999 to 2003, while campus building area increased by 14%.

Automation of campus irrigation – Automating irrigation controls resulted in a 15% reduction in irrigation water use from 2002-03 to 2003-04. Supervisory Control and Data Acquisition system (SCADA) currently serves approximately 75% of the irrigated area on the UC Berkeley campus, with plans to expand to 100%. Campus also installed automated irrigation controllers with repetitive cycles and low-volume heads beginning in the 1980s.

Elimination of once-through cooling during major laboratory renovations and new construction – The UC Regents’ Green Building Policy and Clean Energy Standard requires all new laboratories to meet the equivalent of Labs21 Environmental Performance Criteria standard certification. Labs21 requires that there be no once-through cooling units unless used as direct contact process water. Once-through cooling has already been eliminated during the renovations of the Valley Life Sciences, Hearst Mining and Stanley Hall buildings.

Campus Food Service nozzle replacement – Virtually all food service providers on campus have replaced spray nozzles in their washing facilities This saves an estimated 10,500 gallons per day and \$9,300 annually, not including savings from reduced energy and wastewater costs

Housing and Dining low-flow faucet aerators. As a result of a residence hall water audit, Housing Services will be replacing Unit I, II and III residence halls' assortment of 1.5, 2.0 and 2.5 gallon per minute (gpm) faucet aerators with 0.5 gpm aerators provided free from EBMUD. The faucet aerators are anticipated to save over \$15,000 and 3.4 million gallons of water each year.

University of Copenhagen (KU)

Mainly/mostly it is insulation of buildings, recycling of heating, watersaving, energysaving/-efficiency in electric installations and devices, installation of central technical systems (CTS).

The authorities (Ministry of Environment, energy and housing) has during the past 30 years set up more and more demanding levels of performance when we build new and when we update buildings and infrastructure. That includes par examples implementation of a Energy Management System on KU from 2008. I believe that on KU we do not see (many) "low hanging fruits" to improve further performance. but of course we can be better.

National University of Singapore

For energy consumption, we are actively getting the Campus Sustainability Committee involved in the design development of new buildings on campus to help guide consultants towards more energy efficient buildings by incorporating, where feasible, technologies such as heat recovery system etc. For water, same applies. Additionally, our Estate Maintenance department is actively conducting audits on existing M&E infrastructure to determine re-commissioning strategies for performance optimisation.

University of Oxford

New buildings are designed to meet tighter energy and water consumption targets utilising improved fabric insulation, increased air tightness, more energy efficient building service equipment.

Heat recovery devices installed in ventilation systems.

Exposed internal fabric to exploit thermal mass

Decentralisation of steam systems and some low temperature hot water systems.

Converted most oil boilers to burn gas.

Replaced electric space heating with gas fired hot water heating.

Replaced centralised domestic hot water systems with local hot water heaters.

Replacement building services equipment is always energy efficient eg boilers, motors, chillers.

Programme of loft insulation completed.

Window and door draught-proofing

Re-roofing includes roof insulation upgrade.

Building re-wiring ongoing and includes installation of efficient high frequency lighting.

Automatic lighting controls installed.

Installation of building management system to replace stand-alone controls.

Improvements to building services controls' strategies.

Stand-alone heating optimisers installed

Installation of variable speed drives to pumps and fans.
Automatic urinal controls, 6l volume WC cisterns, low flow shower heads, tap restrictors installed.
Closed loop process cooling systems installed to replace open loop systems saving water.
Continued extension of metering on private electricity networks.
Departmental Environmental Champions scheme set up.
Devolved departmental utility charging established.

The University of Tokyo

New technologies for energy and water saving have been introduced when new building was constructed. Lamp has been replaced with energy saving type.

Yale University

Yale has a target to achieve 10% below 1990 level of emissions by 2020. Energy conservation has been the main technique for reducing energy consumption in the last 3 years, for FY 2005-2007, total MTCE avoided to date is 43,242. Major projects include:

- Recommissioned top 90 buildings
- Lab “occupied” mode reduction
- Lab rebalance and air Exchange Reduction
- Fuel Cell on line
- Building temperature standardisation in Metasys buildings
- Residential College Energy Savings Competition
- Occupancy sensors in remaining colleges
- Occupancy sensors in top 85 buildings
- High Efficiency Filters in all HVAC systems

Planned energy conservation projects, expected to total 34,939 MTCE avoided, include

- Green Construction: LEED Gold Plus
- Cogen installation at SPP
- Technology
 - Efficiency
 - Modulation
 - Geothermal standing column
 - Bio-Diesel
 - Solar PV Panels
 - Micro Wind linear array
 - Micro Wind vertical axis

Yale does include water consumption data in the sustainability metrics report, and there are recommendations for a more sustainable water use policy, however no data was found regarding past efforts to reduce water consumption. *

Do you currently have institutional targets for the reduction of greenhouse emissions, potable water consumption and waste to landfill? If so, what are they?

The Australian National University

Yes.

Energy: To reduce absolute energy consumption and greenhouse gas emission levels to 10% below the base level year (2002) by 2008 based on business as usual projections (noting that projected university growth of 1-2% during this period will also need to be offset).

Water: Reduce water consumption levels by 10% by 2008 compared to the base year (2002).
(Currently being reviewed with the aim of cutting water consumption by 50% by 2013)

Waste: Reduce volume/weight of waste going to landfill by 70% (from 2002 levels) by 2008.

University of California, Berkeley

Greenhouse gas emissions: Reduce greenhouse-gas emissions to 1990 levels by 2014 — six years earlier than the target set by California Assembly Bill 32, the Global Solutions Warming Act.

Waste diversion goals:

- 50% by June 30, 2008
- 75% by June 30, 2012
- Ultimate goal of zero waste by 2020

Construction waste: minimum of 50%, target of 75% from all construction projects

Water: reduce but no specific target.

National University of Singapore

We have targets to reduce energy consumption and increase waste recycling.

University of Oxford

The University is currently in the process of rewriting its environmental policies, targets and implementation programmes for 8 areas of environmental sustainability:

- Energy
- Water
- Waste
- Sustainable Buildings
- Travel
- Biodiversity
- Environmental Purchasing
- Greenhouse Gases

The draft policies, targets and implementation programmes will be finalised in December 2007, and will need to be ratified by the University Council before they can be implemented. The University will ensure that the environmental targets are achievable and measurable, and have allocated accountability, in order to accurately measure success and areas for improvement in the future.

The draft energy target is a 20% reduction of CO₂ emissions by 2010 based on 1990 baseline figures.

One of the 8 areas of environmental sustainability is sustainable buildings. The University will produce guidance for sustainable new builds and refurbishments, so that project sponsors and consultants are aware of the University's sustainable building policies and best practice.

Recommendations in the waste policy are to develop a monitoring and reporting system for the University so that all waste tonnages can be tracked, whether they are recycled, or sent to landfill. The waste tonnages could then be converted into methane emissions (and CO₂ equivalent).

The Travel Policy is "to encourage the use of energy-efficient public and communal transport, bicycles and walking, and to discourage unnecessary use of private motor transport both for travel to the University and travel for other work purposes during the day, with the aim of reducing traffic and parking in Oxford city centre."

The University of Tokyo

Reduction of maintenance cost including energy and water per floor area by 20% from FY 2004 to FY 2008.

Do you have a detailed greenhouse (carbon) inventory for your entire operation?

The Australian National University

Yes

University of California, Berkeley

Yes, see <http://sustainability.berkeley.edu/calcap/inventory.html>

National University of Singapore

We plan to include electricity, waste to landfill and campus fleet for calculation of the GHG emissions.

University of Oxford

Only for building and process related operations.

The University of Tokyo

No. There is overall CO₂ emission data within campus. The emission has not yet been analyzed in terms of purposes or sectors.

What internal reporting on these matters is done by the University?

Who receives these reports?

The Australian National University

We complete an annual environmental performance report that goes to the President. We also produce external reports that go to the Australian Greenhouse Office and (as part of the University Annual Report) go to the Federal Government. Finally, we submit “environmental performance measures” as part of an annual benchmarking of facilities management in the Australian and New Zealand tertiary sector, which is conducted by the Tertiary Education Facility Managers Association (Australasia) (The Australian equivalent/partner of APPA and AUDE)

University of Cambridge

Utility consumption data and associated emissions are reported in the Annual Utilities Report and also to the National (Higher Education Funding Council for England) Estate Management Statistics database.

Utility data and other data relating to waste / transport is reported to the Committee for Environmental Management as part of the Management Review requirements of the University’s Environmental Management System (based on ISO 14001)

University of California, Berkeley

Annual emissions reporting to California Climate Action Registry (outside agency) and to UC Office of the President.

Energy use reported to done to UC Office of the President through budget process.

Environmental performance through Long Range Development Plan Mitigation Monitoring.

Campus Sustainability Assessment update in planning stage.

University of Copenhagen (KU)

Annual reports to the authorities and to the organisation of universities in Denmark.

National University of Singapore

Campus sustainability Unit (Office of Estate and Development), and Office of Safety, Health & Environment are responsible collating pertinent details for monitoring and reporting. These units are subset of the Campus Sustainability Committee (chaired by Deputy President (Administration)). Who receives these reports? NUS Senior Management.

University of Oxford

An annual utilities’ report is sent to; the Environment Panel, the Buildings and Estates Sub Committee and the Policy Resources and Allocation Committee. The report covers energy and water consumption in buildings.

The report on the five yearly staff travel survey is sent to the Environment Panel and the Buildings and Estates Sub Committee.

Annual travel reports are also sent to the Environment Panel, the Buildings and Estates Sub Committee.

The University of Tokyo

Environmental report is prepared and reported at executive meeting, and then published and placed on the university web site.

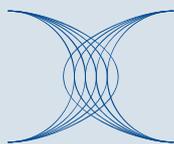
Greenhouse gas emission is reported to Tokyo Metropolitan Government (TMG) according to the TMG regulation.

Yale University

An Annual Report produced by the Office of Sustainability (replacing the Yale Environmental Report) goes to Administration.

An Energy Summary produced by the Facilities Systems Engineering Group on a monthly basis goes to the Associate Vice-President of Facilities.

A Sustainability Metrics Report is produced annually by the Office of Sustainability and circulates within the department as well as going to the Office of Facilities and the Office of the Provost.



Attachment 2: IARU Global Sustainability Index – Emissions Baseline Data Collection Form

Institution	
Reporting Period	
Person Completing Form	
Address	
E-mail	
Tel	
Fax	

Please return this form to:

Mr M Bienias

Director of Estate Management and Building Service

University of Cambridge, 74 Trumpington Street, Cambridge,
CB2 1RW, UK

Tel: +44 1223 37770

Fax: +44 1223 766486

E-mail: mb242@admin.cam.ac.uk

Table 1: Institutional Data

ESTATE DETAILS ⁽¹⁾	Units	Residential	Non-residential	Total	Comment
Number of Staff ⁽²⁾					
Total number of Staff					
Number of Students ⁽³⁾					
Number of undergraduate students					
Number of graduate students					
Total number of students					
Size of the University Estate					
Gross Internal Floor Area ⁽⁴⁾					
Net Internal Floor Area ⁽⁵⁾					
Other measurement ⁽⁶⁾					

Table 2: Emission Sources

EMISSION SOURCES (BUILDINGS) ⁽⁷⁾	Units	Residential	Non-residential	Total	Comment
Energy ⁽⁸⁾					
Electricity from National Network ⁽⁹⁾					
Natural Gas					
LPG					
Gas Oil					
Heavy Fuel Oil					
Coal					
Energy from Third Parties ⁽¹⁰⁾					
Renewable Energy generated on site ⁽¹¹⁾					
Other (please specify)					
Total Energy usage ⁽¹²⁾					
Water ⁽¹³⁾					
Metered fresh water					
Other (please specify)					

EMISSION SOURCES (OTHER)	Units	Residential	Non-residential	Total	Comment
Transport ⁽¹⁴⁾					
Site Vehicles / Pool cars					
Private cars					
Hire cars					
Motorcycles					
Vans / Minibuses					
Local Buses					
Long Distance Coaches					
Air Travel - Short Haul					
Air Travel - Long Haul					
Trains					
Boats					
Delivery vehicles					
Other (please specify)					
Waste ⁽¹⁵⁾					
Waste to landfill					
Waste incinerated					
Waste incinerated with energy recovery					
Waste recycled					
Other (please specify)					
Miscellaneous					
Farm Animals ⁽¹⁶⁾					
Other (please specify) ⁽¹⁷⁾					

Table 3: Conversion Factors

CONVERSION FACTORS ⁽¹⁸⁾	Unit	Conversion Factor	Comment
Energy			
Electricity from National Network ⁽¹⁹⁾			
Natural Gas			
LPG			
Gas Oil			
Heavy Fuel Oil			
Coal			
Energy from Third Parties ⁽²⁰⁾			
Renewable Energy generated on site ⁽²¹⁾			
Other (please specify)			
Water ⁽²²⁾			
Metered fresh water			
Other (please specify)			
Transport ⁽²³⁾			
Site Vehicles / Pool cars			
Private cars			
Hire cars			
Motorcycles			
Vans / Minibuses			
Local Buses			
Long Distance Coaches			
Air Travel - Short Haul			
Air Travel - Long Haul			
Trains			
Boats			
Delivery vehicles			
Other (please specify)			
Waste ⁽²⁴⁾			
Waste to landfill			
Waste incinerated			
Waste incinerated with energy recovery			
Waste recycled			
Other (please specify)			
Miscellaneous			
Farm Animals ⁽²⁵⁾			
Other (please specify) ⁽²⁶⁾			

Table 4: Emissions

CO ₂ EMISSIONS	Units	Residential	Non-residential	Total	Comment
Buildings					
CO ₂ emissions from Buildings (Total)					
CO ₂ emissions from Buildings (per m ²)					
CO ₂ emissions from Buildings (per student)					
Other Sources					
CO ₂ emissions from Other Sources (Total)					
CO ₂ emissions from Other Sources (per m ²)					
CO ₂ emissions from Other Sources (per student)					

Table 5: Notes

1	Where possible, data should be sub-divided to reflect the residential and non-residential estate. The figure for the whole estate should equal the sum for the residential and non-residential parts of the estate. Collegiate Universities may not have access to suitable figures relating to student accommodation in colleges and should include only figures relating to the non-residential estate (i.e. academic & administration).
2	Where possible, please show Full Time Equivalent (FTE) staff. Non-residential staff should include all academic, research, support, administrative and technical staff. Residential staff should include any staff whose primary function is associated with student residences and who are not otherwise included in the figure supplied for the non-residential staff. If an alternative measure to FTE is used please indicate units.
3	Where possible, please show the number of full-time equivalent (FTE) students. The data should be sub-divided to show the number of under-graduate and post graduate. The total should equal the sum of the under-graduate and post graduate students. Include figures for further education students but exclude figures for distance learning and franchise. If an alternative measure to FTE please indicate units.
4	Where possible, floor area should be shown as Gross Internal Floor Area (GIA) converted to square metres (m ²). If an alternative measure to m ² is used please indicate units. GIA includes the total area of buildings owned or occupied or maintained by the institution measured to the internal face of the perimeter walls at each floor level (i.e. the footprint of the building excluding the width of the outside walls). It includes areas occupied by internal areas and partitions. If floor area data is not available to this definition then please provide a figure which matches this as closely as possible and provide an explanation of what has been included in the floor area figure.

5	<p>If GIA figures are not available please indicated Nett Internal Floor Area (NIA) converted to square metres (m²). If an alternative measure to m² is used please indicate units.</p> <p>Net Internal Area is the usable area within a building measured to the internal face of the perimeter walls at each floor level. NIA covers all areas which are used for a specific purpose. It does not include those parts of buildings which enable them to function, i.e. 'balance areas.</p>
6	Where neither GIA nor NIA estimates are available please indicate other metric relating to the size of the University Estate, indicating units used.
7	Please indicate any data on CO ₂ emission sources associated with buildings that your institution collects. Please provide accurate data or reliable estimates where accurate data is unavailable. For any emission sources where accurate data or reliable estimates do not exist please indicate N/A (not available).
8	Where possible, energy consumption data (oil, gas, electricity, coal, steam/hot water, etc) should be converted to kilowatt-hours (kWh). If an alternative measure to kWh is used please indicate units.
9	This is the amount of electricity provided to the University by electricity suppliers. It should exclude <u>any</u> electricity generated on site.
10	This is to account for any energy which is generated locally but not under the direct control of the university and therefore the fuel input <i>has not been accounted for elsewhere in this submission</i> . For example, a university may benefit from energy supplied by a Combined Heat & Power unit which is owned/operated by an independent contractor or shared with a neighbouring organisation, such as a college or a teaching hospital, etc.
11	Please indicate the amount of low carbon energy generated locally from Renewable Energy sources, most likely to include; Wind, Solar PV/Thermal or Biomass, but may include other technologies (please specify):
12	The total energy usage is the sum of all the operational energy associated with buildings. It does not include any assessment of embodied energy associated with construction materials.
13	Metered fresh water consumption data should be converted to cubic metres (m ³). If an alternative measure to m ³ is used please indicate units.
14	<p>Where available, please indicate any accurate data or reliable estimates related to travel and transport at work converted to kilometres. If an alternative measure to kilometres is used please indicate units.</p> <p>For any travel or transport mode for which accurate data or reliable estimates do not exist please indicate N/A (not available).</p> <p>Alternatively, data relating to the amount of fuel used in connection with transport can be accepted.</p>
15	<p>Where available, please indicate any accurate data or reliable estimates related to waste disposal and recycling converted to metric tonnes. If an alternative measure to metric tonnes is used please indicate units.</p> <p>For any waste streams for which accurate data or reliable estimates do not exist please indicate N/A (not available)</p>
16	Please indicate any emission sources from farm animals on University agricultural facilities, for example dairy / beef herds or sheep shown as head. If an alternative measure to head is used please indicate units.

17	Please indicate any other emission sources not mentioned elsewhere and state measurement units used.
18	Please indicate any nationally or regionally accepted conversion factors to convert emission sources into carbon dioxide (CO ²). Please specify the source of the conversion factor. Where there is no known appropriate factor please use the conversion factors listed in Annex A.
19	The conversion factor used to estimate CO ² emissions associated with electricity supplied from the national network is based on the generating mix relevant to that university/ country (i.e. proportion of coal, oil, gas, nuclear, hydro, renewables, etc). The UK value issued by the DEFRA is 0.43 kg/kWh, which is applicable to the UK only. The figure will vary significantly internationally depending on the fuel mix in individual countries. To enable comparison between international universities please indicate the appropriate conversion factor based on your national / regional situation. If there are no national or regional conversion factors, please use the UK factors shown in Annex A
20	To avoid double counting, the emissions factor for energy from third parties type of energy should only relate to energy used by the university and generated from sources not accounted for elsewhere in this submission.
21	It is recognised that all forms of energy generation have some carbon emissions associated with them over their life cycle, mainly due to their manufacturing process, or fuel transportation in the case of biomass. However, such emissions from renewable energy are considered to be outside the scope of this survey.
22	Please indicate any nationally or regionally accepted conversion factors to convert water treatment and distribution emissions (e.g. pumping, filtration, disinfection) emission sources into carbon dioxide (CO ²) equivalent. Please specify the source of the conversion factor.
23	Please indicate any nationally or regionally accepted conversion factors to convert travel and transport (e.g. car, train, bus, air travel) emission sources into carbon dioxide (CO ²) equivalent. Please specify the source of the conversion factor.
24	Please indicate any nationally or regionally accepted conversion factors to convert waste management emissions sources (e.g. methane emissions from landfill) into carbon dioxide (CO ²) equivalent. Please specify the source of the conversion factor.
25	Please indicate any nationally or regionally accepted conversion factors to convert farm animal emissions sources (e.g. beef / dairy cattle, sheep) into carbon dioxide (CO ²) equivalent. Please specify the source of the conversion factor.
26	Please indicate any nationally or regionally accepted conversion factors to convert any other identified emission sources not mentioned earlier into carbon dioxide (CO ²) equivalent. Please specify the source of the conversion factor.

Annex A: UK Carbon Dioxide Conversion factors

Fuel Type	Units	kg CO2 per unit	Source
Grid Electricity ¹	kWh	x 0.43	DEFRA (UK)
Natural Gas	kWh therms	x 0.19 x 5.43	DEFRA (UK)
Gas Oil	tonnes kWh litres	3190 0.25 2.69	DEFRA (UK)
Diesel	tonnes kWh litre	3164 0.25 2.63	DEFRA (UK)
Petrol	tonnes kWh litres	3135 0.24 2.30	DEFRA (UK)
Fuel Oil	tonnes kWh	3223 0.27	DEFRA (UK)
Coal ²	tonnes kWh	2548 0.32	DEFRA (UK)
LPG	tonnes kWh litres	0.214 6.27 1.49	DEFRA (UK)
Renewables ³	kWh	0.0	DEFRA (UK)
Transport			
Small petrol car >1.4 litres	miles kilometers	0.26 0.16	DEFRA (UK)
Medium petrol car 1.4 - 2.1 litres	miles kilometers	0.30 0.19	DEFRA (UK)
Large petrol car > 2.1 litres	miles kilometers	0.35 0.22	DEFRA (UK)
Average petrol car	miles kilometers	0.29 0.18	DEFRA (UK)
Small diesel car >2.0 litres	miles kilometers	0.26 0.16	DEFRA (UK)
Large diesel car <2.0 litres	miles kilometers	0.31 0.19	DEFRA (UK)
Average diesel car	miles kilometers	0.27 0.17	DEFRA (UK)
Rail	person / kms	0.04	DEFRA (UK)
Air - Long Haul	person / kms	0.11	DEFRA (UK)
Air - Short Haul	person / kms	0.15	DEFRA (UK)
Other			
Water	m ³	0.21	
Dairy cattle	head / year	2100	IPCC
Non-dairy cattle	head / year	1008	IPCC
Sheep	head / year	168	IPCC
Horses	head / year	378	IPCC
Goats	head / year	105	IPCC

(See following page for source and notes pertaining to the above table)

Source: Based on the National Atmospheric Emissions Inventory for 2003 and the UK Greenhouse Gas Inventory for 2003 developed by Netcen (2005), Digest of UK Energy Statistics DTI 2004

- 1 The factor for electricity has been changed slightly from the previous guidelines to come into line with calculations for the Climate Change Levy Agreements and future requirements for Emissions Trading. It was calculated on the projected fuel mix for the grid 1998-2000. Actual figures may differ from the projections, but to help with year on year comparisons we plan to use a constant value for the purposes of these Guidelines until the year 2010.
- 2 Average emission factor for coal used in sources other than power stations and domestic, i.e. industry sources including collieries, Iron & Steel, Autogeneration, Cement production, Lime production, Other industry, Miscellaneous, Public Sector, Stationary combustion - railways and Agriculture. Users who wish to use coal factors for types of coal used in specific industry applications should use the factors given in the UKETS.

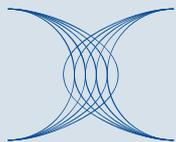
References

DEFRA: Guidelines for Company Reporting on Greenhouse Gas Emissions, UK Department of Environment, Food and Rural: July 2005:

<http://www.defra.gov.uk/environment/business/envrp/gas/envrpgas-annexes.pdf>

IPCC: Intergovernmental Panel on Climate Change, Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories Workbook (Volume 2) Agriculture:

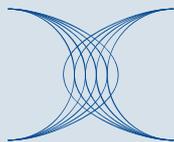
<http://www.ipcc-nggip.iges.or.jp/public/gl/invs5c.htm>



Attachment 3: Campus Climate Protection Program Summary

(See attached)

Replace this page with the A3 fold-out
“Campus Climate Protection Program
Summary”



Attachment 4: Green Building Rating Systems

COMPARATIVE OVERVIEW OF ENVIRONMENTAL ASSESSMENT METHODS IN IARU MEMBER COUNTRIES

Prepared for:
ANUgreen

Prepared by:
Mishka Talent¹

July 2007

¹ Mishka Talent, College of Engineering and Information Technology, email: u2548687@anu.edu.au

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Introduction

Sustainable building design is a methodology that integrates environmental resource pressures with construction in an attempt to achieve sustainable development. It includes formal and informal initiatives developed by governments, professional organizations and private industry (Bunz *et al* 2006).

Environmental Building Rating Schemes (EBRS) provide a formal framework for assessing the environmental impact of buildings. EBRS's have been developed in many countries, and have become important in the last decade in particular as a measure of sustainable development. While most EBRS's provide users with a consistent and comprehensive system for describing the flow of energy, air, water and other resources throughout the life cycle of a building (IEA 2004), there are wide variations between countries. These differences generally stem from environmental and geo-political differences among countries.

This report reviews the most prevalent and current environmental assessment methods that exist in each IARU member country (Table 1). It compares and contrasts selected criteria of some assessment methods in each country in an attempt to find some common ground. Discussion focuses on the criteria of each environmental assessment method and its weighting. In the final section of this report, comparisons are made with international frameworks and recommendations are made to guide each university in attaining best practice building standards. Annexes 1-7 show re-weighted (as percentages) EBRS's for each country while Annexes 8 and 9 use common metrics to compare the EBRS's in selected IARU countries.

This report serves as a reference for IARU members to compare building rating schemes in fellow member countries. Comparisons are made between guidelines for offices, as they provided the best indicators of university facilities. All research for this report was obtained through publicly available online resources.

Country	University	Environmental Assessment Methods	Date launched
Australia	Australian National University	Green Star	2003
Denmark	University of Copenhagen	Energimærke, BEAT	2001
China	Peking University	GOBAS, LEED	2006
Japan	University of Tokyo	CASBEE	2003
Singapore	National University of Singapore	Green Mark	2005
Switzerland	Swiss Federal Technical Institute	MINERGIE, SIA	1998
United Kingdom	University of Cambridge	BREEAM	1990
United Kingdom	University of Oxford	BREEAM	1990
United States	University of California, Berkeley	LEED	2000
United States	Yale University	LEED	2000

Table 1. IARU member universities by country, with most prominent environmental assessment methods and date of inception.

University of Oxford and the University of Cambridge (United Kingdom)

The Building Research Establishment Environmental Assessment Method (BREEAM) is an environmental assessment method for buildings originally developed for the United Kingdom and released in 1990. The Building Research Establishment is owned by the Foundation for the Built Environment, a registered charity which provides a range of research services and consultancy.

BREEAM is a voluntary evaluation scheme to assess a buildings performance based on eight (8) criteria: energy, transport, pollution, materials, water, land use and ecology, health and wellbeing and management. Within each category are approximately 10 sub-criteria to which points are assigned – the highest points are awarded for ‘best practice’. All types of buildings are rated against these eight criteria; however, the weighting of each category varies. For office buildings, water has a weighting of 5 %, land use 8 %, and materials 11 %, while the remaining categories are almost equally weighted at approximately 15 % each (see Annex 1 for a detailed breakdown).

By the accumulation of points, a building may be assigned one of five general categories: fail, pass, good, very good or excellent. A building is considered very good if it scores above 55 % and excellent if it receives above 70 %.

Several versions of BREEAM exist for assessing Courts, EcoHomes, EcoHomes XB, Industrial, International, Multi Residential, Offices, Prisons, Retail, Schools and Bespoke (all other buildings). Each building type has a different weighting, but the same eight criteria apply.

BREEAM for offices consists for two sections: Design and Procurement for new or refurbished buildings, and Management and Operation for existing buildings. Both tools are intended to be used separately depending on the state of the office. They vary only slightly; the most noticeable difference is that the materials criteria are weighted very lightly for operations of a building, as would be expected. For the purposes of this report, however, the two have been combined to give a better description of the life cycle of a building rated under BREEAM. This is mainly for comparison with other rating schemes which generally have a more complete life-cycle analysis (LCA).² It is notable that there are not criteria for the demolition of the building.

It is also worth mentioning that the Building Research Establishment in conjunction with the government has developed the Code for Sustainable Homes. It uses the same categories as BREEAM with the exception of the transport criterion, but has added surface water run off and waste. One star (*) is the entry level – above the level of the Building Regulations; and six stars (*****) is the highest level – reflecting exemplar development in sustainability terms (DCLG 2006). The rating scheme will begin on August 1st 2007 and will be compulsory for all public housing. The government has also developed a Standard Assessment Procedure (SAP) for Energy Rating of

² Lifecycle analysis usually refers to design, production, construction, operation, maintenance, demolition, disposal of a building

Dwellings. SAP 2005 is adopted by government as part of the UK national methodology for calculation of the energy performance of buildings.³

University of California, Berkeley and Yale University (United States)

The Leadership in Energy and Environmental Design (LEED) is a Green Building Rating System developed by the United States Green Building Council (USGBC)⁴ and released in 2000. LEED-NC for new construction for Multiple Buildings and On-Campus Building Projects is considered for this analysis.

LEED-NC evaluates a building by assigning points to 64 requirements in 5 categories (Annex 2). Categories include sustainable site (20 %), water efficiency (7%), energy and atmosphere (25 %), materials and resources (19 %) and indoor environmental quality (22 %). Generally 1 point (1.4 %) is assigned to each requirement except for energy performance, to which up to 10 points can be allocated. Bonus points can be achieved in a 6th category called Innovation and Design process (7 %) which is aimed at site specific design improvements and for employing a LEED accredited Professional. This final category was not used in comparison with other assessment methods and each other category was re-weighted accordingly (Annex 8).

The level of certification that a building can receive is based on the number of points acquired. There are 4 certification categories: Certified (38 %), Silver (48%), Gold (57 %) and Platinum (75 %). Estimates suggest that only 10 % of all commercial buildings in the United States are capable of meeting even the Certified level (Reed 1997).

The American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE) have developed the ASHRAE GreenGuide. These guidelines cover the early design and practical engineering suggestions for implementing 'green' design for heating, refrigeration, ventilation, and air-conditioning. This guide is used for implementing various design criteria for LEED. It is mentioned here only for later comparison with other country building codes. The *Energy Policy Act of 1992*⁵ (EPAct) requires States to ensure that new non-residential buildings meet or exceed the efficiency standards recommended by the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).

LEED and BREEAM are two of the most well recognized building assessment methods. They both have similar points-based approaches to building classification, and can be compared fairly easily. The five categories (ignoring bonus points) of LEED can be rearranged to the 8 categories of BREEAM (Annex 1). The most notable difference is the lack of importance that LEED places on transport and management compared with BREEAM. Instead, LEED places much more importance on Energy and Materials.

³ <http://projects.bre.co.uk/sap2005/>

⁴ <http://www.usgbc.org>

⁵ Pub L No 102-486, 106 Stat 2776.

Australian National University (Australia)

Green Star is the national environmental assessment tool for buildings in Australia. It was developed by the Green Building Council of Australia (GBCA) and released in 2003.

Under Green Star, buildings are evaluated under eight differently weighted criteria. These include management (10 %), indoor environment quality (20 %), energy (25%), transport (10 %), water (15 %), materials (10 %), land use and ecology (5%), and emissions (5 %). Generally, 1 or 2 points are awarded to 5 – 10 requirements within each category.

Certification is based on a star rating where 1 star is the lowest rating and 6 stars is the highest. Points are realized by meeting requirements within each category. A 4 star building (score 45-59) is considered best practice, and is the minimum level set for rating by the GBCA. 'World Leadership' status can be achieved with 6 stars (score 75-100). See Annex 3 for a complete breakdown of star ratings and scoring criteria.

Green Star is based heavily on BREEAM and to a lesser extent on LEED. The eight criteria in Green Star follow directly from the eight used in BREEAM. Aside from this superficial similarity, however, comparison between BREEAM and Green Star is difficult. Firstly, Green Star places less importance (as indicated by weighting) on management, transport and pollution but nearly twice as much importance on water and materials. Furthermore, within each criterion there are many discrepancies, such as flooding minimization in BREEAM and underground car park ventilation in Green Star, which makes direct comparison between the two building assessment methods very difficult.

Australia also has a number of energy rating schemes.⁶ The Australian Building Greenhouse Rating (ABGR) Scheme is a national, government-funded energy (greenhouse gasses) rating scheme. The energy rating of a building is represented on a scale of zero (sub-standard) to five (best practice) stars. Four (4) stars represents an emission of less than 192 kgCO₂/m²/yr while 5 stars represents an emission of less than 137 kgCO₂/m²/yr. There are more than 20 similar rating tools in Australia, a few of which are mandatory in some states (Bowe 2004).

⁶ FirstRate 5, BERS, AccuRate are residential energy rating schemes and NatHERS is a government recognized framework for building thermal software analysis.

University of Tokyo (Japan)

The Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) was developed by the Japan Sustainable Building Consortium (JSBC) and released in 2001 (Japan Sustainable Building Consortium 2007). CASBEE was developed from the concept of Building Environmental Efficiency (BEE), which was adapted from *eco-efficiency* as defined by the World Business Council on Sustainable Development (WBCSD). It was developed from Sustainable Building Tool (SBTool, formally GBTool) (iiSBE 2006).

CASBEE is dissimilar to BREEAM and LEED as it considers the sustainability of a building by separately considering the quality (Q) of the building and the load (L) effects that the building has on the environment. Q represents the living environment in terms of amenities such as air quality, lighting and durability while L represents the buildings load on the environment such as energy and water use, pollution and material use.

More than 110 conditions are divided between 3 weighted measurements of quality (indoor environment (20 %), quality of service (15 %) and outdoor environment on site (15 %)), and 3 load measurements (off-site environment (20%), resource and materials (15 %), and energy (15 %)). Each condition is weighted usually on a level 1-5⁷ or may be excluded where it is not suitable for the building type. Q/L is plotted on a radar chart (Annex 4) to give a CASBEE ranking. The ranking is scored between 0.0 and 3.0 where 3.0 or higher (also called S class) is considered more sustainable (see Annex 4). A building must achieve both a high quality ranking and a low load rating to achieve a high score and be considered sustainable.

Four (4) design tools are used over the lifecycle of a building. These include the Pre-design Tool, the Design for Environment Tool, the Eco-Labeling Tool and the Sustainable Operations Tool.⁸ While LEED, BREEAM and Green Star all contain some requirements which pertain to a life cycle analysis (LCA), the four tools of CASBEE provide a much clearer and more comprehensive life-cycle building assessment (Bunz 2006).

CASBEE was developed for the hot and humid weather of Japan and other Asian countries. Many of the technologies used by western countries cannot be applied to monsoon climates without considerable modification (Murakami *et al* 2002). Furthermore, given the conceptually different framework for considering Q and L, it is not possible to compare CASBEE with the rating tools mentioned above. However, by excluding many 'quality of service' requirements and re-weighting the other requirements, a comparison was made with BREEAM (Annex 8). Further discussion of this comparison is left until the final section of this report.

⁷ Level 3 corresponds to ordinary technical and social levels at the time of assessment and level 1 is generally earned by meeting building standard laws

⁸ No tool has yet been developed for the demolition of the building.

Peking University (China)

China does not have all-encompassing standards for environmentally sustainable construction. Rather, a repertoire of area specific standards exists that give some guidelines to environmentally thoughtful construction. Such standards are based on national energy laws, provincial codes and departmental regulations (Hui 2000:6).

Codes for reducing energy consumption of buildings were first introduced in 1986. These codes divided the country into five climatic zones, with Peking University located in the cold to severe cold zone. The Ministry of Construction (MOC) issued an energy-saving code⁹ for cold and severe cold climates which set standards for insulation in walls and rooves, double glazing, lighting restrictions of about 10 watts per m² and conditions on heating, ventilation and air-conditioning. These standards, however, are half as stringent as those requirements set out by the ASHRAE (Langer and Watson 2004).

The Hong Kong government developed its own energy efficient regulations in 1995. This statutory control for new commercial buildings and hotels uses the overall thermal transfer value (OTTV) method (Building Authority 1995). Lam and Hui (1996) have concluded that this method was only suitable for warm climates such as Hong Kong, Singapore, Malaysia, Philippines and Thailand. Thus it is unlikely to be suitable for Beijing. Hong Kong has also developed its own building rating system – Hong Kong Building Environmental Assessment Method (HK-BEAM) based on BREEAM. While similar in methodology, HK-BEAM has a much stronger focus on energy and the indoor environment. As of 2005 only 100 buildings have received certification.

China has yet to establish a construction-related energy efficiency labelling system, but in recent years, it has created numerous government agencies which are in the process of establishing assessment methods (He Huiyu 2007). Some of these are mentioned below.

One of the most widely discussed building assessment method is the Green Olympic Building Assessment System (GOBAS) for the 2008 Olympics (Yi *et al* 2006). This system was developed by the Ministry of Science and Technology (MoST) with technical support from Beijing's Qinghua University. This system of analysis is conceptually similar in design to CASBEE, although the criteria are fairly different. To a lesser extent, it was also based on LEED (Langer and Watson 2005) although the link between them is not clear in the criteria.

GOBAS, like CASBEE judges a buildings impact on the environment by considering the quality of the building (Q) and then the load on the environment (L) (Yi *et al* 2006). The quality of a building is measured by three categories: Quality of Land, Quality of Services and Quality of Physical Environment. The load is measured by 5 categories: Necessity to Carry out the Project, Effects on the Surrounding Environment, Energy Consumption,

⁹ Building code *JGJ 26-95* for residential properties and *GB 50189-93* for tourist hotels are the two main codes (can be seen at <http://arch.hku.hk/research/BEER/> (English translation))

Materials and Water Consumption.¹⁰ Due to the lack of available information, these criteria could not be weighted and therefore not compared with CASBEE.

A number of EBRS currently under development are worthy of mention:

- In Beijing, the Ministry of Construction (MOC) is developing the China Intelligent and Green Building Association (CIGBA) (Langer and Watson 2004), which is in the process of developing (Turner 2003) a number of green construction-related standards (Chunming 2007). According to statistics from the construction ministry, the cost of a building that saves 60% of the energy per unit is only 5-7 % higher than an ordinary building (People's Daily Online 2005).
- The Shanghai Green Building Promotion Council (SHGBC) and the Association of Energy Efficiency in Buildings (AEEB) are developing a Shanghai-specific green building certification system, most likely by adapting LEED or GOBAS (Langer and Watson 2007).
- China Ecological Residential Technology Assessment Manual (GHEM 2002) is used for addressing environmental issues in residential properties and is overseen by the China Housing Industry Association
- The China Academy of Building Research is continually publishing energy related standards (e.g. 'green lighting standard') (Jinping unknown).

With a lack of government direction and lack of international recognition, the private sector only uses LEED. The first certified building was in 2005. The LEED rating system can bring Chinese projects the most international recognition. To date, only a small number of buildings have been certified by LEED (Yang 2005).

¹⁰ This manual could not be purchased online by the author and no information was found to the weightings of each category. Category names were translated by Yu Ping Chan.

National University of Singapore (Singapore)

Green Mark is the national green building-rating tool used in Singapore. It was developed by the Building and Construction authority and launched in January 2005. Green mark may be legislated shortly (Yien 2007). A certified level must be obtained for all public buildings. Currently the Building Control Act also mandates an Envelope Thermal Transfer Value (ETTV), however this only covers air-conditioned buildings and does not constitute a complete environmental assessment and is therefore not considered for this discussion.

Under the Green Mark assessment system, points are awarded for incorporating environment-friendly features which exceed normal practice (Building & Construction Authority 2006a). Points are allocated to 30 requirements in 5 categories: Energy Efficiency (35 %), Water Efficiency (15 %), Site/Project Development & Management (Building Management & Operation for existing buildings) (20 %), Indoor Environmental Quality & Environmental Protection (15 %) and Innovation (15 %) (Building & Construction Authority 2006^b).

Buildings can be awarded Certified, Gold, Gold^{plus} or Platinum. All buildings must meet some prerequisite requirements (accounting for 30% of overall score) and must score a minimum of 50 % of points from within each category. Green Mark Platinum requires at least 85 points. Buildings must be inspected triennially to maintain awarded Green Mark status.

Green mark can be easily compared with BREEAM (Annex 1). For comparison, each of the 30 requirements was allocated to the 8 categories of BREEAM. Compared with BREEAM, Green Mark places very little emphasis on transport (1%) pollution (4%), materials (6 %) and very strong emphasis on energy (36 %) and water (18 %).

The strong emphasis on energy and water is likely to be due to geo-political affairs in Singapore. Despite high rainfall, Singapore imports fresh water from Malaysia, which saw unrest in the region in 1997 (Zachary 1997). Also almost all energy is imported (fossil fuels) and recent price increases have led to government pressure to reduce consumption. Thus, while the weighting of some environmental issues varies considerably to BREEAM, Green Mark has been adapted not only to match political as well as environmental considerations within the region.

University of Copenhagen (Denmark)

The Environmental Assessment and Classification of Buildings (EACB) is the chief environmental assessment tool used in Denmark (Dinesen *et al* 2001). It was developed by the Danish Building and Urban Research Institute and released in 2001.

EACB evaluates a building on seven (7) criteria using a combination of points and LCA. These criteria include: energy consumption, material consumption, waste, contributions to global climate change, contribution to air pollution, indoor climate (air quality, heat, light, noise), and other indicators (chemicals, water consumption, running, localisation and other conditions to be chosen by the evaluators). A points system is only used for the latter two criteria. An LCA tool called BEAT (see below) is used to classify each of the former 5 categories to either an A, B or C class. The building is also given an overall class rating, A (just slightly above standard), B (quite good) and C (most environmentally friendly, cutting edge technology).

Building Environmental Assessment Tool (BEAT) is a LCA-based IT-inventory tool and database for the environmental assessment of building products, building elements and buildings. The database currently contains data for most conventional primary building products used in the Danish building industry (cement, concrete, gypsumboards etc.), as well as a large number of commonly used building elements, and a number of energy sources and means of transport (Hansen and Dammann 2002). The environmental impact of materials used in construction are calculated over their expected life-time and presented as an environmental effect (e.g. CO₂ – equivalents for different substances which contribute to global warming) and as normalized and weighted environmental profiles (Wentzel *et al* 1997).

As a member of the European Union (EU), Denmark is obligated to EU mandates, including the EU ratified directive 2002/91/EC which calls for mandatory regulation of the energy efficiency of new and refurbished buildings and the energy certification (or labelling) of new and existing buildings.¹¹

Building performance labelling began in 1982 with the Heat Consultant Scheme, which was replaced in 1996/1997 with the *Act to Promote Energy and Water Savings in Buildings* (Ministry of Environment and Energy Danish Energy Agency 1996). There are now two rating schemes, Energy Management Scheme for Large Buildings (Energimærkning af huse og ejerlejligheder) (ELO), which covers large buildings greater than 1,500 m², and Energy Certification Scheme for Small Buildings (EM). Both are administered by the Danish Energy Authority. For large buildings, actual consumption is recorded on the label rather than an estimation of use based on design (as with EM). Labels for large buildings must be re-issued each year, whereas small buildings are only labelled upon sale. The label (called Energimarke) comprises four criteria – Heating, Electricity, Water, and Environmental Impact. Each criterion is rated on a scale A (low consumption) to M (high consumption).

¹¹ Only applicable when residential buildings are sold – see <http://europrosper.energyprojects.net/main.asp?Show=D>

Even though the scheme is mandatory, only around 42 % of potential buildings are registered in the scheme. This is most likely because there are no penalties for non-participation (Bauwens *et al* 2005). Compared with other rating schemes, there is very little detail, no rating mechanism (e.g. GOLD to imply best practice), and no minimum standard. However it has been much more widely adopted than labelling systems in other countries.

Swiss Federal Technical Institute (Switzerland)

Switzerland distinguishes mandatory requirements (based upon laws and the standardisation by the Swiss Association of Engineers and Architects, SIA) and non-mandatory specifications (directives, regulations of the state-of-the-art and recommendations). In 1988, Switzerland put into force its first directive of building performance, regulating the consumption of heating energy for the first time. This directive was based upon SIA 380/1 (1988) which in its turn has been modified, reissued as well as adjusted to European standardisation last July as SIA 380/1 (2007). To this date, all calculations of effective heating energy are based on SIA 380/1 and its assumptions.

Since June 2006 an additional four voluntary certifiable standards exist: MINERGIE¹², MINERGIE-P, MINERGIE-ECO and MINERGIE-P-ECO.

In addition to the mandatory requirements MINERGIE demands a ventilation concept, reduced energy consumption for heating (80% of mandatory requirement) as well as a certain maximum consumption of energy (40 kWh/m²/yr for heating, warm water, auxiliary energy for ventilation, heat energy distribution and cooling). MINERGIE-P (according to the German *Passivehouse*) requires a ventilation system, far lower energy consumption for heating (allowing only 20% of mandatory consumption), a maximum of 25 kWh/m²/yr and a proven airtight outer shell as well as high-efficient electrical equipment, which is required by the users.

The supplement ECO takes into account both health (light, noise and indoor air quality) and building ecology (raw materials, production and deconstruction) with an elaborate list of questions. The four possible combinations of MINERGIE certificates are all developed from mandatory requirements and take into account the non-mandatory specifications as well, see

Figure 1. Therefore the standards are not precisely rating systems but rigid standards where a certain building passes or fails the demands implemented by the regulations.

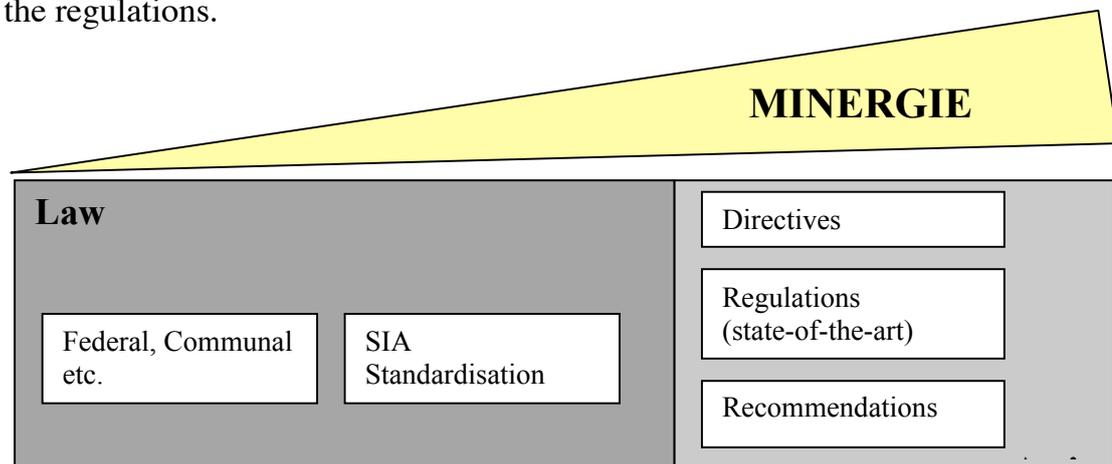


Figure 1 Mandatory requirements, non-mandatory specifications and MINERGIE

¹² The brand MINERGIE® is attended to by the association MINERGIE and supported Government of Switzerland, the industry and individuals. The brand and label MINERGIE has been launched in 1998, MINERGIE-P in 2002 and MINERGIE-ECO in 2006.

Apart from the standards specified above, the SIA together with the Swiss Federal Office of Energy, SFOE, is in the process of developing an edificial energy pass (resulting in fact sheet SIA 2031). Thus it should be possible to compare the energy consumption of existing and newly set-up buildings (using A for best to G for worst). This energy pass aims at improving the incentive to renovate buildings.

Furthermore the SIA has recently worked out its recommendation SIA 112/1 "Sustainable Building Process" (2004) as well as the documentation SIA D 0216 "Efficiency Path to Energy Use" (2006). Both papers are non-mandatory but provide a strong basis for Green Buildings where at this time MINERGIE-P-ECO is the most rigorous standard in Switzerland.

All standards focus on the developing process of buildings. Therefore, services provided by building operations and facility management are not rated. Neither are the effects of Transport taken into account (whereas SIA D 0216 states that induced traffic needs further research).

Looking at MINERGIE-P-ECO (in particular at the parts MINERGIE-P and -ECO) the two major issues are the topics Energy (45%, all of which derive from MINERGIE-P) as well as Health and Wellbeing (30%, 3% from MINERGIE-P, 27% from ECO). With regards to the embedded energy (grey energy), the environmental compatibility of materials (16%, all from ECO) is third most important. MINERGIE-P requires the use of renewable energy and ECO rates certain pollution due to auxiliary products of insulation leading to the topic Pollution (5%, mostly ECO), which is rated fourth important (besides, Switzerland knows a very demanding Clean Air Act regulating for example the maximum output of nitric oxides as well as sulphur oxides). To conclude, certain questions from ECO deal with the topics Land Use (2%) and Water (2%).

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 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 and Denmark 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 have been made. All comparisons are for guidelines relating to office-type buildings, except LEED which is for multiple-buildings and on-campus buildings.¹³ Mandatory building regulations generally fall far short of environmental assessment methods and are usually inline with the minimum 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), SIA380/1 (Switzerland) 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 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 45 % 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 (45%). MINERGIE (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.

¹³ LEED for multiple-buildings and on-campus buildings has the same weighting for each criterion as LEED-NC (new constructions).

While sub-metering of energy use is common, only Energinet (Denmark) uses this information to re-evaluate a building's 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 CO₂ emissions from using a building are more than 10 times higher than the combined energy (embodied and use) and CO₂ 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. Weighted values range between 12 % for Green Mark to 30 % for MINERGIE-P-ECO (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 and MINERGIE-P-ECO 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°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 2% for MINERGIE-P-ECO / 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 are site- and country-specific, comparing criteria (e.g. water use, energy consumption, CO₂ 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.

Both BREEAM (13%) and Green Star (9%) place considerable importance on transport facilities. CASBEE and MINERGIE-P-ECO 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.

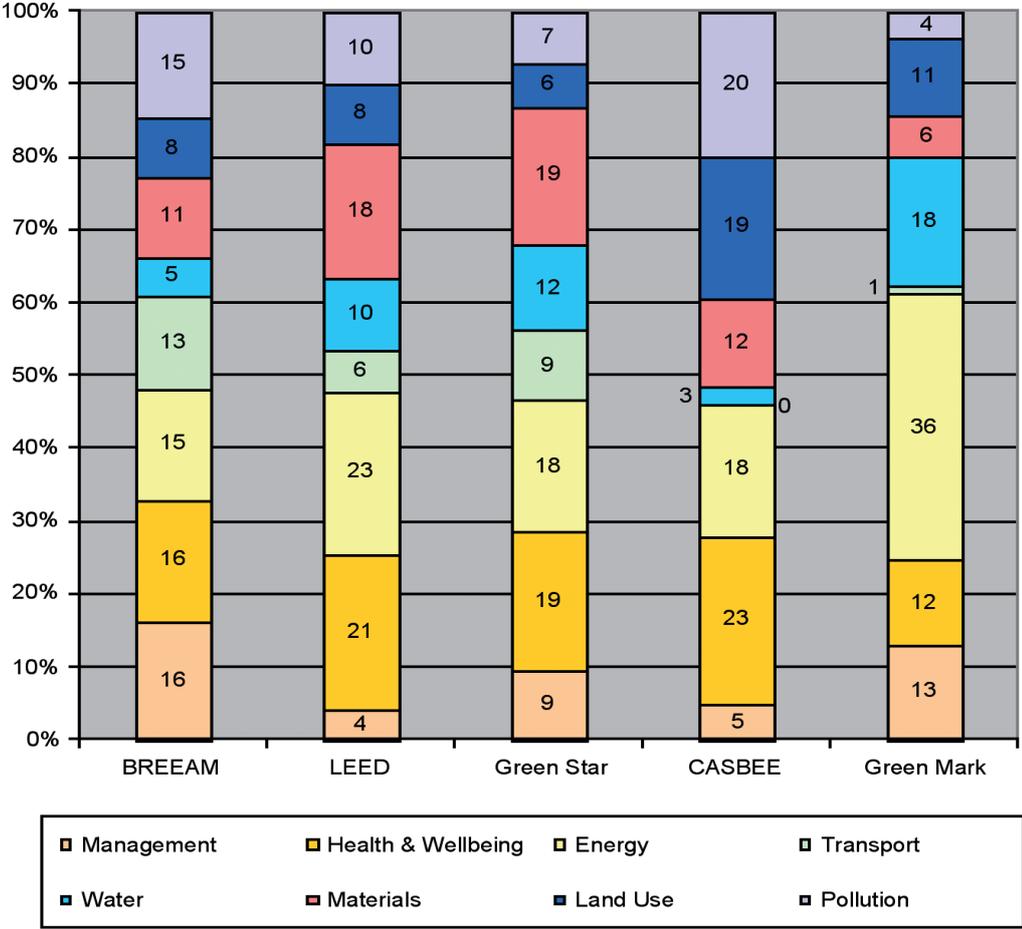


Figure 2. Normalised weightings for EBRS for selected IARU countries

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 CO₂ 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 or MINERGIE-P-ECO weights pollution at only 4% or 5%, respectively.

While BREEAM, and to a lesser extent LEED, have been widely used as the basis for EBRs 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 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 be 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, 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 spreadsheet¹⁴) 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):¹⁵

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 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

¹⁴ Tools available for download at <http://greenbuilding.ca/download/sbc2008/SBTool/>

¹⁵ <http://www.iisbe.org/>

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 - _____ [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 Tredal (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 at http://www.ens.dk/graphics/Publikationer/Laws/actsav.html#IndexMark2_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
38. Swiss Standards:
www.minergie.ch about MINERGIE, MINERGIE-P and ECO
www.sia.ch about Swiss building regulations

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
Tenant 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 <i>Green Guide to Specs.</i>	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 Sourced	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 Innovation	1.2	--
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 1: MINERGIE-P-ECO ASSESSMENT CRITERIA

As mentioned before there is a certain weighting of criteria but since the demands have to be fully met one could not appoint certain percentages to single aspects.

Category/Requirement	Percentage Score
1 Management	0
2 Health and Wellbeing	30
Adequately Day lit	
Illuminance Levels	
Independent Lighting Control	
Air Intake	
Thermal Comfort	
Local Temperature Control	
Legionella	
Internal Noise Levels	
Smoking	
Carbon Dioxide Control	
VOC and Formaldehyde Concentration	
Hazardous Materials	
Mould Prevention	
Radon	
Electromagnetic Pollution	
Function of De- and Humidification	
3 Energy	45
CO2 Emissions	
Heat Energy Demand	
Electricity for Lighting	
Lighting Zoning Control	
Energy Source	
4 Transport	0
5 Water	2
Water Consumption	
6 Materials	16
Recycled Building Materials	
Materials Responsibly Sourcesd	
PVC Minimisation	
Flooring	
Joinery	
Disassembly / Deconstruction	
Compactness	
Materialisation Façade / Structure	
Statics	
Weatherability Materials	

7 Land Use	2
Decontaminated Land	
Species Protection	
8 Pollution	5
Renewable Energy	
Pollution due to Production Process (additional regulations through national law)	
Total	100.0

ANNEX 8: CRITERIA CAPARISON BETWEEN SELECTED EBRs

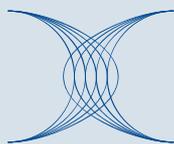
	BREEAM	LEED	Green Star	CASBEE	Green Mark	MINERGIE-P-ECO
Management	16	4	9	5	13	0
Health and Wellbeing	16	21	19	23	12	30
Energy	15	23	18	18	36	45
Transport	13	6	9	0	1	0
Water	5	10	12	3	18	2
Materials	11	18	19	12	6	16
Land Use	8	8	6	19	11	0
Pollution	15	10	7	20	4	5
Rating 1	25	38	10	--	50	
Rating 2	41	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
Tenant 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 <i>Green Guide to Specs.</i>	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



Attachment 5: Global Standards for Environmental Sustainability

Jennifer Zhu, June 2007
ANU Green/Yale Office of Sustainability

In 2000 the UN General Assembly adopted a set of goals placed at the heart of the global agenda. These eight Millennium Development Goals provide a framework for the UN system to work together towards a common end, with goal number seven devoted to environmental sustainability. Yale and Columbia Universities have developed two quantitative standards: the ESI to measure the ability of nations to protect the environment over the next several decades, and the EPI to determine current national environmental protection results. Drawing on the techniques employed by the two studies, a GCSS is aimed to be set for comparisons across the IARU universities, and the procedure leading up to such a global standard is discussed.

United Nations Millennium Development Goal # 7

To ensure environmental sustainability:

- Integrate the principles of sustainable development into country policies and programmes; reverse loss of environmental resources
- Reduce by half the proportion of people without sustainable access to safe drinking water
- Achieve significant improvement in lives of at least 100 million slum dwellers, by 2020

Environmental Sustainability Index

Why an ESI?

- Provides a composite profile of national environmental stewardship based on a compilation of 21 indicators that derive from 76 underlying data sets
- Identifies issues that deserve greater attention with societies and also those at the leading edge of policy
- Facilitates a mechanism for making environmental management more quantitative, empirically grounded and systematic

- Commitment to environmental indicators and greater emphasis on statistical analysis can strengthen environmental problem solving at the local level, the national policy level, and to the global level

Key Findings and Implications

Highly developed countries endowed with natural resources, strong economies and low population densities ranked at the top, and countries with serious environmental stresses, poor policy responses and social challenges are at the bottom.

The ESI ranking provides a relative gauge of environmental stewardship. The index has provided a useful tool to search for role models and best practices, where lagging countries could look towards the leaders and adopt their policy instruments, technologies and approaches.

Environmental Performance Index

Why an EPI?

- Focus on current environmental performance within the context of sustainability and narrowly tracks results for a core set of environmental issues
- Provides a data analysis tool for classifying issues, trends and policy options globally
- Quantitative indicators that permit cross-country comparisons that further the potential for evaluating results, benchmarking performance, and clarifying what can be achieved in particular circumstances
- Useful for assessment of the effectiveness of governmental policies relating to the environment against relevant performance goals

Key Findings and Implications

Countries that had developed economies with high capacity for sophisticated environmental protection and heavy investment in protecting the environmental health of their citizens ranked at the top, and densely populated industrializing countries with under-investment in environmental infrastructure and lack of capacity for aggressive pollution control or systematic natural resource management ranked lowest.

The EPI results provide information for the analysis of national scale environmental performance. A graphical analysis of the scores across the indicators portrays the distribution and extent to which countries have or have not achieved the ideal target, and this examination gives insights into the nature of global policy challenges from the perspective of environmental sustainability.

Comparison of the ESI and EPI

	ESI (2005)	EPI (2006)
focus	broad set of factors affecting sustainability encompassing the environmental past, present, and future	narrow areas across a core set of environmental issues for which all governments are being held accountable
variables used	76 variables > 21 indicators > 5 components > ESI score	16 indicators > 6 components > EPI score
statistical calculation methods used	country selection > standardisation > transformation > imputation > winsorisation > ESI	country selection > conversion to proximity to target measure > winsorisation > EPI
measuring country performance	comparisons between countries, providing a relative measure of environmental performance	absolute target established by international agreements, national standards, or scientific consensus
treatment of missing data	Markov Chain Monte Carlo simulation model technique	countries with insufficient data were omitted (few exceptions)
weighting	equal weighting of indicators	PCA weighting of indicators
correlation of index with other factors	economic development, economic performance, GDP, growth competitiveness, central role of governance	GDP per capita, environmental governance, human development, global competitiveness, ecosystem vitality
peer group and cluster analysis classification	population density, environmental stress, land area, human vulnerability, global stewardship	level of development, regional groupings, climatic circumstances, demographic structures
limitations	difficulties persist with the quality and completeness of the data and methodological issues	usefulness is limited by data problems, methodological questions and inherent uncertainties
conclusions	cannot determine the precise position of a country, but can clearly identify the leaders and laggards	indicates each country's performance in response to the challenges of environmental protection

IARU Campus Sustainability

Towards a Global Campus Sustainability Standard

In a world that is shrinking all the time, the issue of long term sustainability for higher education and research institutions around the world is becoming an increasingly important one.

Collaboration and sharing of information gathered by the International Alliance of Research Universities (IARU) forms an integral part of addressing this issue. A numerical value is useful for gauging the performance of a particular campus, but the focus for determining a Global Campus Sustainability Standard (GCSS) is not on ranking but rather capacity and potential for improvement.

While metrics and figures are useful tools for decision making in the context of sustainability, one major challenge is that each university collects and integrates campus data differently, and the methods used for data monitoring and reporting vary from country to country. For similar reasons to the development of the ESI and EPI, the establishment of a GCSS for comparing the metric data and analyses of universities in the IARU can initiate a solution to this problem.

Qualitative Survey

Before diving straight into the numbers, it is perhaps a good idea to understand where each university stands in terms of policies, inventories, plans, and finances in the context of sustainability. A series of questions can identify some common ground for comparison

- Administration
 - Policies on environmental stewardship and campus emissions
 - Established sustainability organizations and governance
- Inventory Analysis
 - GHG calculations
 - CO2 emissions
- Plans
 - Past strategy implementation
 - Future goals and targets
- Financial Aspects
 - Estimated costs
 - Funding

This survey can take on the form of a questionnaire requiring detailed responses, and should be included in the final sustainability report.

Data Collection and Metrics

Because the concept of environmental sustainability is fundamentally multi-dimensional, a broad definition of the term that is agreed upon by general consensus is useful to determine the scope of data relevant to sustainability/environmental performance that is collected by each university, as well as the method employed to obtain metrics. A balance needs to be struck between an

exhaustive array of indicators and enough indicators to tell a cohesive and whole, yet clear and concise, story. The main factors in a university context include

- Energy
 - Power from renewable sources
 - Power from non-renewable sources
- Transport
 - Air travel
 - University fleet
 - Private vehicle commute
 - Public transport commute
 - Bike/walk commute
- Waste
 - Waste to landfill
 - Recycled waste
- Consumption
 - Material
 - Organic food
 - Inorganic food
 - Water

To facilitate these measurements towards an indicator value so that they are comparable across campuses that differ in size, population and other factors, the raw data needs to be normalized to eliminate certain unavoidable trends. This can be achieved by identification of an appropriate relative ratio (%) or denominator (per square m, per capita).

This information could be provided from areas including

- teaching
- research
- residential
- construction
- commercial
- administration

An alternative set of sustainability indicators, developed by Yale to measure its progress towards sustainability, is presented below. It may be possible to analyse some of these qualitatively.

Use of Natural Resources

- Water
 - Water Consumption
 - Waste Water Reuse
 - Water Discharge Quality
- Land
 - Certified Sustainably Managed Forests
 - Protected Land

- Air
 - GHG Emissions
 - NOx Emissions
 - SOx Emissions
 - Particulate Emissions
- Energy
 - Energy Consumption
 - Renewable Energy Use
- Food
 - Total Waste Food Composted
 - Local and/or Organic Food Purchased

Systems and Processes

- Integrated Waste Management
 - Total Waste Production
 - Recycling
 - Hazardous Waste Production
 - Radioactive Waste Production
- Procurement
 - Appliance Energy Efficiency
 - Recycled Paper Purchasing
 - Chlorine-Free Paper Purchasing
- Landscape
 - Inorganic Fertilizer Use
 - Impervious Surface Area
 - Pesticide Use
- Transportation
 - Commuting Distance
 - Car Dependence
 - Average Fuel Efficiency of University Fleet
- Building Design & Construction
 - Deferred Maintenance Ratio (Facilities Condition Index)
 - Building Space
 - LEED Certified Buildings

Sustainability within Culture

- Health
 - Total Lost Workdays/Total Hours of sick leave
 - Workplace Injuries Reported per Capita
 - Indoor Air Quality

- Education
 - Sustainable Development Literacy
 - Students participating in sustainability curriculum
 - Courses addressing sustainability
- Research
 - Total Research Awards
 - Research Collaboration
 - Sustainability Research Funding
- Finance
 - Total University Income
 - Financial Aid Awarded
 - Ethically and Environmentally Sound Investments
- Labor
 - Average years of education of workforce
 - Workforce Equality
 - Job Descriptions incorporating Sustainability
- Community
 - Reported Campus Crime
 - Student Gender Equality
 - Graduation/Retention Rate

While this list provides a detailed profile of the university, it can perhaps include too much information resulting in a lack of clarity and increased computational complexity, as well as limiting the capacity for comparison across campuses in various countries.

Methodology for a Numerical GCSS Index

Because the focus of the GCSS is on improvement rather than ranking, a measurement of performance against an absolute target established by international consensus will be more relevant for this purpose. This is the approach adopted by the EPI study, and seems to have quite clearly identified strengths and weaknesses in countries' environmental policy and management on a national level. The challenge in this comparison across campuses is for the IARU is to agree on a quantitative set of global targets that will be the reference for a proximity-to-target measurement of relevant factors.

Weighting is a standard method to adjust for unequal levels of certainty, there are many statistical methods to determine weights, and generally there exists no unique set. The ESI computation used equal weights based on the premise that no objective mechanism exists to determine the relative importance of the different aspects of environmental sustainability on a global level, and this is arguably the most transparent and intuitive method to calculate a multi-faceted numerical index for comparison.

When it comes to treatment of missing data, there are two standard options, the ESI approach was to fill the gaps with plausible estimates from a simulation method, while the EPI imposed stringent data requirements such that countries with significant data gaps were not included. Both methods

have advantages and disadvantages, but for assessing university campuses, it would perhaps be best to choose the indicators from the common collected metrics based on having a significant proportion of complete data. This ensures missing data is minimized and logically takes care of the determination of the relevant indicators to calculate a numerical index.

Possible Drivers and Comparative Analysis

Perhaps other information that is just as important as the GCSS itself are the factors that cause and drive sustainability. Both the ESI and EPI were measured against other factors, and several correlations were found, giving an indication of possible determinants of environmental policy success. On one hand additional data collection could consume large amounts of time and effort, but on the other hand, conducting such bivariate data analyses may yield interesting and relevant results.

To provide a relevant context for judging performances between university campuses, it is logical to form groups that have similar underlying characteristics. Both the ESI and EPI carried out cluster analyses, which grouped countries by the identification of statistically related groups based on similarity of indicator scores. This allowed countries to look for models of environmental success in countries facing similar challenges, and also encouraged political competition between counties within a peer group. It is perhaps not so relevant to conduct cluster analysis for the 10 universities in the IARU, but with inclusion of more campuses world wide, this could become a worthwhile option.

Sustainability Reporting

Defining, measuring, and rigorously reporting on economic, environmental, and social issues of an institution provides good global stewardship and accountability, especially in the context of sustainability. Important principles include

- **Reliability:** transparent disclosure of the procedures and assumptions in report preparation to establish validity of information
- **Clarity:** presentation of information in a manner that is understandable by a maximum number of users while still maintaining a suitable level of detail
- **Balance:** avoid bias in selection and presentation of information and provide a neutral assessment of overall performance
- **Comparability:** framed to a global standard so as to facilitate comparison to earlier reports as well as to reports of comparable institutions
- **Accuracy:** sufficiently detailed information that is able to be reproduced with the minimum amount of uncertainty
- **Ongoing Monitoring:** provide information on a regular schedule that meets user needs and comports with the nature of the information itself

Information relevant to the GCSS from the Sustainability Reporting Guidelines recommends the following structure of a sustainability report

1. **Strategy and Analysis:** a statement from the senior decision maker and discussion of the reporting institution's key impacts, risks and opportunities
2. **Organisational Profile and Governance:** an description of the institution's structure, policies, management systems, and stakeholder engagement efforts
3. **Report Structure:** overview of report profile, parameters, scope, boundary and measurement procedures as well as the limitations
4. **Performance Indicators:** measures of performance of the reporting institution by numerical indicators and their uncertainties and sensitivity analysis
5. **Summary of Main Findings:** a description of the obtained results with possible explanations of causes concluding with an evaluation and future implications

This reporting standard, if adopted by all institutions, will enable ease of cross institutional comparison and analysis.

Implications of the GCSS

The establishment of a GCSS, developed from the models of the ESI and EPI which are methods designed to compare global environmental/sustainability performances, will enable the different universities of the IARU across the globe to be compared in a meaningful and valid way in the context of campus sustainability. The completion of a qualitative survey and the conduction of a quantitative analysis for each campus will give two sets of results that compliment each other.

The GCSS analysis that encompasses the many aspects of sustainability for the campuses would need to be conducted on a yearly basis to provide the most current information and facilitate progress reporting. Keeping the method as clear and simple as possible will aid this process. In addition, accurate and reliable data collected over a number of years can lead to information about rates and progress, as well as predicted trends into the short and long term future of the universities involved.

The value of the GCSS is not necessarily in overall rankings but from careful analysis of the underlying data and indicators. As mentioned earlier, the focus is on cooperation for improvement, and the benefit of the data can indicate which institution is a leader in what area, highlight good and bad policy practices and identify priorities for action. The results can provide a useful tool for evaluating implemented environmental strategies as well as improving policies.

Constant monitoring and reporting of metrics as well as refinement of the computational methodology itself is essential for the GCSS to succeed. As more data becomes available, as more universities decided to partake in such a comparison, and as more appropriate techniques to quantify sustainability achievements develop, the GCSS can only become more of a key player on the international stage of campus sustainability.

References

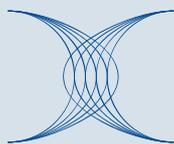
United Nations (2005). “UN Millenium Development Goals”. <<http://www.un.org/millenniumgoals/#>>

Esty, Daniel C., Marc Levy, Tanja Srebotnjak, Alexander de Sherbinin (2005). 2005 “Environmental Sustainability Index: Benchmarking National Environmental Stewardship”. New Haven, Conn.: Yale Center for Environmental Law and Policy.

Esty, Daniel C., Marc A. Levy, Tanja Srebotnjak, Alexander de Sherbinin, Christine H. Kim, and Bridget Anderson (2006). “Pilot 2006 Environmental Performance Index”. New Haven: Yale Center for Environmental Law & Policy.

Global Reporting Initiative (2006). “Sustainability Reporting Guidelines: Version 3”. Amsterdam.

Various emails between staff from the universities in the IARU



Attachment 6: Standardising Greenhouse Calculators

Jennifer Zhu, June 2007
ANU Green/Yale Office of Sustainability

For the institutions in the International Alliance of Research Universities (IARU), the key goal is to become leaders in addressing global challenges. The issue of long term campus sustainability is at the heart of the challenge, and an essential aspect towards achieving this is the compilation of data that quantifies the amounts and sources of emissions of greenhouse gases attributable to the existence and operations of the institutions. Conducting a greenhouse gas (GHG) emissions inventory is the first and crucial step for effective management and mitigation options.

The Need for an Inventory Standard

The quickest and most efficient way of calculating a GHG inventory is using one of the many online emissions calculators. However, when comparing results for institutions around the world, the computation method for deriving the emissions is primarily dependent upon the characteristics of the country's, and sometimes the local region's, energy supply. The output metrics of weight of emitted carbon dioxide equivalent (eCO₂) can also vary from country to country. When it comes down to comparing between universities in the IARU, two factors need to be accounted for

- *The unit in which the metric for the emissions is stated:* setting a standard for SI units of kilograms eCO₂ will enable valid cross campus comparisons, and this can be achieved by a simple numerical conversion.
- *The way the metric for the emissions is calculated:* this is later analysed in detail for a few greenhouse calculators. Some points to note
 - there are many calculators available on the internet, however only those that detailed the conversion factors and their sources were examined
 - the emitted carbon coefficients are usually obtained from a nationally standard value, sometimes region-specific, and are constantly being updated
 - the calculators are predominantly for the counties of US, UK and Australia, calculators in other countries were very hard to find, and only the most relevant one from each country was investigated

Principles and Scope of GHG Emissions Reporting

The World Business Council for Sustainable Development and the World Resource Institute (WBCSD/WRI) jointly established a set of accounting standards. GHG accounting and reporting should be based upon the principles

- *Relevance*: define boundaries that reflect decision making needs of all stakeholders
- *Completeness*: account for all sources within chosen organizational and operational boundaries
- *Consistency*: allow meaningful comparison of performance over time and within other contexts
- *Transparency*: disclosure of assumptions and clear references to computational methodology
- *Accuracy*: address all relevant issues with precision to ensure validity and reliability

The scope of the reporting for an institutional context is comprised of three categories

- Direct sources of GHG owned and/or controlled by the institution
- Indirect GHG emissions associated with generation of imported sources of energy
- All other indirect sources of GHG emissions resulting from institution activities and community members

These categories can be further subdivided to cover the entire scope for data collection and entry. Clean Air – Cool Planet utilises the following sections designed specifically for a campus inventory

- Energy
 - Purchased electricity
 - Purchased steam/hot water
 - On campus cogeneration
 - On campus stationary energy use
- Transportation
 - University Fleet
 - Air travel
 - Student, faculty and staff commuting
- Agriculture
 - Fertiliser
 - Animals
- Solid Waste
 - Incineration
 - Landfill
- Refrigeration and other Chemicals
 - All other GHGs
- Offsets
 - Actions taken to offset emissions

In addition to emission source data, institution data including demography, budget and physical size, is also important to include in the analysis for distributions of emissions among the various sources. This allows scaling for a meaningful global comparison. Data needs to be collected on a yearly basis to examine trends and projections, and to provide a context for the effects and impacts over time.

Global Standards: Greenhouse Gases (GHGs), Carbon Dioxide Equivalents (eCO₂) and Global Warming Potential (GWP)

The gases that should be included in a GHG emissions inventory are those that are GHGs and these have been specified by the Kyoto Protocol to the UN Framework Convention on Climate Change

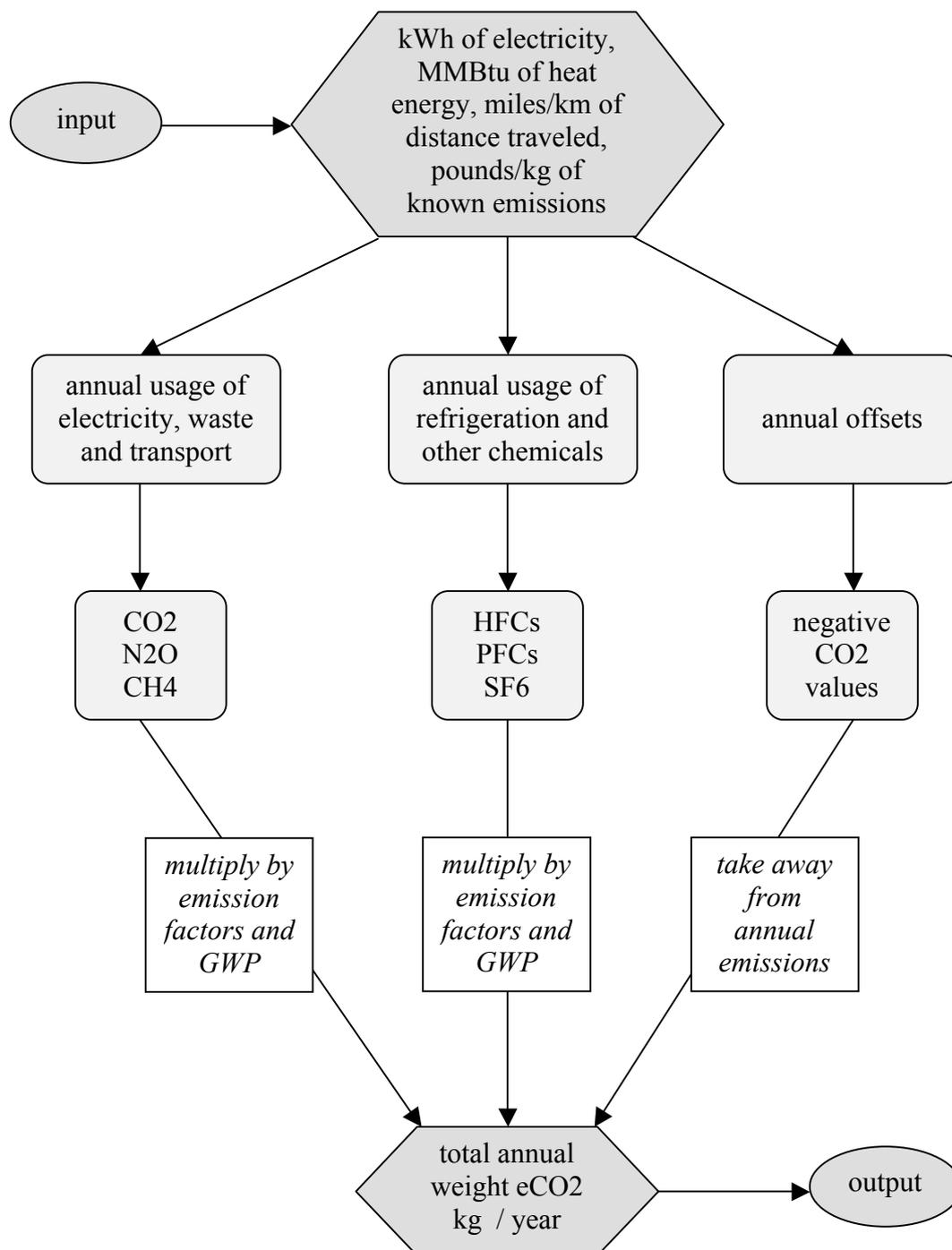
- Carbon dioxide (CO₂)
- Methane (CH₄)
- Nitrous oxide (N₂O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF₆)

The International Emissions Trading Association (IETA) has provided a universal standard of measurement against which the impact of releasing different GHGs can be evaluated. The units are yearly carbon dioxide equivalents (eCO₂), and the figure is given in terms of weight which can be standardised to the SI unit of kg per annum.

Every GHG has a Global Warming Potential (GWP) specified by the Intergovernmental Panel on Climate Change (IPCC) which describes the effect of the particular gas on climate change relative to an equivalent amount of CO₂ calculated over a specific time interval.

Variations in Computation Methodology

The eCO₂ is found through applying a standard series of calculations to generate a value that represents the annual weight of eCO₂ released into the atmosphere. There are many online calculators, and the variations in emission factors are examined.



US: Clean Air – Cool Planet

This carbon calculator is specifically designed for the constitution of an inventory of greenhouse gases emitted by a university campus, and hence is very relevant to the institutions in the IARU. Its main objective is to provide a very useful, if not vital, foundation for a discussion on the issue of climate change and methods of management and mitigation.

The calculator is a Microsoft Excel spreadsheet that consists of three steps: collection of data, calculating GHG emissions and analysing/summarising the results. It includes the GHG specified by the Kyoto Protocol and covers a range of time from 1990-2020, producing charts and graphs for presentation. The spreadsheets are based on workbooks provided by the Intergovernmental Panel on Climate Change (IPCC) with a few modifications for campus specific analysis.

This calculator can seem quite complex, with multiple worksheets, formulae and cell references. However, all that is required of the user is to enter in collected data, with the rigorous maths and science behind the calculations being already set up. Conversion factors and relevant formulae are built into the calculator so the output is automatically calculated. In addition to the resulting numerical values, it will generate graphs and charts to create an emissions profile.

The emissions factors used in this calculator were obtained from the US Environmental Protection Agency, the US Department of Energy and the US Department of Transportation, with the published data ranging from 2002 through to 2006. This can be adjusted in the data entry worksheet for different states in the country.

Australia: Australian Greenhouse Office

There does not seem to be a GHG emissions calculator specifically designed for a university campus, many focus on household and personal emissions. Upon request from the Australian Greenhouse Office (AGO), an emissions calculator was supplied from the “Greenhouse Challenge Plus” members section.

The input information includes energy fuels and processes, petroleum products transport, waste synthetic gases, fugitive emissions and offsets. This covers the main aspects of a university campus. The input format is straightforward, data entry is in consumption units which are converted to basic units and multiplied by the emission factor to obtain eCO₂ per annum. Compared to the Clean Air – Cool Planet calculator, this one is simpler to use, however it is not as detailed, does not produce charts and has no temporal component.

The emission factors are updated in line with the AGO publication “Factors and Methods Workbook: for use in Australian greenhouse emissions reporting”, with the latest edition published in 2005. The emission factors can be adjusted for each state in the country.

There are also many other technical tools available from the AGO for members which may be useful in terms of evaluating campus sustainability, however this is not available world wide.

UK: Carbon Calculator

There do not seem to be many online GHG emissions calculators for the UK, and none were designed specifically for university campuses. A personal emissions calculator was found at Warwick University’s Carbon Footprint Group website.

The four main categories of input information were travel, heating, electricity and shopping, which is perhaps not an ideal spread of variables for a university campus. The site explains in detail how the emissions are calculated, but does not specify where the conversion factors are obtained from or the date of publication for those factors.

On-Campus Electricity Generation: Yale University

Yale collects yearly metrics regarding campus energy usage, and calculates the GHG emissions in metric tons carbon equivalent (MTCE). This includes emissions from the two Yale cogeneration powerplants and purchased electricity, which make up the majority of the emissions, and does not include transportation, carbon sinks and other emissions.

The coefficients used in the calculation of emissions from the powerplants are values calibrated with the boilers by the facilities systems engineers at Yale. The coefficient for calculating the emissions from the purchased electricity is the accepted value for the Yale local region.

The powerplant emissions coefficients are particular for Yale, and provide an example of factors calculated specifically for the relevant university. Other universities with generators on campus should be following a similar methodology for their inventories, ideally also including the coefficients associated with transportation, carbon sinks and other emissions.

Other Countries: World Resources Institute SafeClimate Carbon Footprint Calculator

An effort was made to find GHG emissions calculators for other countries, however this proved to be a difficult task. Online calculators were few and far between, and language was sometimes a problem.

One calculator that was applicable to emissions from various countries was from the World Resources Institute, which determines eCO₂ emissions from energy consumption and transport by car and plane. Because the focus is on household emissions, the scope is not one that encompasses all aspects of a university campus's emissions, but does cover the two major GHG sources. The data input is straightforward and easy to enter online, though not always applicable.

The coefficients used in the computation were from the World Business Council for Sustainable Development GHG protocol initiative calculation tools. For the US and Canada regions, the province or state could be chosen, while the factors for other countries worldwide are from the International Energy Agency, the latest figures from 2004.

The advantages for this calculator are its simplicity and global application, but there are issues with the relevance and accuracy of international coefficient data. The value in this particular calculator would be to gain an overall estimate in GHG emissions for energy and transport for each campus, however the details of each university's inventory cannot be taken into account.

Unfamiliarity with the governmental or other organisations meant emissions factors for each of the countries was hard to find. It is recommended that each of the universities in the IARU supply their respective GHG emissions calculators and/or emissions coefficients. In particular, campuses with onsite power generators will need to specify the calibrated coefficients for those energy sources.

For complete international consistency, it may be possible to modify an existing calculator for calculations of different countries. Clean Air – Cool Planet appears to be the most effective calculator that strikes a balance between data scope, user-friendliness and computation complexity. It will also allow an experienced and proficient user to change certain aspects of the spreadsheet, and with coefficients for the countries supplied by each university, a global calculator that encompasses all the relevant countries could be constructed.

Implications for the IARU

The establishment of a global standard to compare GHG emissions will enable the universities in the IARU to meaningfully compare their individual impacts on the environment. While data collection and calculation can be time consuming, the results of an absolute as well as comparative analysis can be very interesting. With the inventory metrics, each institution can evaluate the effectiveness of current practices and facilitate the management and implementation of policies to improve campus sustainability.

In order for comparison across universities in the IARU that differ in size, population and other factors, the resulting metric for kg of eCO₂ emitted per annum for each campus needs to be normalized to eliminate certain unavoidable trends. This can be achieved by identification of an appropriate relative ratio (%) or denominator (per square m, per capita). It may also be the case that universities are missing data, and this will need to be specified clearly and efforts made to gather the relevant data for future inventories.

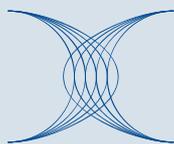
The analysis between universities with emissions inventory metrics is not necessarily just a summed figure for kg of eCO₂ per annum. Breaking down the eCO₂ emissions for different sections mentioned above and comparing campuses within those categories is also important in identifying where the most and least emissions are coming from and factoring the relative amounts into campus planning and development.

The GHG inventory is also a key indicator of an institution's environmental/sustainability performance. The raw numerical values as well as the scaled figures obtained from the inventory can be used for the calculation of a Global Campus Sustainability Standard (GCSS) index, which aims to assess the institution's capacity and potential for improvement.

Furthermore, the information gathered from the GHG inventory is not just solely confined to the universities themselves. Relative assessments for GHG emissions can also be made for the particular institution with other infrastructure within its region. Emissions coefficients vary across the globe, and examination of this conversion factor data can lead to conclusions being made about the nature of the country's electricity industry, environmental consequences of citizen habits and the cultural attitude towards sustainable behaviour. A multitude of information from global inventory analyses is the result.

References

- World Business Council for Sustainable Development (2001). "The Greenhouse Gas Protocol: a corporate accounting and reporting standard".
- United Nations (1998). "Kyoto Protocol to the United Nations Framework Convention on Climate Change"
- International Emissions Trading Association (2007). "What are Carbon Dioxide Equivalents (CO₂ eq)?" <<http://www.ieta.org/ieta/www/pages/index.php?IdSitePage=123>>
- Intergovernmental Panel on Climate Change (1996). "Climate Change 1995: The Science of Climate Change"
- Clean Air – Cool Planet (2006). "Campus Carbon Calculator v5.0" [Microsoft Excel Spreadsheet] Downloaded from <<http://www.cleanair-coolplanet.org/toolkit/content/view/43/124/>> and "Campus Carbon Calculator: User's Guide".
- Australian Greenhouse Office. (2006). "Emissions Calculator" [Microsoft Excel Spreadsheet] Downloaded from <<http://www.greenhouse.gov.au/challenge/members/emissions.html>> and "AGO Factors and Methods Workbook: For use in Australian greenhouse emissions reporting".
- Warwick University Carbon Footprint Project Group (2005). "Carbon Calculator" [on-line] <<http://www.carboncalculator.co.uk/index.php>>
- World Resources Institute (2001). "Calculator" [on-line] <<http://www.safeclimate.net/calculator/>> and World Business Council for Sustainable Development. (2007). "GHG Protocol Initiative: Calculator Tools" from <<http://www.ghgprotocol.org/templates/GHG5/layout.asp?type=p&MenuId=OTax>>
- Yale Facilities Systems Engineering Group and various emails between staff from the universities in the IARU



SC5. Integrating Education and Campus Management in the Context of Campus Sustainability

The following paper briefly outlines an integrative model of sustainability for the higher sector before presenting a case study of the ‘Integrating Sustainability Project’ at the ANU; it focuses in particular on the benefits of linking curriculum with campus sustainability initiatives.

There are four areas in which universities can contribute to a more sustainable future, these include: research for sustainability, education for sustainability, sustainable campus operations and community outreach. As noted by Tilbury *et al* (2005:1)¹ in order for higher education institutions to more deeply address sustainability “there is a need to link campus management to research, curriculum and administration practice such that sustainability is embedded across every aspect of institutional operations in a synergistic way”. Common ways that these synergies can be exploited relatively easily include:

- ***Encouraging student involvement in campus sustainability projects through their course work/ research.*** This benefits students and staff in a number of ways. For example, Sustainability Program Managers can get very high quality input into various elements of a university’s environmental program, and students benefit from working on a ‘real life’ project that has the possibility of being implemented within their university. Aside from the professional development opportunities this provides, this process also develops the capacity of students to act as change agents with regards to sustainability and further develops their connection and commitment to their university, as a place that values their research and input.
- ***Linking research to sustainable campus operations.*** Most universities carry out research that can directly contribute to the enhancement of sustainability programs. In some cases linkages with industry can be developed that will provide funding opportunities. For example the ANU has recently implemented a comprehensive food waste composting project using a large in-vessel composting unit. Alongside this, the ANU is presently developing a research grant proposal to investigate how microbial communities can be exploited to further refine the composting process. Researchers at the ANU will use the in-vessel composting machine to carry out experiments on these microbial communities. This research is of great interest to the composting industry and can potentially provide significant research funding for the ANU.

1 Tilbury *et al* (2005) *A National Review of Environmental Education and its Contribution to Sustainability in Australian Further and Higher Education*. Canberra: Australian Government Department of Environment and Heritage and Australian Research Institute in Education for Sustainability

- **Linking sustainability campus operations with the broader community.** Universities are particularly well placed to develop partnerships with local community groups and governments who are themselves tackling sustainability issues; this helps reinforce the leadership role of the university as well as acting as a conduit through which the research of the university can be operationalised.

Case Study – ANU ‘Integrating Sustainability Project’

The Integrating Sustainability Project was formed in 2007 with the aim of fostering interest in Education for Sustainability throughout the disciplines with a particular focus on linking curriculum to campus sustainability initiatives. The Integrating Sustainability Project is the result of collaboration between the *Fenner School of Environment and Society* and the university’s corporate environmental management division, *ANUgreen*.

The Integrating Sustainability Project is designed to assist the ANU in training its graduates to make connections between the environmental, economic and social dimensions of their current studies and future professions. To that end, the project has two main goals:

- Foster integration of education for sustainability across the ANU curriculum by:
 - Providing professional development opportunities for lecturers interested in weaving the concepts of sustainability into their courses, and;
 - Conducting an audit of sustainability-specific curriculum content currently offered at the ANU.
- Expand opportunities for students to engage in practical sustainability related initiatives on campus by:
 - Promoting experiential learning through research-led teaching, learning communities and project based learning; and;
 - Linking curriculum to campus operations and offering opportunities for hands-on campus projects to be included in the assessment of selected courses.

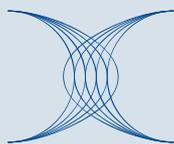
The project seeks to develop an integrative and holistic approach to sustainability initiatives at the ANU by adopting a “whole-of-university” approach. This approach explicitly links research, educational, operational and outreach activities and engages students in each of these aspects rather than confining their education solely to the classroom. The project will address the relationship of the campus, community and curriculum by offering more students the opportunity to engage in practically oriented sustainability related initiatives on campus. The ANU sustainability office, *ANUgreen*, is a national leader in operational sustainability with significant achievements being realised in water reuse, energy efficiency, recycling and biodiversity conservation. Campus management and operations can play a significant role in teaching students about the importance of sustainability and its practical applications. This very successful collaboration has had far reaching effects at the ANU including raising the profile of university sustainability initiatives, providing solutions to sustainability problems, building trust between students, managers and academics and providing meaningful learning experiences for students.

As a result of this project, in second semester 2007 over 200 students from numerous courses around the ANU including Greenhouse Science, Economic Modelling, Management for Sustainability and Human Ecology are conducting research into various aspects of the ANU's Sustainability Program from a number of disciplinary perspectives. Projects include: greenhouse gas abatement policy, economic analysis of greenhouse abatement, environmental and economic issues relating to carbon sequestration, abating air miles etc. These projects will contribute towards the development of a comprehensive and effective greenhouse abatement policy for the ANU.

Dr David Carpenter

Integrating Sustainability Project

ANUgreen and Fenner School of Environment and Society, ANU



SC6. Interns for Sustainable Campuses – Proposed Exchange Program

Proposal to further develop an IARU Student Exchange for Sustainability (SES) program

The IARU encourages student exchange between partner universities in a number of fields. The ANU and Yale have recently conducted a small student exchange program that involved 2 students from each university working in the Sustainability Offices of the partner university for 4-6 weeks on issues as far ranging as: greenhouse gas abatement, sustainability metrics, green building design and the web-based marketing of sustainability programs. This exchange program has proved very beneficial for a number of reasons, for example, the program:

- provided students with an excellent, skill-based learning experience that enhances their employment opportunities in the sustainability field;
- further strengthens the working relationship between sustainability offices' in partner universities;
- facilitates the exchange of ideas about sustainable campus management between partner universities;
- provides the universities in question with skilled students whose knowledge about campus sustainability issues can contribute to the enhancement of campus sustainability programs; these students can also act as mentors for other students involved in campus sustainability projects.

At the ANU, in particular, these internships were very competitive and were only awarded to students who were the most academically qualified, and who could make a significant contribution back to the ANU upon their return from Yale. It would be envisaged that these internships could develop into highly competitive prestigious scholarships for students with an interest in sustainability issues.

Aside from the benefits indicated above, extending this program to include all IARU partners would have the added benefit of contributing to the harmonisation of sustainability initiatives between partner universities, as students could work on IARU-based sustainability initiatives in partner universities.

