GO GREEN

Sustainable buildings

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Additional information including the full list of contributory organizations can be found at: www.itu.int/ITU-T/climatechange/ess/index.html

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Sustainable buildings

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Executive summary

In most countries, buildings are the largest driver for both energy use and CO_2 emissions. Europe's buildings use over 40% the continent's energy and are responsible for 40% of its carbon emissions. In the US, the corresponding figures are even larger, with buildings accounting for 48% of total US GHG emissions.

Among developing countries, the share of buildings in total energy use and emissions is much lower, with China's buildings, for example, representing a 10% share of that nation's energy use. But rapid economic growth and industrialization in these countries is pushing a booming construction sector. As a result, by 2030, Asian countries are expected to contribute a third of worldwide GHG emissions. Consequently, the challenge to reduce the energy and GHG footprints of new and existing buildings is a very serious one.

ICT companies build and operate facilities that can demand large amounts of energy and material use in all phases of the life cycle. Managing their environmental impacts on their buildings results in economic benefits and helps them meet their societal obligations.

Applying sustainability management to buildings requires work under three main headings: construction, lifetime use and decommissioning. Throughout these stages, the three-fold objective is to be efficient in the use of resources, protective of the occupants' health and well-being, and reducing the negative impacts, such as waste and pollution.

There are a number of standards, methodologies and tools that have been put in place to assist organizations in delivering excellent environmental performance with regard to their building stock. The document discusses alternative offerings such as LEED, Green Globes, Green Building (Europe), BREEAM, the International Green Construction Code, the German Sustainable Building Council, the Green Building Council of Australia, Estidama from the UAE, and CASBEE from Japan. Apart from design and construction, best practices are also discussed with regard to buildings operation and maintenance, and improvements.

While good design can reduce energy bills by 25%, the initial capital costs may not be the lowest. In order to deal with a narrow economic outlook, some designers and owners have started using life cycle assessment as a scientific evaluation of actual performance, rather than simply buying into certain prescribed practices.

The toolkit

This document on Sustainable buildings is part of a set of documents that together form the Toolkit on environmental sustainability for the ICT sector. The toolkit is the result of an ITU-T initiative, carried out together with over fifty partners, which provides detailed support on how ICT companies can build sustainability into the operations and management of their organizations. The documents in the toolkit cover the following:

- Introduction to the toolkit
- *Sustainable ICT in corporate organizations*, focusing on the main sustainability issues that companies face in using ICT products and services in their own organizations across four main ICT areas: data centers, desktop infrastructure, broadcasting services and telecommunications networks.
- *Sustainable products*, where the aim is to build sustainable products through the use of environmentally-conscious design principles and practices, covering development and manufacture, through to end-of-life treatment..
- *Sustainable buildings*, which focuses on the application of sustainability management to buildings through the stages of construction, lifetime use and de-commissioning, as ICT companies build and operate facilities that can demand large amounts of energy and material use in all phases of the life cycle.
- *End-of-life management*, covering the various EOL stages (and their accompanying legislation) and provides support in creating a framework for environmentally-sound management of EOL ICT equipment.
- *General specifications and key performance indicators*, with a focus on the matching environmental KPIs to an organization's specific business strategy targets, and the construction of standardized processes to make sure the KPI data is as useful as possible to management.
- *Assessment framework for environmental impacts*, explores how the various standards and guidelines can be mapped so that an organization can create a sustainability framework that is relevant to their own business objectives and desired sustainability performance.

Each document features a discussion of the topic, including standards, guidelines and methodologies that are available, and a check list that assists the sustainability practitioner make sure they are not missing out anything important.

1 Introduction

In most countries, buildings are the largest driver for both energy use and CO_2 emissions. The approximately 160 million buildings of the EU, for example, are estimated to use over 40% of Europe's energy and to drive over 40% of its carbon dioxide emissions. According to the US Energy Information Administration, the share of energy and greenhouse gas (GHG) emissions associated with buildings is even larger in the US, amounting to 48% of total emissions.

In several developed countries, emissions from buildings, and their proportion on total emissions, have been steadily increasing over the last fifty years. Larger sized buildings and an increasing number of energy-using appliances within these buildings have been the main drivers for such growth.

In developing countries, on the other hand, the share of buildings on total energy use and emissions is much lower (e.g. in the order of 10% of the total in China). However, with rapid industrialization and urbanization, energy use and the GHG emissions associated with buildings are increasing rapidly in those developing countries where dramatic economic growth is associated with a booming construction sector. A significant number of new buildings are therefore added every year in many developing countries. In the 2000-2005 periods, for example, China added about 6.5 billion square meters of new residential buildings.

Projections for GHG emissions associated with buildings estimate that worldwide GHG emissions will reach about 15 billion CO_2 by 2030, with Asian countries contributing to about 1/3 of such emissions.

Reducing the energy and GHG footprint in both existing and new buildings represents therefore a key challenge and opportunity to tackle global warming.

ICT companies build and operate facilities that can demand large amounts of energy and material consumption in all phases of the life cycle. Increasing energy efficiency is always a key goal for ICT companies and it can begin with the facilities themselves. There are numerous schemes that have been adopted globally that can lead to more sustainable design, construction and operation of buildings.

Sustainable building refers to both the structure and a process that is more environmentally responsible during the entire life cycle of a building. These life cycle stages are:

- site selection;
- design;
- construction;
- operation and maintenance;
- renovation;
- demolition.

Looking at it more broadly, it could possibly be combined under three main headings:

1. Construction – site selection, design, construction
2. Lifetime use – operation and maintenance
3. Decommissioning – renovation and demolition.

New building technologies, and in particular ICT automation and new materials, are constantly being introduced to enhance the sustainable building process with the goal of reducing the impact of the building on the surrounding environment by:

- using resources more efficiently (e.g. energy, water);

- enhancing and protecting the health and well-being of the occupants;
- reducing negative impacts (e.g. waste, sewage, pollution).

Sustainable buildings optimize one or all of these objectives during all phases of the life cycle.

Sustainable or "green" building codes and assessment schemes have been developed on a global basis to give guidance on the factors to review during a building's life cycle that enhance sustainability and minimize environmental impact.

As an example, the Leadership in Energy and Environmental Design (LEED) standards have seen great adoption within the North American market in particular. LEED standards are guidelines to designing, building and operating more environmentally friendly buildings.

A final step in almost all sustainable or "green" building codes and schemes is an independent assessment to determine whether a building has met the requirements of a scheme and a final ranking that demonstrates how sustainable a building has been built or is being operated.

Using LEED as an example, a building can be rated as Platinum, Gold, Silver or Certified after an assessment.

To a large degree, decisions made at the budgeting, design, procurement and construction stages of a development affect the success of the building in terms of sustainability outcomes (Great Britain, Dept. of Health, 2011). Therefore, sustainability and its implications for planning and design should be considered at the onset of all new-builds, as the earlier it is considered the more the sustainability benefits are maximized. For example, the on-site layout and form of the building offer the best opportunities to improve environmental benefits without major capital costs. In addition, choices about heating and cooling, which contribute largely to energy use, are important considerations to meet carbon targets (Lockie and Bourke, 2009). Failure to take sustainability into account at the onset can result in costly alterations having to be made at a later stage and opportunities missed to include sustainable measures into the design and structure of the building.

1.1 Target audience

This document gives an overview of green building design and construction specifications according to a number of global standards. The section explores different areas of concern with regards to developing more environmentally friendly buildings.

Its content is appropriate for any company in the ICT sector that:

- designs and builds facilities, including data centers;
- operates and maintains facilities;
- is looking to add green procurement criteria to building and space procurement process.

There are many business benefits for deciding to pursue a strategy and process for sustainable buildings. These benefits can be:

- lower operating costs;
- higher return on investment;
- greater tenant attraction;
- enhanced marketability;
- productivity benefits;
- reduced liability and risk;

- a healthier place to live and work;
- demonstration of a commitment to corporate social responsibility;
- future proofed assets;
- competitive advantages.

2 Design and build specifications

2.1 Overview

Sustainable buildings are structures that are built in an environmentally responsible manner by maximizing use of materials, minimizing use of resources and ensuring the health and well-being of occupants and the surrounding built environment both today and for generations to come.

With respect to the LEED guidelines (and this is consistent with almost all other "green" building guidelines), there are seven topics that should be addressed in the designing and building of new environmentally friendly buildings.

1) **Sustainable sites**: Sites should be selected by determining which site would pose the least environmental threat if construction were to take place. Pollution prevention including controlling soil erosion, waterway sedimentation and airborne dust generation are important factors to be considered. Sites should also be chosen that are closer to urban development where supporting infrastructure is available; this will preserve green spaces and wildlife areas. The redevelopment of brownfields would be preferential as no new land is needed. Alternative transportation is another important factor to consider. The availability of public transport, bicycle parking and shower facilities can minimize the GHG emissions associated with travel to a building. Other factors that promote sustainability would be, for example, preferential parking for low-emission vehicles and/or hybrids. Biodiversity can be promoted by designing large amounts of open space in the new building complexes. Another factor are the water management systems that take into account the natural environment design for storm-water systems to ensure proper management of water. Reduction of the heat island effects from roofs and parking lots as well as the reduction of light pollution is another factor that should be taken into account to promote sustainability.

2) **Water efficiency**: The main goal is to increase water efficiency use within the building, thereby reducing the amount of water needed for operations. Some methods which can be designed in a building include water efficient landscaping to reduce irrigation requirements and the use of innovative wastewater management technologies.

3) **Energy and atmosphere**: Energy systems should be properly installed and calibrated to perform to their intended efficiency levels. This should reduce the overall energy use and lower operating costs. A minimum level of acceptable energy performance for the facility should be determined and monitored. A refrigerant management system to reduce refrigerant losses and resulting potential ozone depletion. Various methods for on-site renewable energy production can reduce the overall footprint of the building and other means of using green power. Methods to monitor, verify and continually improve on energy consumption are key to ensuring that energy performance is maintained. In the UK, it is estimated that construction is responsible for 50% of the emissions of greenhouse gases and 60% of that emission is attributable to space heating of buildings. Buildings also use energy in the heating of water, lighting, mechanical ventilation and machinery such as lifts

4) **Materials and resources**: The construction process is highly energy dependent, particularly through the manufacture and **transport** of materials. (Morton R., 2009). The amount of landfill waste created during construction and operation can be reduced by efficient use of materials and designing for recycling. Specifying used construction materials can reduce the need for virgin materials. Specifying materials that are locally sourced, that come from certified sustainable sources (e.g. Forest

Stewardship Council (FSC) forest products), that contain recycled materials or are rapidly renewable enhances overall environmental sustainability and lowers the embedded carbon footprint of a building.

5) **Indoor environmental quality**: To enhance the well-being of occupants, design should use low emitting materials in construction including sealants, adhesives, paints, coatings, flooring, wood and agrifibre. Ventilation systems that promote outdoor air ventilation are preferable and should not allow for outside pollution to enter the building, if possible. Buildings should be designed to maximize the use of natural light for all occupants. Lighting and heating systems should be designed to manually or automatically turn off to reduced energy consumption.

6) **Innovation in design**: Design decisions should be made early in the process as good design can greatly reduce the energy consumption of a building; for example, the orientation and location of a building can compromise shading and ventilation decisions. This part of the assessment encourages and rewards design and construction methods that are particularly innovative. Since there are no real criteria, this allows for architects and contractors to experiment and innovate and receive credit in the scoring system.

The UK guidance below proposes[1] that a Low Carbon Design Taskforce should be created and that this taskforce could develop a blueprint that focuses on four levels in design:

- site selection – transport and integration with other services;
- orientation – to maximize daylight, shade, and ventilation naturally;
- thermal issues – shape, density, materials and systems for winter heating and summer cooling;
- use of renewable forms of energy.

7) **Regional priority**: Designs should be maximized to take into account regional priorities. In colder climates, buildings could be designed to maximize heating efficiency; in hotter climates, cooling and water usage would gain more importance in the design process.

Green buildings are designed to minimize their environmental footprint and, at the same time, improve the well-being of the persons who live, work and play in those buildings:

"While improved building performance significantly reduces resource use, effective urban planning reduces a city's overall environmental impact by reducing the movement of people between buildings and pressure on municipal infrastructure."[2]

2.2 Standards

2.2.1 LEED

The U.S. Green Building Council (USGBC) is a Washington, D.C.-based organization that was established to develop a cost-efficient and energy-saving green building process to enhance economic prosperity and sustainability. USGBC works toward its mission of market transformation through the LEED green building certification programme, a wide range of educational offerings, advocacy work in support of green buildings and communities and a network of chapters and affiliates to engage all interested stakeholders in the process.

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1 Great Britain National Health Service, Sustainable Development Unit Saving carbon improving health: NHS carbon reduction strategy for England, 2009, NHS Sustainable Development Unit, Great Britain National Health Service, www.sdu.nhs.uk/documents/publications/1237308334_qylG_saving_carbon,_improving_health_nhs_carbon_reducti.pdf.

2 www.vancouvereconomic.com/userfiles/file/green-building-profile.pdf.

The LEED® green building certification programme is a voluntary, consensus-based national rating system for buildings designed, constructed and operated for improved environmental and human health performance. LEED addresses all building types and emphasizes state-of-the-art strategies in five areas: sustainable site development, water savings, energy efficiency, materials and resources selection, and indoor environmental quality.[3]

Prerequisites and credits in the LEED 2009 for New Construction and Major Renovations address seven topics:

- sustainable sites (SS);
- water efficiency (WE);
- energy and atmosphere (EA);
- materials and resources (MR);
- indoor environmental quality (IEQ);
- innovation in design (ID);
- regional priority (RP).

Figure 1: LEED 2009 for New Constructions and Major Renovations: Prerequisites and Credits	
SS Prerequisite 1: Construction activity pollution prevention	To reduce pollution from construction activities by controlling soil erosion, waterway sedimentation and airborne dust generation.
SS Credit 1: Site selection	To avoid the development of inappropriate sites and reduce the environmental impact from the location of a building on a site.
SS Credit 2: Development density and community connectivity	To channel development to urban areas with existing infrastructure, protect green fields, and preserve habitat and natural resources.
SS Credit 3: Brownfield redevelopment	To rehabilitate damaged sites where development is complicated by environmental contamination and to reduce pressure on undeveloped land.
SS Credit 4.1: Alternative transportation – Public transportation access	To reduce pollution and land development impacts from automobile use.
SS Credit 4.2: Alternative transportation – Bicycle storage and changing rooms	To reduce pollution and land development impacts from automobile use.
SS Credit 4.3: Alternative transportation – Low-emitting and fuel-efficient vehicles	To reduce pollution and land development impacts from automobile use.
SS Credit 4.4: Alternative transportation – Parking capacity	To reduce pollution and land development impacts from automobile use.
SS Credit 5.1: Site development – Protect or restore habitat	To conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity.
SS Credit 5.2: Site development – Maximize open space	To promote biodiversity by providing a high ratio of open space to development footprint.
SS Credit 6.1: Storm-water design – Quantity control	To limit disruption of natural hydrology by reducing impervious cover, increasing on-site infiltration, reducing or eliminating pollution from storm-water run-off and eliminating contaminants.

[3] www.usgbc.org/Default.aspx.

SS Credit 6.2: Storm-water design – Quality control	To limit disruption and pollution of natural water flows by managing storm-water run-off.
SS Credit 7.1: Heat island effect – Non-roof	To reduce heat islands to minimize impacts on microclimates and human and wildlife habitats.
SS Credit 8: Light pollution reduction	To minimize light trespass from the building and site, reduce sky-glow to increase night sky access, improve night-time visibility through glare reduction and reduce development impact from lighting on nocturnal environments.
WE prerequisite 1: Water use reduction	To increase water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems.
WE Credit 1: Water efficient landscaping	To limit or eliminate the use of potable water or other natural surface or subsurface water resources available on or near the project site for landscape irrigation.
WE Credit 2: Innovative wastewater technologies	To reduce wastewater generation and potable water demand while increasing the local aquifer recharge.
WE Credit 3: Water use reduction	To further increase water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems.
EA prerequisite 1: Fundamental commissioning of building energy systems	To verify that the project's energy-related systems are installed, and calibrated to perform according to the owner's project requirements, basis of design and construction documents. Benefits of commissioning include reduced energy use, lower operating costs, fewer contractor callbacks, better building documentation, improved occupant productivity and verification that the systems perform in accordance with the owner's project requirements.
EA prerequisite 2: Minimum energy performance	To establish the minimum level of energy efficiency for the proposed building and systems to reduce environmental and economic impacts associated with excessive energy use.
EA prerequisite 3: Fundamental refrigerant management	To reduce stratospheric ozone depletion.
EA Credit 1: Optimize energy performance	To achieve increasing levels of energy performance beyond the prerequisite standard to reduce environmental and economic impacts associated with excessive energy use.
EA Credit 2: On-site renewable energy	To encourage and recognize increasing levels of on-site renewable energy self-supply to reduce environmental and economic impacts associated with fossil fuel energy use.
EA Credit 3: Enhanced commissioning	To begin the commissioning process early in the design process and execute additional activities after systems performance verification is completed.
EA Credit 4: Enhanced refrigerant management	To reduce ozone depletion and support early compliance with the Montreal Protocol while minimizing direct contributions to climate change.
EA Credit 5: Measurement and verification	To provide for the ongoing accountability of building energy consumption over time.
EA Credit 6: Green power	To encourage the development and use of grid-source, renewable energy technologies on a net zero pollution basis.
MR Prerequisite 1: Storage and collection of recyclables	To facilitate the reduction of waste generated by building occupants that is hauled to and disposed of in landfills.
MR Credit 1.1: Building reuse – maintain existing walls, floors and roof	To extend the life cycle of existing building stock, conserve resources, retain cultural resources, reduce waste and reduce environmental impacts of new buildings as they relate to material manufacturing and transport.

MR Credit 1.2: Building reuse – maintain interior non-structural elements	To extend the life cycle of existing building stock, conserve resources, retain cultural resources, reduce waste and reduce environmental impacts of new buildings as they relate to material manufacturing and transport.
MR Credit 2: Construction waste management	To divert construction and demolition debris from disposal in landfills and incineration facilities. Redirect recyclable recovered resources back to the manufacturing process and reusable materials to appropriate sites.
MR Credit 3: Materials reuse	To reuse building materials and products to reduce demand for virgin materials and reduce waste, thereby lessening impacts associated with the extraction and processing of virgin resources.
MR Credit 4: Recycled content	To increase demand for building products that incorporate recycled content materials, thereby reducing impacts resulting from extraction and processing of virgin materials.
MR Credit 5: Regional materials	To increase demand for building materials and products that are extracted and manufactured within the region, thereby supporting the use of indigenous resources and reducing the environmental impacts resulting from transportation.
MR Credit 6: Rapidly renewable materials	To reduce the use and depletion of finite raw materials and long-cycle renewable materials by replacing them with rapidly renewable materials.
MR Credit 7: Certified wood	To encourage environmentally responsible forest management.
IEQ prerequisite 1: Minimum indoor air quality performance	To establish minimum indoor air quality (IAQ) performance to enhance indoor air quality in buildings, thus contributing to the comfort and well-being of the occupants.
IEQ Prerequisite 2: Environmental tobacco smoke (ETS) control	To prevent or minimize exposure of building occupants, indoor surfaces and ventilation air distribution systems to environmental tobacco smoke (ETS).
IEQ Credit 1: Outdoor air delivery monitoring	To provide capacity for ventilation system monitoring to help promote occupant comfort and well-being.
IEQ Credit 2: Increased ventilation	To provide additional outdoor air ventilation to improve indoor air quality (IAQ) and promote occupant comfort, well-being and productivity.
IEQ Credit 3.1: Construction indoor air quality management plan – during construction	To reduce indoor air quality (IAQ) problems resulting from construction or renovation and promote the comfort and well-being of construction workers and building occupants.
IEQ Credit 3.2: Construction indoor air quality management plan – before occupancy	To reduce indoor air quality (IAQ) problems resulting from construction or renovation to promote the comfort and well-being of construction workers and building occupants.
IEQ Credit 4.1: Low-emitting materials – adhesives and sealants	To reduce the quantity of indoor air contaminants that is odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.
IEQ Credit 4.2: Low-emitting materials – paints and coatings	To reduce the quantity of indoor air contaminants that is odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.
IEQ Credit 4.3: Low-emitting materials – flooring systems	To reduce the quantity of indoor air contaminants that is odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.
IEQ Credit 4.4: Low-emitting materials – composite wood and agrifibre products	To reduce the quantity of indoor air contaminants that is odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

IEQ Credit 5: Indoor chemical and pollutant source control	To minimize building occupant exposure to potentially hazardous particulates and chemical pollutants.
IEQ Credit 6.1: Controllability of systems – lighting	To provide a high level of lighting system control by individual occupants or groups in multi-occupant spaces (e.g. classrooms and conference areas) and promote their productivity, comfort and well-being.
IEQ Credit 6.2: Controllability of systems – thermal comfort	To provide a high level of thermal comfort system control37 by individual occupants or groups in multi-occupant spaces (e.g. classrooms or conference areas) and promote their productivity, comfort and well-being.
IEQ Credit 7.1: Thermal comfort – design	To provide a comfortable thermal environment that promotes occupant productivity and well-being.
IEQ Credit 7.2: Thermal comfort – verification	To provide for the assessment of building occupant thermal comfort over time.
IEQ Credit 8.1: Daylight and views – daylight	To provide building occupants with a connection between indoor spaces and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building.
IEQ Credit 8.2: Daylight and views – views	To provide building occupants a connection to the outdoors through the introduction of daylight and views into the regularly occupied areas of the building.
ID Credit 1: Innovation in design	To provide design teams and projects the opportunity to achieve exceptional performance above the requirements set by the LEED Green Building Rating System and/or innovative performance in Green Building categories not specifically addressed by the LEED Green Building Rating System.
Id Credit 2: Leed accredited professional	To support and encourage the design integration required by LEED to streamline the application and certification process.
RP Credit 1: Regional priority	To provide an incentive for the achievement of credits that address geographically-specific environmental priorities.

2.2.2 Green Globes

The Green Globes system[4] is a building environmental design and management tool through an online assessment protocol, rating system and guidance for green building design, operation and management. It is an interactive tool and provides market recognition of a building's environmental attributes through third-party verification.

The Green Globes assessment and rating system is the result of more than eleven years of research and refinement by a wide range of prominent international organizations and experts.

The genesis of the system was the Building Research Establishment's Environmental Assessment Method (BREEAM). In 1996, the Canadian Standards Association (CSA) published BREEAM Canada for Existing Buildings. More than 35 individuals participated in its development, including representatives from federal and provincial departments, the National Research Council and University of Toronto.

In 2000, the system took a leap forward in its evolution, becoming an online assessment and rating tool under the name Green Globes for Existing Buildings. Also in that year, the Canadian Department of National Defense and Public Works and Government Services supported the development of a system for the Design of New Buildings. The product underwent a further iteration in 2002 by a team of experts including representatives from Arizona State University, the Athena Institute, BOMA (Building Owners and Managers

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4 www.greenglobes.com/about.asp.

Association of Canada) and several federal departments including Public Works and Governments Services, and Natural Resources Canada.

In 2004, Green Globes for Existing Buildings was adopted by BOMA, where it now operates under the name BOMA BESt. In addition, the Green Building Initiative (GBI) acquired the rights to distribute Green Globes in the United States. GBI has committed to continually refine the system to ensure that it reflects ongoing advances in research and technology, by involving stakeholders in an open and transparent process. The Green Globes system has also been used by the Continental Association for Building Automation (CABA) to power a building intelligence tool, called Building Intelligence Quotient (BiQ).

To that end, in 2005, GBI became the first green building organization to be accredited as a standards developer by the American National Standards Institute (ANSI). The GBI ANSI technical committee was formed in early 2006 and the official Green Globes ANSI standard was published in 2010.

Today, the Green Globes system is used by large developers and property management companies, including, the Canadian federal government, which has adopted the programme for its entire real estate portfolio.[5]

2.2.3 Green Building (Europe)

In its Green Paper on Energy Efficiency, the European Commission (EC) identified the building sector as an area where important improvements in energy efficiency can be realized. According to the Green Paper, the building sector accounts for more than 40% of the final energy demand in Europe. At the same time, improved heating and cooling of buildings constitutes one of the largest potentials for energy savings. Such savings would also improve the energy supply security and the EU's competitiveness, while creating jobs and raising the quality of life in buildings.

The Green Building Programme[6] (GBP) is a voluntary programme that started in 2005. It is meant to enhance the realization of cost-effective energy efficiency potentials by creating awareness and providing information support and public recognition to companies the top management of which is ready to show actual commitment to adopt energy efficient measures in non-residential buildings.

These are the important requirements for participation:

- an Energy Audit;
- an Action Plan;
- execution of the Action Plan;
- commitment to report energy consumption on a regular basis.

The GBP is managed by the European Commission Directorate General (DG) Joint Research Council (JRC), which sets the rules and the structure of the programme and is responsible for the final acceptance of GB Partners and GB Endorsers.

GBP provides documents ("Modules") defining the technical nature of an appropriate commitment for each energy service covered in the programme. The modules are complemented by Guidelines on horizontal issues, such as "Financing", "Energy Audit" and "Energy Management".

5 www.greenglobes.com/about.asp.

6 www.eu-greenbuilding.org/.

GBP encourages its Partners to tap a large reservoir of profitable investments without the need for specific incentives from the Commission. GBP investments use proven technology, products and services for which efficiency has been demonstrated.

Being a Green Building Partner gives a company the chance of presenting its actions for its organization's and the world's sustainable future to the broad public. The company will be an important multiplier to encourage other organizations to follow suit.

The benefits are:

- Recognition and approval of the action for enhancing the energy efficiency of the building stock by the European Commission
- Competitive advantages as an organization being certified for its responsibility in the field of energy efficiency
- Presentation and communication of the organization and the Good-Practice-Example within the public relations of the GB Programme.

GBP will be complementary to the Building Energy Performance Directive as it will stimulate additional savings in the non-residential building sector.

2.2.4 BREEAM – Europe

BRE Environmental Assessment Method (BREEAM[7]) is a voluntary measurement rating for green buildings that was established in the UK by the Building Research Establishment (BRE).

BREEAM is one of the world's foremost environmental assessment methods and rating systems for building. There are over 200 000 buildings with certified BREEAM assessment ratings and over a million registered for assessment since it was first launched in 1990.

BREEAM sets standards for best practice in sustainable building design, construction and operation and has become one of the most comprehensive and widely recognized measures of a building's environmental performance.

A BREEAM assessment uses recognized measures of performance, which are set against established benchmarks, to evaluate a building's specification, design, construction and use. The measures used represent a broad range of categories and criteria from energy to ecology. They include aspects related to energy and water use, the internal environment (health and well-being), pollution, transport, materials, waste, ecology and management processes.

BREEAM addresses wide-ranging environmental and sustainability issues and enables developers, designers and building managers to demonstrate the environmental credentials of their buildings to clients, planners and other initial parties.

BREEAM:

- uses a straightforward scoring system that is transparent, flexible, easy to understand and supported by evidence-based science and research;
- has a positive influence on the design, construction and management of buildings;
- defines and maintains a robust technical standard with rigorous quality assurance and certification.

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7 www.breeam.org/page.jsp?id=66

Figure 2: Issues covered in BREEAM Handbook for New Construction BREEAM Handbook for New Construction[8]	
Energy	**Water**
Reduction of CO_2 emissions	Water consumption
Energy monitoring	Water monitoring
Energy efficient external lighting	Water leak detection and prevention
Low or zero carbon technologies	Water efficient equipment (process)
Energy efficient cold storage	**Waste**
Energy efficient transportation systems	Construction waste management
Energy efficient laboratory systems	Recycled aggregate
Energy efficient equipment (process)	Operational waste
Drying space	Speculative floor and ceiling finishes
Transport	**Materials**
Public transport accessibility	Life cycle impacts
Proximity to amenities	Hard landscaping and boundary protection
Cyclist amenities	Responsible sourcing of materials
Maximum car parking capacity	Insulation
Travel plan	Designing for robustness
Land use and ecology	**Pollution**
Site selection	Impact of refrigerants
Ecological value of site / protection of ecological features	NO_x emissions from heating/cooling source
Mitigating ecological impact	Surface water run-off
Enhancing site ecology	Reduction of night-time light pollution
Long-term impact on biodiversity	Noise attenuation
Health and well-being	**Management**
Visual comfort	Sustainable procurement
Indoor air quality	Responsible construction practices
Thermal comfort	Construction site impacts
Water quality	Stakeholder participation
Acoustic performance	Service life planning and costing
Safety and security	**Innovation**
	New technology, process and practices

2.2.5 International Green Construction Code

In 2009, the International Code Council launched the development of a new International Green Construction Code (IgCC) initiative, subtitled “Safe and Sustainable: By the Book,” committed to developing a model code focused on new and existing commercial buildings addressing green building design and performance.

8 www.breeam.org/BREEAM2011SchemeDocument/.

2.2.6 German Sustainable Building Council (DGNB)

The DGNB[9] focuses heavily on the establishment and further development of its certification system. As a tool for the assessment and certification of sustainable buildings, it is one of the leading systems worldwide, mainly due to its comprehensive quality concept, which takes equal account of economics, ecology, and socio-cultural aspects and is based on a holistic view of the building's entire life cycle. It is therefore possible to define sustainability targets beginning in the planning phase.

The results are anticipated to be future-oriented buildings with high quality standards documented by the DGNB certificate in gold, silver, or bronze. The DGNB System can also be used outside of Germany. Due to its conformity with present and future EU regulations, it is a tool that can ensure high building quality and performance.

The criteria in the DGNB's core system define sustainable building in six fields. The site quality does not play a role in the assessment of the total performance index.

Figure 3: Six criteria in the DGNB assessment	
Ecological quality	
Global warming potential	Ozone depletion potential
Photochemical ozone creation potential	Acidification potential
Eutrophication potential	Risks to the local environment
Other effects on the local environment	Sustainable use of resources/wood
Microclimate	Non-renewable primary energy demand
Total primary energy demand and proportion of renewable primary energy	Other uses of non-renewable resources
Waste by category	Drinking water demand and volume of waste water
Space demand	
Economic quality	
Building related life cycle costs	Suitability for third-party use
Sociocultural and functional quality	
Thermal comfort in winter	Thermal comfort in summer
Interior air hygiene	Acoustic comfort
Visual comfort	User control possibilities
Quality of outdoor spaces	Safety and risk of hazardous incidents
Handicapped accessibility	Space efficiency
Suitability for conversion	Public access
Bicycling convenience	Assurance of design and urban development quality in a competition
Per cent for art	Quality features of use profile
Social integration	
Technical quality	
Fire prevention	Sound insulation
Quality of building envelope with regard to heat and humidity	Building services' backup ability

9 www.dgnb.de/_en/index.php.

Building services' ease of use	Building services' equipment quality
Durability	Ease of cleaning and maintenance
Resistance to hail, storms, and flooding	Ease of dismantling and recycling
Process quality	
Quality of project preparation	Integral planning
Optimization and complexity of planning method	Evidence of sustainable aspects in call for and awarding of tenders
Creation of conditions for optimal use and management	Construction site/construction process
Quality of contractors/pre-qualification	Quality assurance for construction
Commissioning	Controlling
Management	Systematic inspection, maintenance, and servicing
Qualification of operating staff	
Site quality	
Risks in the micro-environment	Conditions in the micro-environment
Public image and condition state of site and neighbourhood	Access to transportation
Proximity to use-specific facilities	Connections to public services (utilities)
Legal situation for planning	Extension options/reserves

2.2.7 Green Building Council of Australia

Launched in 2002, the Green Building Council of Australia (GBCA[10]) is an organization that is committed to developing a sustainable property industry for Australia by encouraging the adoption of green building practices. It is uniquely supported by both the industry and governments across the country.

The Green Building Council's mission is to develop a sustainable property industry for Australia and drive the adoption of green building practices through market-based solutions.

Objectives: Its key objectives are to drive the transition of the Australian property industry towards sustainability by promoting green building programs, technologies, design practices and operations as well as the integration of green building initiatives into mainstream design, construction and operation of buildings.

Green Star is a comprehensive, national, voluntary environmental rating system that evaluates the environmental design and construction of buildings. With more than 4 million square metres of Green Star-certified space around Australia, and a further 8 million square metres of Green Star-registered space, Green Star has transformed Australia's property and construction market.

Green Star was developed for the property industry in order to:

- establish a common language;
- set a standard of measurement for green buildings;
- promote integrated, whole-building design;
- recognize environmental leadership;
- identify building life cycle impacts, and

10 www.gbca.org.au/.

- raise awareness of green building benefits.

Green Star covers a number of categories that assess the environmental impact that is a direct consequence of a project site selection, design, construction and maintenance. The nine categories included within all Green Star rating tools are:

- management;
- indoor environment quality;
- energy;
- transport;
- water;
- materials;
- land use and ecology;
- emissions;
- innovation.

2.2.8 Estidama – United Arab Emirates

The Abu Dhabi Urban Planning Council (UPC) is recognized internationally for large-scale sustainable urban planning and for rapid growth. Plan Abu Dhabi 2030 urban master plan addresses sustainability as a core principle. Estidama[11], which is the Arabic word for sustainability, is an initiative developed and promoted by the UPC. Estidama is the intellectual legacy of the late Sheikh Zayed bin Sultan Al Nahyan and a manifestation of visionary governance promoting thoughtful and responsible development. The leadership of Abu Dhabi are progressing the principles and imperatives for sustainable development, through Estidama, while recognizing that the unique cultural, climatic and economic development needs of the region require a more localized definition of sustainability.

Estidama is not just a rating method or something people do, it is a vision and a desire to achieve a new sustainable way of life in the Arab world. The ultimate goal of Estidama is to preserve and enrich Abu Dhabi's physical and cultural identity, while creating an always improving quality of life for its residents on four equal pillars of sustainability: environmental, economic, social, and cultural. This touches all aspects of life in Abu Dhabi – the way they build, the way they resource, the way they live, the choices they make – all in an effort to attain a sustainable state of living.

Estidama arose from the need to properly plan, design, construct and operate sustainable developments with respect to the traditions embedded within the rich local culture, on one hand, and the harsh climatic nature of the region on the other. To this end, project owners, developers, design teams and even residents need to think differently about how they approach the design and planning process.

Estidama began in 2009 and is the first programme of its kind that is tailored to the Middle East region. In the immediate term, Estidama is focused on the rapidly changing built environment. It is in this area that the UPC is making significant strides to influence projects under design, development or construction within the Emirate of Abu Dhabi.

Estidama will continually evolve to embrace the rapidly changing concepts for sustainability, and ground them in the environmental, social, cultural, and economic needs of the Gulf Cooperation Council (GCC) region. Estidama sets the path for a bright future for the Emirate, its citizens, its residents and the

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[11] http://estidama.org/?lang=en-US.

generations to follow. Consequently, the success of Estidama will depend on everyone in the Emirate to create a better future for all.

The Pearl Rating System for Estidama aims to address the sustainability of a given development throughout its life cycle from design through construction to operation. The Pearl Rating System provides design guidance and detailed requirements for rating a project's potential performance in relation to the four pillars of Estidama.

The Pearl Rating System is organized into seven categories that are fundamental to more sustainable development. These form the heart of the Pearl Rating System:

- **Integrated development process**: Encouraging cross-disciplinary teamwork to deliver environmental and quality management throughout the life of the project.
- **Natural systems**: Conserving, preserving and restoring the region's critical natural environments and habitats.
- **Liveable buildings**: Improving the quality and connectivity of outdoor and indoor spaces.
- **Precious water**: Reducing water demand and encouraging efficient distribution and alternative water sources.
- **Resourceful energy**: Targeting energy conservation through passive design measures, reduced demand, energy efficiency and renewable sources.
- **Stewarding materials**: Ensuring consideration of the 'whole-of-life' cycle when selecting and specifying materials.
- **Innovating practice**: Encouraging innovation in building design and construction to facilitate market and industry transformation.

2.2.9 CASBEE – Japan

Construction, which consumes and discards resources and energy in enormous quantities, is a field that must be acted upon to develop and promote techniques and policies able to assist the drive towards sustainability.

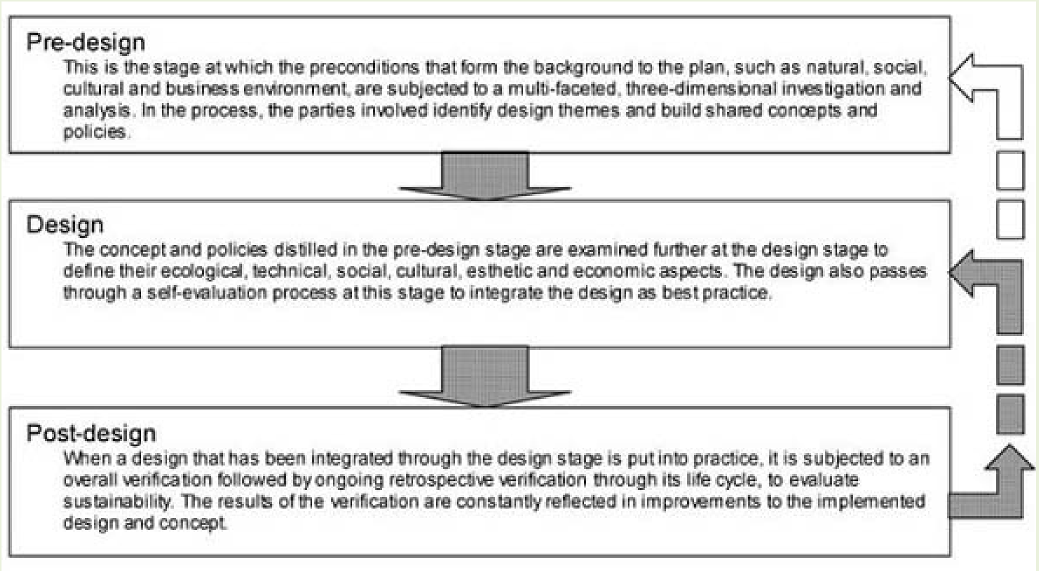
There has been a growing movement towards sustainable construction since the second half of the 1980s, leading to the development of various methods for evaluating the environmental performance of buildings. Methods developed overseas include BREEAM (Building Research Establishment Environmental Assessment Method) in the UK, LEEDTM (Leadership in Energy and Environment Design) in the USA, and GB Tool (Green Building Tool) as international projects. These methods have attracted interest around the world. This kind of assessment, with the publication of the results, is one of the best methods now available to provide an incentive for clients, owners, designers and users to develop and promote highly sustainable construction practices.

CASBEE[12] was developed according to the following policies:

1) The system should be structured to award high assessments to superior buildings, thereby enhancing incentives to designers and others.
2) The assessment system should be as simple as possible.
3) The system should be applicable to buildings in a wide range of applications.
4) The system should take into consideration issues and problems peculiar to Japan and Asia.

12 www.ibec.or.jp/CASBEE/english/overviewE.htm.

Figure 4: CASBEE - The cyclical process of business design



2.3 Best environmental practices

Case study: Waterfront Toronto Minimum Green Building Requirements –Toronto, Canada

LEED Gold Certification

Intent: To confirm, through third-party certification, that high-level green building performance has been achieved.

Requirements: Achieve Gold certification under LEED® Canada-NC 2009, or the most up-to date version of LEED® Canada-NC at the time of Request for Proposal (RFP) issuance, for all eligible buildings. Must achieve the following credits:

a) WEc1: Water Efficient Landscaping (4 points)

b) WEc3: Water Use Reduction (4 points)

c) EAc1: Optimize Energy Efficiency (50% cost savings relative to Model National Energy Code for Buildings (MNECB) (1997) [excluding process loads and assuming a code compliant heating and cooling plant])

d) EAc2: On-Site Renewable Energy (3% of annual energy cost, 2 points)

e) EAc5: Measurement and Verification (3 points).

Figure 5: Toronto Waterfront: Green Building Requirements

Smart building	To encourage conservation among building residents and occupants by providing them with a means to track and control their utility usage, and to pay for energy based on each suite's actual consumption, and to satisfy the requirements for data transfer associated with the Waterfront Toronto Intelligent Communities (WTIC) network.
Electric vehicle infrastructure	To reduce non-point source emissions associated with automobile use.
Green roof	To create buildings that provide a visual connection between community residents and plant life, provide habitat and increase biodiversity, help reduce the

	urban heat island effect, and contribute to sustainable storm-water management.
Engagement and support	To provide building owners/operators and occupants with the information necessary to operate and maintain the building optimally.
Bicycle parking and storage	To reduce emissions associated with automobile use by supporting effective bicycle infrastructure.
Waste management	To minimize waste going to landfills and to encourage all building residents and occupants to participate in responsible waste management.
District energy	To provide buildings with cost-effective, energy from community-scale clean energy sources.
Community integration	To engage the development team to consider how building design options can positively impact the adjacent buildings and surrounding community.
Long-term flexibility	To provide building characteristics that allow for future changes without structural modifications.
Progress tracking system	To track developer progress with respect to fulfilling Waterfront Toronto's Minimum Green Building Requirements.

Case Study: UNEP Building – Nairobi, Kenya

An architectural piece that exemplifies sustainable building design is the United Nations compound located on the outskirts of Kenya's capital city. The new building takes environmental sustainability to a new level. It consists of four buildings linked by airy walkways, flooded with natural light, and with green areas individually landscaped and themed, all of which can accommodate 1,200 staff members.

The simple design enables the building to act as a chimney, where warm air is drawn up from ground level and through the office areas, and then escapes beneath the sides of the vaulted roof, maintaining comfortable temperatures in the offices and air circulation throughout the building.

Figure 6: UNEP Building, Nairobi - Green building features	
Water	Water features at the entrance to each of the four blocks are fed by rainwater harvested from the roof. Water saving taps and lavatories will reduce water consumption. Wastewater is treated in a state-of-the-art on site aeration facility and the clean water is used to irrigate the landscaped compound. Rainwater is collected from the roof and used to irrigate the landscaped areas around the building. No fresh water will be needed to irrigate the planted areas.
Lighting	Glazed roof lights are set into the building's flat roof, and toughened glass set at floor level beneath them on each floor, enabling natural light to penetrate right through the ground floor. Low energy fluorescent lighting, together with a daylight sensing and presence detection system significantly reduces energy use while ensuring adequate light to work by.
Solar power	Solar panels cover the roof space and will generate all the building's energy needs, making it energy neutral over the year. Water for the coffee station kitchens is solar heated.
Light and ventilation	A central atrium runs the length of the building, allowing natural light to flood into offices, while encouraging airflow and comfortable internal temperatures by drawing warm air up and out of the building.

Ventilation	Open plan offices help air circulation and temperature control, and also encourage a more cooperative working environment. Windows can be opened and closed for temperature regulation, while high quality solar glass insulates the building against the heat and the cold.
Technology	Data centers that use air and cool water to maintain server temperatures remove the need for costly air conditioning.
Design	The building faces north-south, achieving maximum daytime lighting with minimum heat intake.
Green areas	The area around the building has been planted with indigenous trees. Landscaped areas beneath the atrium in the center of each block are planted to need minimal water, to encourage biodiversity, and to create cool and beautiful interior gardens.
Green IT	Notebook computers use only a third of the electricity used by desktop PCs, which are being replaced throughout the building.
Materials	The carpets have a very high recycled content and are 100% recyclable, and all paints are environmentally friendly.

Case study: Toronto Green Standards – Toronto, Canada

The Toronto Green Standard (TGS[13]) is a two-tiered set of performance measures with supporting guidelines related to sustainable site and building design for new public and private development. The supporting guidelines include:

- Urban Design Streetscape Manual
- Bird Friendly Development Guidelines
- Guidelines for the Design and Management of Bicycle Parking Facilities
- Design Guidelines for 'Greening' Surface Parking Lots.

Toronto's Energy Efficiency Office (EEO) reviews the energy reports submitted to determine if the building has been designed to achieve, at minimum, the TGS Tier 2 target. A key feature of the programme is that buildings that meet the requirements of TGS may be eligible for financial incentives for the energy savings achieved.

The "High Performance New Construction Program" offers design assistance and substantial financial incentives for building owners and design decision makers who exceed the electricity efficiency specified in the Ontario Building Code.

The Toronto Green Standard and the Better Buildings Partnership-NC won the 2009 Federation of Canadian Municipalities-CH2M Hill Sustainable Communities Award in the Buildings category, as an example of an innovative project contributing to sustainable community development in Canada.

Case study: Suzlon One Earth – Pune, India

Suzlon Energy Limited[14] pledged to create the greenest office in India. The building is three levels high and is located on 10.5 acres. It achieved LEED for New Construction Platinum certification from the India Green Building Council, as well as Five-Star GRIHA (Green Rating for Integrated Habitat Assessment) certification.

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13 www.toronto.ca/planning/environment/greendevelopment.htm.

14 http://demo.usgbc.name/projects/suzlon-one-earth.

5% (154 kilowatts) of its annual energy is generated on-site through conventional and building-integrated photovoltaic panels (20%) and wind turbines (80%). All balance energy required for the campus is generated through Suzlon's off-site wind turbines, making One Earth technically a zero energy project.

Drawing clues from vernacular architecture while respecting nature and culture, the design provides 90% of the work stations with daylight and external views, allowing inhabitants to enjoy seasons and weather conditions, and to connect with the time of the day. Aluminium louvers act as a protective skin, allowing daylight and cross-ventilation. Energy is saved by employing LED lighting systems and solar water heating. 100% of sewage grey water is recycled into flushing, landscaping and air cooling systems, while 100% of rainwater is harvested. Glass exhaust chimneys with tropical plants act as visual connectors between all floors and allow aeration of the basement parking area. The focus of the complex is a central courtyard that features a forty-metre traditional obelisk reaching out to the sky from the basement and a waterfall facing a crescent cafeteria. This central garden plaza encourages communication, informal interaction and team gathering amongst Suzlon's more than 1 500 colleagues and provides a visual presentation for occupants and visitors. This corporate campus is a counterblast to prevailing glass-box architecture occurring across India and is a game changer in terms of how corporate campuses have been designed to-date in India.

The project site was selected for the advantages of an already-developed area. It is flanked by offices of other corporations and a high-density residential area. Given its location, the building has accessibility to urban infrastructure and facilities, public transport, and established infrastructure for power and water supply.

Suzlon One Earth is a 100% renewable energy campus with both on- and off-site renewable energy that includes wind and solar. 100% of outdoor lighting and the communication server are run on renewable energy resources. Energy efficiency is also met through intelligent lighting occupancy sensors, efficient envelope design featuring high-performance glazing, over-deck insulation, reduced interior light density and day lighting optimization made possible through the use of glass cylinders and open interactive bays.

In terms of water usage, 100% of wastewater is recycled by an on-site sewage plant and used for landscaping, air conditioning and washroom flushing. Site landscaping features native and adapted plant species combined with pebble drains to collect excess water. Together, these strategies drastically reduce storm-water run-off. Inside, low-flow faucets, touchless urinals with bytronic sensors and concealed dual-flush toilets conserve water.

Around 80% of materials used in construction were regional materials from within a radius of 800 kilometres. Additionally, around 10% of the materials are rapidly renewable, such as bamboo. 85% of construction waste was recycled.

To address indoor environmental quality, CO_2 sensors were installed in densely-occupied spaces and near workstations. The heating, ventilation and air conditioning (HVAC) system was designed for 30% higher ventilation rates than American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards.

Suzlon One Earth strives for its occupants to be environmentally aware, socially responsible and compatible with the built space. The Synefra project team, along with the Suzlon Human Resources team, conducted pre-occupancy education programmes to orient tenants to the facility and explain the norms that would need to be adopted. Suzlon has identified various processes to recognize and develop human behavioural skills to understand and appreciate the inter-relationship between man and his biophysical surrounding, and has modified its policy at One Earth to match the infrastructure.

The project is based upon the principle of promoting awareness about sustainability, to the extent of even declaring the entire campus a non-smoking zone, which led many employees to drop their age-old smoking habits. The campus is used as a communication tool to portray the interdependence of the natural and man-made environments. Among the various communication strategies adopted at Suzlon One Earth are green design education, green signage and green tours. The end result is an inter-disciplinary human resource that learns about and from the environment on a continuous basis.

Case Study: Infosys BPO Limited, Jaipur, India

The building housing Infosys BPO Limited, the business process outsourcing subsidiary of Infosys Technologies Limited, in Jaipur, India, has a LEED Platinum rating. Built on a total floor area of 330,000 square feet, the Infosys BPO building is one of the largest platinum rated buildings in India. The building was conceived and built with a holistic approach to sustainability in five key areas: sustainable site development, water saving, energy efficiency, materials selection and indoor environmental quality. This building is expected to consume 30% less energy as compared to the base case building, as per ASHRAE 90.1-2004 requirements.

Salient features of the Infosys BPO building in Jaipur include:

- Efficient building envelope: a high performance building envelope consisting of insulated walls and spectrally selected windows with a low window to wall ratio, reduces the total heat gain in the building.
- Efficient lighting & equipment: a lighting design specification of 0.65 watts per square foot achieves a 40% improvement over traditional designs. Lighting design coupled with the use of 5-star rated, energy efficient computers reduces the energy load as well as internal heat gains.
- Efficient air-conditioning: the air-conditioning system is equipped with multi-stage air handling units which operate on free cooling, evaporative cooling and air-conditioning modes during nights and winter, achieving more than 30% efficiency over a traditional system.
- Onsite renewable energy: a battery-free 250 KW roof top solar photovoltaic installation meets 7.5% of the total power requirement and takes advantage of the high solar insolation in Jaipur.
- Low energy materials: 13% of the total material is recycled material, thereby reducing virgin material exploitation. 80% of the total material is manufactured locally and over 59% of this material has also been extracted regionally, thereby reducing pollution due to transportation.
- Water sustainability: 57 interconnected recharge wells have been built across the campus to capture & sequester every drop of rain water. Low flow dual-flush toilets, sensor based urinals and other water efficient fixtures have been provided, reducing water consumption by over 40%. Sewage water is treated in a state-of-the-art Membrane Bio Reactor (MBR) plant and reused for flushing and air-conditioning. 100% of the water required for landscaping is from treated water and no potable water is used.

2.4 Metrics

2.4.1 LEED 2009 for new construction and major renovations project

Figure 7: Scoring system for LEED 2009: New constructions and major renovations

Scoring system		
Sustainable sites		**26 possible points**
Prerequisite 1	Construction activity pollution prevention	Required
Credit 1	Site selection	1
Credit 2	Development density and community connectivity	5
Credit 3	Brownfield redevelopment	1
Credit 4.1	Alternative transportation – public transportation access	6
Credit 4.2	Alternative transportation – bicycle storage and changing rooms	1

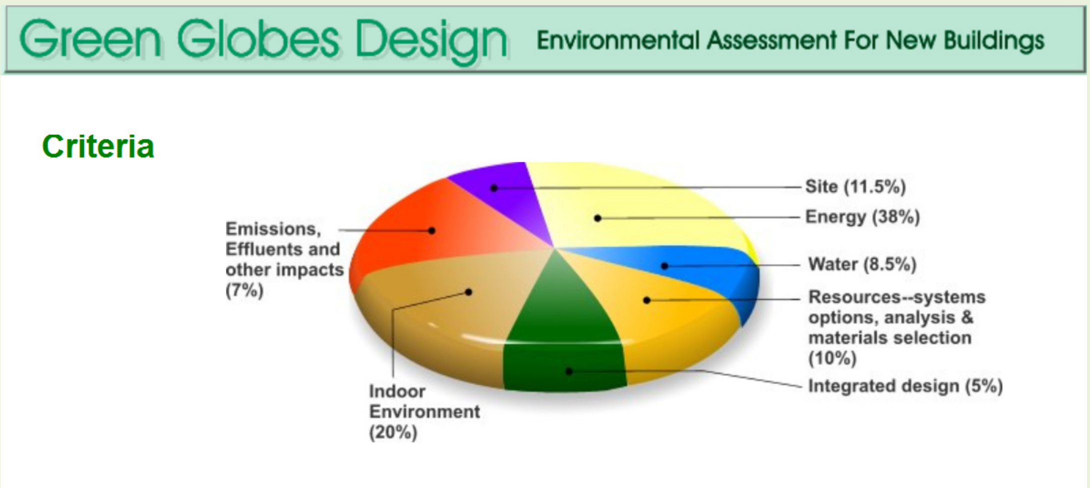
Credit 4.3	Alternative transportation – low emitting and fuel efficient vehicles	3
Credit 4.4	Alternative transportation – parking capacity	2
Credit 5.1	Site development – Protect or restore habitat	1
Credit 5.2	Site development – Maximize open space	1
Credit 6.1	Storm-water design – Quantity control	1
Credit 6.2	Storm-water design – Quality control	1
Credit 7.1	Heat island effect – Non-roof	1
Credit 7.2	Heat island effect – Roof	1
Credit 8	Light pollution reduction	1
Water efficiency		**10 possible points**
Prerequisite 1	Water use reduction	Required
Credit 1	Water efficient landscaping	2-4
Credit 2	Innovative wastewater technologies	2
Credit 3	Water use reduction	2-4
Energy and Atmosphere		**35 possible points**
Prerequisite 1	Fundamental commissioning of building energy systems	Required
Prerequisite 2	Minimum energy performance	Required
Prerequisite 3	Fundamental refrigerant management	Required
Credit 1	Optimize energy performance	1-19
Credit 2	On-site renewable energy	1-7
Credit 3	Enhanced commissioning	2
Credit 4	Enhanced refrigerant management	2
Credit 5	Measurement and verification	3
Credit 6	Green power	2
Materials and resources		**14 possible points**
Prerequisite 1	Storage and collection of recyclables	Required
Credit 1.1	Building reuse – Maintain existing walls, floors and roof	1-3
Credit 1.2	Building reuse – Maintain existing interior non-structural elements	1
Credit 2	Construction waste management	1-2
Credit 3	Materials reuse	1-2
Credit 4	Recycled content	1-2
Credit 5	Regional materials	1-2
Credit 6	Rapidly renewable materials	1
Credit 7	Certified wood	1
Indoor environmental quality		**15 possible points**
Prerequisite 1	Minimum indoor air quality performance	Required
Prerequisite 2	Environmental Tobacco Smoke (ETS) control	Required
Credit 1	Outdoor air delivery monitoring	1
Credit 2	Increased ventilation	1
Credit 3.1	Construction indoor air quality management plan – during construction	1
Credit 3.2	Construction indoor air quality management plan – before occupancy	1
Credit 4.1	Low-emitting materials – adhesives and sealants	1

Credit 4.2	Low-emitting materials – paints and coatings	1
Credit 4.3	Low-emitting materials – flooring systems	1
Credit 4.4	Low-emitting materials – Composite wood and agrifibre products	1
Credit 5	Indoor chemical and pollutant source control	1
Credit 6.1	Controllability of systems – Lighting	1
Credit 6.2	Controllability of systems – Thermal comfort	1
Credit 7.1	Thermal comfort – Design	1
Credit 7.2	Thermal comfort – Verification	1
Credit 8.1	Daylight and views – Daylight	1
Credit 8.2	Daylight and views – Views	1
Innovation in design		**6 possible points**
Credit 1	Innovation in design	1-5
Credit 2	LEED accredited professional	1
Regional priority		**4 possible points**
Credit 1	Regional priority	1-4

Figure 8: LEED 2009 scoring structure	
LEED 2009 for new construction and major renovations	
100 base points; 6 possible Innovation in Design and 4 Regional Priority points	
Certified	40-49 points
Silver	50-59 points
Gold	60-79 points
Platinum	80 points and above

2.4.2 Green Globes

Figure 9: Green Globes assessment criteria



2.4.3 BREEAM rating benchmarks

The BREEAM[15] rating benchmarks for new construction projects assessed using the 2011 version of BREEAM are as follows:

Figure 1: BREEAM rating benchmarks

BREEAM Rating	% score
OUTSTANDING	85
EXCELLENT	70
VERY GOOD	55
GOOD	45
PASS	30
UNCLASSIFIED	<30

In this respect, each BREEAM rating level broadly represents performance equivalent to:

- Outstanding: Less than the top 1% of the UK new non-domestic buildings (innovator)
- Excellent: Top 10% of the UK new non-domestic buildings (best practice)
- Very Good: Top 25% of the UK new non-domestic buildings (advanced good practice)
- Good: Top 50% of the UK new non-domestic buildings (intermediate good practice)
- Pass: Top 75% of the UK new non-domestic buildings (standard good practice).

Environmental section weightings

Environmental weightings are fundamental to any building environmental assessment method as they provide a means of defining, and therefore ranking, the relative impact of environmental issues. BREEAM uses an explicit weighting system derived from a combination of consensus-based weightings and ranking by a panel of experts. The outputs from this exercise are then used to determine the relative value of the environmental sections used in BREEAM and their contribution to the overall BREEAM score.

[15] www.breeam.org/filelibrary/Technical%20Manuals/SD5073_BREEAM_2011_New_Construction_Technical_Guide_ISSUE_2_0.pdf.

Figure 11: BREEAM weightings for environmental assesssment

Environmental section	Weighting
Management	12%
Health & Wellbeing	15%
Energy	19%
Transport	8%
Water	6%
Materials	12.5%
Waste	7.5%
Land Use & Ecology	10%
Pollution	10%
Total	100%
Innovation (additional)	10%

2.2.4 Green Star certified ratings

The following Green Star certified ratings are available:

- **4 Star Green Star certified rating** (score 45-59) signifies 'Best Practice' in environmentally sustainable design and/or construction
- **5 Star Green Star certified rating** (score 60-74) signifies 'Australian Excellence' in environmentally sustainable design and/or construction
- **6 Star Green Star certified rating** (score 75-100) signifies 'World Leadership' in environmentally sustainable design and/or construction.

2.4.5 PEARL rating levels

Within each section, there are both mandatory and optional credits; credit points are awarded for each optional credit achieved. To achieve a 1 Pearl rating, all the mandatory credit requirements must be met. To achieve a higher Pearl rating, all the mandatory credit requirements must be met along with a minimum number of credit points.

Figure 12: PEARL rating benchmarks

Requirement	Pearl Rating Achieved
All mandatory credits	1 Pearl
All mandatory credits + 60 credit points	2 Pearl
All mandatory credits + 85 credit points	3 Pearl
All mandatory credits + 115 credit points	4 Pearl
All mandatory credits + 140 credit points	5 Pearl

3 Building maintenance, repair and operations

3.1 Overview

Sustainable building operations guidelines provide building owners and operators with the tools needed to minimize environmental impacts during the utilization phase of a building's life cycle. The guidelines for maintenance, repair and operations (MRO) were developed to ensure that buildings designed and constructed for environmental sustainability would continue to operate their systems in a manner that minimizes a building's impact and continues to ensure the health and well-being of occupants and the surrounding built environment.

Since many of the systems that have been integrated into a building to maximize energy efficiency and minimize environmental impact are dependent on ICTs, integrating MRO green building standards into an ICT company's built environment provides therefore an excellent opportunity for ICT companies to demonstrate not only their commitment to sustainability, but also the power of ICTs to reduce emissions.

3.2 Standards

3.2.1 LEED guidelines for existing buildings: operations and maintenance

The LEED 2009 green building rating system for existing buildings: operations and maintenance16 is a set of performance standards for certifying the operations and maintenance of existing commercial or institutional buildings and high-rise residential buildings of all sizes, both public and private. The intent is to promote high performance, healthy, durable, affordable, and environmentally sound practices in existing buildings.

LEED for existing buildings: operations and maintenance encourages owners and operators of existing buildings to implement sustainable practices and reduce the environmental impacts of their buildings over their functional life cycles. Specifically, the rating system addresses exterior building site maintenance programmes, water and energy use, environmentally preferred products and practices for cleaning and alterations, sustainable purchasing policies, waste stream management, and ongoing indoor environmental quality.

LEED for existing buildings: operations and maintenance provides owners and operators of existing buildings an entry point into the LEED certification process and is applicable to the following:

- building operations, processes, systems upgrades, minor space-use changes, and minor facility alterations or additions, and
- buildings new to LEED certification as well as buildings previously certified under LEED for New Construction, LEED for Schools, or LEED for Core and Shell; these may be either ground up new constructions or existing buildings that have undergone major renovations.

Categories:

- sustainable sites;
- water efficiency;
- energy and atmosphere;
- materials and resources;

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[16] www.usgbc.org/ShowFile.aspx?DocumentID=8876.

- indoor environmental quality;
- innovation in operations;
- regional priority.

Figure 13: LEED guidelines for Existing Buildings	
SS Credit 1: LEED certified design and construction	To reward environmentally sensitive building design and construction, thereby enabling high-performance building operations to be achieved more easily.
SS Credit 2: Building exterior and hardscape management plan	To encourage environmentally sensitive building exterior and hardscape management practices that provide a clean, well-maintained and safe building exterior while supporting high-performance building operations.
SS Credit 3: Integrated pest management, erosion control and landscape management plan	To preserve ecological integrity, enhance natural diversity and protect wildlife while supporting high-performance building operations and integration into the surrounding landscape.
SS Credit 4: Alternative commuting transportation	To reduce pollution and land development impacts from automobile use for commuting.
SS Credit 5: Site development – protect or restore open habitat	To conserve existing natural site areas and restore damaged site areas to provide habitat and promote biodiversity.
SS Credit 6: Storm-water quantity control	To limit disruption of natural hydrology by reducing impervious cover, increasing on-site infiltration, reducing or eliminating pollution from storm-water run-off and eliminating contaminants.
SS Credit 7.1: Heat island reduction – non-roof	To reduce heat islands4 to minimize impacts on microclimates and human and wildlife habitats.
SS Credit 7.2: Heat island reduction – roof	To reduce heat islands to minimize impacts on microclimates and human and wildlife habitats.
SS Credit 8: Light pollution reduction	To minimize light trespass from the building and site, reduce sky-glow to increase night sky access, improve night-time visibility through glare reduction and reduce development impact from lighting on nocturnal environments.
WE Prerequisite 1: Minimum indoor plumbing fixture and fitting efficiency	To reduce indoor fixture and fitting water use within buildings so that the burdens on potable water supply and wastewater systems will be reduced.
WE Credit 1: Water performance measurement	To measure building and subsystem water performance over time to understand consumption patterns and identify opportunities for additional water savings.
WE Credit 2: Additional indoor plumbing fixture and fitting efficiency	To maximize indoor plumbing fixture and fitting efficiency in buildings to reduce the use of potable water13 and consequent burden on municipal water supply and wastewater systems.
WE Credit 3: Water efficient landscaping	To limit or eliminate the use of potable water14, or other natural surface or subsurface resources available on or near the project site, for landscape irrigation.
WE Credits 4.1-4.2: Cooling tower water management	To reduce potable water15 consumption for cooling tower equipment through effective water management and/or use of non-potable make-up water.
EA Prerequisite 1: Energy efficiency best management practices – planning, documentation and opportunity assessment	To promote continuity of information to ensure that energy-efficient operating strategies are maintained and provide a foundation for training and system analysis.

EA Prerequisite 2: Minimum energy efficiency performance	To establish the minimum level of operating energy efficiency performance relative to typical buildings of a similar type to reduce environmental and economic impacts associated with excessive energy use.
EA Prerequisite 3: Fundamental refrigerant management	To reduce stratospheric ozone depletion.
EA Credit 1: Optimize energy efficiency performance	To achieve increasing levels of operating energy performance relative to typical buildings of a similar type to reduce environmental and economic impacts associated with excessive energy use.
EA Credit 2.1: Existing building commissioning – Investigation and analysis	Through a systematic process, to develop an understanding of the operation of the building's major energy-using systems, options for optimizing energy performance and a plan to achieve energy savings.
EA Credit 2.2: Existing building commissioning – implementation	To implement minor improvements and identify planned capital projects to ensure that the building's major energy-using systems are repaired, operated and maintained effectively to optimize energy performance.
EA Credit 2.3: Existing building commissioning – ongoing commissioning	To use commissioning to address changes in facility occupancy, use, maintenance and repair. Make periodic adjustments and reviews of building operating systems and procedures essential for optimal energy efficiency and service provision.
EA Credit 3.1: Performance measurement – building automation system	To provide information to support the ongoing accountability and optimization of building energy performance and identify opportunities for additional energy-saving investments.
EA Credit 3.2: Performance measurement – system-level metering	To provide accurate energy-use information to support energy management and identify opportunities for additional energy-saving improvements.
EA Credit 4: On-site and off-site renewable energy	To encourage and recognize increasing levels of on- and off-site renewable energy to reduce environmental and economic impacts associated with fossil fuel energy use.
EA Credit 5: Enhanced refrigerant management	To reduce ozone depletion and support early compliance with the Montreal Protocol while minimizing direct contributions to global climate change.
EA Credit 6: Emissions reduction reporting	To document the emissions reduction benefits of building efficiency measures.
MR Prerequisite 1: Sustainable purchasing policy	To reduce the environmental impacts of materials acquired for use in the operations, maintenance and upgrades of buildings.
MR Prerequisite 2: Solid waste management policy	To facilitate the reduction of waste generated by building occupants that is hauled to and disposed of in landfills or incineration facilities.
MR Credit 1: Sustainable Purchasing – ongoing consumables	To reduce the environmental and air quality impacts of the materials acquired for use in the operations and maintenance of buildings.
MR Credits 2.1-2.2: Sustainable purchasing – durable goods	To reduce the environmental and air quality impacts of the materials acquired for use in the operations and maintenance of buildings.
MR Credit 2.1: Electric-powered equipment	
MR Credit 2.2: Furniture	
MR Credit 3: Sustainable purchasing – facility alterations and additions	To reduce the environmental and air quality impacts of the materials acquired for use in the upgrade of buildings.
MR Credit 4: Sustainable purchasing – reduced mercury in lamps	To establish and maintain a toxic material source reduction programme to reduce the amount of mercury brought onto the building site through purchases of lamps.

MR Credit 5: Sustainable purchasing – food	To reduce the environmental and transportation impacts associated with food production and distribution.
MR Credit 6: Solid waste management – waste stream audit	To facilitate the reduction of ongoing waste and toxins generated by building occupants and building operations that are hauled to and disposed of in landfills or incineration facilities.
MR Credit 7: Solid waste management – ongoing consumables	To facilitate the reduction of waste and toxins generated from the use of ongoing consumable products by building occupants and building operations that are hauled to and disposed of in landfills or incineration facilities.
MR Credit 8: Solid waste management – durable goods	To facilitate the reduction of waste and toxins generated from the use of durable goods by building occupants and building operations that are hauled to and disposed of in landfills or incineration facilities.
MR Credit 9: Solid waste management – facility alterations and additions	To divert construction and demolition debris from disposal to landfills and incineration facilities. Redirect recyclable recovered resources back to the manufacturing process and reusable materials to appropriate sites.
IEQ Prerequisite 1: Minimum indoor air quality performance	To establish minimum indoor air quality (IAQ) performance to enhance indoor air quality in buildings, thus contributing to the health and well-being of the occupants.
IEQ Prerequisite 2: Environmental Tobacco Smoke (ETS) control	To prevent or minimize exposure of building occupants, indoor surfaces and systems to environmental tobacco smoke (ETS).
IEQ Prerequisite 3: Green cleaning policy	To reduce the exposure of building occupants and maintenance personnel to potentially hazardous chemical, biological and particulate contaminants, which adversely affect air quality, human health, building finishes, building systems and the environment.
IEQ Credit 1.1: Indoor Air quality best management practices – Indoor air quality management program	To enhance indoor air quality (IAQ) by optimizing practices to prevent the development of indoor air quality problems in buildings, correcting indoor air quality problems when they occur and maintaining the well-being of the occupants.
IEQ Credit 1.2: Indoor Air quality best management practices – Outdoor air delivery monitoring	To provide capacity for ventilation system monitoring to help sustain occupant comfort and well-being.
IEQ Credit 1.3: Indoor air quality best management practices – Increased ventilation	To provide additional outdoor air ventilation to improve indoor air quality (IAQ) for improved occupant comfort, well-being and productivity.
IEQ Credit 1.4: Indoor air quality best management practices – reduce particulates in air distribution	To reduce exposure of building occupants and maintenance personnel to potentially hazardous particulate contaminants, which adversely affect air quality, human health, building systems and the environment.
IEQ Credit 1.5: Indoor air quality best management practices – Indoor air quality management for facility alterations and additions	To prevent indoor air quality (IAQ) problems resulting from any construction or renovation projects to help sustain the comfort and well-being of construction workers and building occupants.
IEQ Credit 2.1: Occupant comfort – occupant survey	Intent: To provide for the assessment of building occupants' comfort as it relates to thermal comfort, acoustics, indoor air quality (IAQ), lighting levels, building cleanliness and any other comfort issues.
IEQ Credit 2.2: Controllability of systems – lighting	To provide a high level of lighting system control by individual occupants or groups in multi-occupant spaces (e.g. classrooms or conference areas) to promote the productivity, comfort and well-being of building occupants.

IEQ Credit 2.3: Occupant comfort – thermal comfort monitoring	To support the appropriate operations and maintenance of buildings and building systems so that they continue to meet target building performance goals over the long term and provide a comfortable thermal environment that supports the productivity and well-being of building occupants.
IEQ Credit 2.4: Daylight and views	To provide building occupants with a connection between indoor spaces and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building.
IEQ Credit 3.1: Green cleaning – High-performance cleaning programme	To reduce the exposure of building occupants and maintenance personnel to potentially hazardous chemical, biological and particulate contaminants, which adversely affect air quality, human health, building finishes, building systems and the environment.
IEQ Credit 3.2: Green cleaning – Custodial effectiveness assessment	To reduce the exposure of building occupants and maintenance personnel to potentially hazardous chemical, biological and particulate contaminants, which adversely affect air quality, human health, building finishes, building systems and the environment, by implementing, managing and auditing cleaning procedures and processes.
IEQ Credit 3.3: Green cleaning – Purchase of sustainable cleaning products and materials	Intent: To reduce the environmental impacts of cleaning products, disposable janitorial paper products and trash bags.
IEQ Credit 3.4: Green cleaning – Sustainable cleaning equipment	To reduce the exposure of building occupants and maintenance personnel to potentially hazardous chemical, biological and particulate contaminants that adversely affect air quality, human health, building finishes, building systems and the environment, from powered cleaning equipment.
IEQ Credit 3.5: Green cleaning – Indoor chemical and pollutant source control	To reduce the exposure of building occupants and maintenance personnel to potentially hazardous chemical, biological and particulate contaminants that adversely affect air quality, human health, building finishes, building systems and the environment.
IEQ Credit 3.6: Green cleaning – Indoor integrated pest management	To reduce the exposure of building occupants and maintenance personnel to potentially hazardous chemical, biological and particulate contaminants that adversely affect air quality, human health, building finishes, building systems and the environment.
IO Credit 1: Innovation in operations	To provide building operations, maintenance and upgrade teams with the opportunity to achieve additional environmental benefits achieved beyond those already addressed by the LEED 2009 for Existing Buildings: Operations and Maintenance Rating System.
IO Credit 2: LEED® Accredited professional	To support and encourage the operations, maintenance, upgrade and project team integration required by LEED to streamline the application and certification process.
IO Credit 3: Documenting sustainable building cost impacts	To document sustainable building cost impacts.
RP Credit 1: Regional priority	To provide an incentive for the achievement of credits that address geographically specific environmental priorities.

3.3 Best environmental practices

3.3.1 Systems assessment

Using a systematic process, a thorough understanding of the operation of the building's major energy-using systems should be undertaken with the goal of the development of a plan to optimize energy performance and efficiency. As an example of such a systemic process would be to conduct an energy audit that meets the requirements of the American Society of Heating, Refrigerating and Air- Conditioning Engineers (ASHRAE), Level II, Energy Survey and Analysis.

3.3.2 Building exterior and site

To operate a building in a more environmentally friendly manner, a plan to deal with the issue of the building site and outside operation and landscaping should be developed.

Areas to be considered could include:

- ice and snow removal;
- exterior cleaning;
- low water landscaping;
- green procurement;
- integrated or natural pest control;
- erosion control;
- availability and promotion of alternative or lower impact transportation;
- elimination of gasoline powered maintenance equipment and vehicles;
- reduction of heat island effect;
- open grid parking structures;
- storm-water management.

3.3.3 Building management system

The U.S. Green Buildings Council (USGBC) estimates that commercial office buildings use 20% more energy on average than necessary. Thus, implementing sustainable building operations provides an opportunity to optimize energy efficiency and reduce GHG emissions.

Building management systems (BMSs) use ICT hardware and software to manage many functions of a building which can include heating, ventilation and air conditioning (HVAC), lighting, electric power, security, access control, and fire management among others.

The features of BMS include the monitoring, controlling and optimizing of the above-mentioned systems with the goal of improving energy efficiency without impacting on the comfort of building occupants.

Another potential area for BMS use is with the continued expansion of the Smart Grid. The BMS can be used to minimize costs through reductions in electricity purchases based on real-time demand/pricing signals from the grid and the integration of renewable energy sources into a buildings electricity mix.

3.3.4 Lighting

Recent advances in lighting technology (including LEDs and higher efficiency fluorescents) can dramatically reduce electricity usage and costs. Many of these new innovations are especially useful in applications that require lighting to be turned on for an extended period of time, as they also have the benefit of extended lifetimes which reduce the overall life cycle costs. When designed properly, an LED circuit will approach 80% efficiency, which means 80% of the electrical energy is converted to light energy, and the remaining 20% is lost as heat energy.

3.3.5 Waste

A waste audit of a building's ongoing waste stream provides a benchmark that can be used to develop policies, procedures, recycling and reduction programmes to divert waste from landfill sites.

3.3.6 Sustainable procurement

Policies and procedures for more sustainable procurement can have a bearing on the environmental impact of a building and the comfort level for the occupants of the building. Green procurement standards that maximize energy efficiency can lead to a reduction in building energy demand. Procurement policies that minimize packaging and food waste result in lower cost and volume for solid waste removal. Procurement standards that minimize chemicals known to negatively affect indoor air quality through a process of prohibition or preferential treatment for substitutes (e.g. green cleaning supplies, low off gassing of new materials) will ensure a higher level of building occupant comfort and satisfaction.

This may be a key area for enhancing sustainability of projects. For example, in 2004 it was identified that the National Health Service (NHS) in the UK is responsible for 25% of England's public sector emissions; three primary sectors are namely responsible for this: travel (18%), building energy (22%) and procurement (60%). Procurement therefore provides a great opportunity to reduce a building's carbon footprint.

A study done by the Sustainability Development Commission and Stockholm Environment Institute showed that procurement, materials and transport can have a greater impact on carbon emission than the energy required running a facility (Sustainable development commission, 2009).

Case Study: FBI regional headquarters, Chicago, USA

The FBI Chicago Field Office[17] is over 800 000 square feet, a three-building complex consisting of a ten-story office building, two separate guard shacks, a two-level structured parking deck, two levels of below-grade parking that total 200 000 square feet, and a connecting one-story vehicular annex facility that is over 50 000 square feet. At any time, the facility can have from 650 to 700 employees, with these totals fluctuating higher on a frequent basis. The Chicago FBI is the only tenant and the project was designed as a build-to-suit for the government. Although the building was not rated green during construction, USAA pursued certification post-occupancy and, in December of 2008, was awarded the world's first LEED Platinum certification under the LEED for Existing Buildings: Operations and Maintenance rating system from USGBC.

USAA's approach to sustainability efforts is to drive the business case. Specifically, the team effort to improve efficiency and reduce the environmental impact was driven by the desire to maximize occupant comfort, as well as improve financial performance. The facility has many sustainable policies in place that have helped us achieve an ENERGY STAR rating of 95% and water use reduction of 43%.

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17 http://demo.usgbc.name/projects/fbi-regional-headquarters.

The exterior is comprised of a highly-finished architectural pre-cast concrete expressing a ten-foot module around openings consisting of light blue vision glass and a bluish-coloured spandrel glass panel. The combination of these two materials results in a very glassy looking building and conveys an attractive and professional appearance of this government facility. The parking garage is constructed of the same pre-cast material as the office building and is recessed into the landscape while surrounded by dense plantings.

The office building features a dramatic two-level main entryway with a large glass “net-wall” which has a stressed cable structure support. These very transparent and innovative walls help visually and symbolically connect the inner space to the exterior plaza. The main lobby features marble panels on the west wall, granite flooring, and pre-cast concrete with wood panels on the north and south walls. Additional features include upgraded general office areas, granite walls in the elevator lobbies, and upgraded executive office areas and conference rooms with materials such as granite, custom millwork and fabric wall covering.

The building’s facade, primarily composed of architectural pre-cast concrete, is a green material readily available from sources near the site and easily recycled at the end of a product’s life. The exterior walls with the 60% pre-cast concrete and high-performance, low-emissive glass creates a very energy-efficient envelope. Larger column bays and spans increase natural light and views to the outside. The window areas on the exterior translate to ample daylight for the interior, with large window units extending from the nine-foot, six-inch ceilings to a low sill height of approximately twenty inches above the finished floor. The result is enhanced employee comfort and productivity.

The project site is 12 acres located just west of downtown Chicago in an area called the Illinois Medical District. The FBI Chicago complex creates a major landscaped green space along the entire Roosevelt Road and Damen Avenue frontages, totalling approximately four acres or 40% of the entire site area.

The facility is located in the west loop area of Chicago, Illinois, and the overall design concept embodies the key features of a modern class-A private sector office building development, including: sensitivity to the neighbourhood context; creation of a flexible and attractive workplace; and inclusion of low environmental impact design concepts.

The land was previously used as a bus depot that had exceeded its useful life. The removal of this depot and the other undesirable material left on the site contributed to the revitalization of the area.

3.4 Existing buildings: checklist

Figure 14: LEED 2009 for Existing Buildings: Operations and Maintenance project checklist

Sustainable sites		**26 possible points**
Credit 1	LEED certified design and construction	4
Credit 2	Building exterior and hardscape management plan	1
Credit 3	Integrated pest management erosion control and landscape management plan	1
Credit 4	Alternative commuting transportation	3-15
Credit 5	Site development: protect or restore open habitat	1
Credit 6	Storm-water quantity control	1
Credit 7.1	Heat island reduction: non-roof	1
Credit 7.2	Heat island reduction: roof	1
Credit 8	Light pollution reduction	1
Water efficiency points		**14 possible points**
Prerequisite 1	Minimum indoor plumbing fixture and fitting efficiency	Required

Credit 1	Water performance measurement	1-2
Credit 2	Additional indoor plumbing fixture and fitting efficiency	1-5
Credit 3	Water efficient landscaping	1-5
Credit 4.1	Cooling tower water management: chemical management	1
Credit 4.2	Cooling tower water management: non-potable water source use	1
Energy and Atmosphere		**35 possible points**
Prerequisite 1	Energy efficiency best management practices: planning, documentation and opportunity assessment	Required
Prerequisite 2	Minimum energy efficiency performance	Required
Prerequisite 3	Fundamental refrigerant management	Required
Credit 1	Optimize energy efficiency performance	1-18
Credit 2.1	Existing building commissioning: investigation and analysis	2
Credit 2.2	Existing building commissioning: implementation	2
Credit 2.3	Existing building commissioning: ongoing commissioning	2
Credit 3.1	Performance measurement: building automation system	1
Credit 3.2	Performance measurement: system level metering	1-2
Credit 4	On-site and off-site renewable energy	1-6
Credit 5	Enhanced refrigerant management	1
Credit 6	Emissions reduction reporting	1
Materials and resources		**10 possible points**
Prerequisite 1	Sustainable purchasing policy	Required
Prerequisite 2	Solid waste management policy	Required
Credit 1	Sustainable purchasing: ongoing consumables	1
Credit 2.1	Sustainable purchasing: electric-powered equipment	1
Credit 2.2	Sustainable purchasing: furniture	1
Credit 3	Sustainable purchasing: facility alterations and additions	1
Credit 4	Sustainable purchasing: reduced mercury in lamps	1
Credit 5	Sustainable purchasing: food	1
Credit 6	Solid waste management: waste stream audit	1
Credit 7	Solid waste management: ongoing consumables	1
Credit 8	Solid waste management: durable goods	1
Credit 9	Solid waste management: facility alterations and additions	1
Indoor environmental quality		**15 possible points**
Prerequisite 1	Minimum indoor air quality performance	Required
Prerequisite 2	Environmental Tobacco Smoke (ETS) control	Required
Prerequisite 3	Green cleaning policy	Required
Credit 1.1	Indoor air quality best management practices: Indoor air quality management program	1
Credit 1.2	Indoor air quality best management practices: outdoor air delivery monitoring	1
Credit 1.3	Indoor air quality best management practices: Increased ventilation	1
Credit 1.4	Indoor air quality best management practices: Reduce particulates in air distribution	1

Figure 15: LEED 2009 for Existing Buildings: scoring benchmarks	
LEED 2009 for Existing Buildings: Operations and Maintenance	
100 base points; 6 possible Innovation in Operations and 4 Regional Priority points	
Certified	40-49 points
Silver	50-59 points
Gold	60-79 points
Platinum	80 points and above

4 Building improvement

This section gives an overview of sustainability considerations that can be taken into account during the improvement or renovation phase of a building's life.

Building efficiency is essential to reducing energy consumption. The International Energy Agency shares as part of their World Energy Outlook that buildings account for 16% of the global energy consumption, and in the U.S. nearly 40% of the country's total energy use is for buildings. While commercial buildings are constructed each year, often to a high level of efficiency, the majority of opportunities in reducing energy consumption over the next few decades lie in existing building retrofits. This section will provide an overview of some of these opportunities.

4.1 Overview

There are many benefits to performing a building retrofit outside of energy efficiency, for example:

- **Increased building value** – Based on added building efficiency and modernization, a study conducted in 2009 by Henley University in the UK found that building sale prices could be increased by as much as 35% when LEED certified, and 31% if ENERGY STAR certified. These certified buildings were compared to comparable non-certified buildings when controlling for differences in lease contract, age, height, quality, and sub-market. For non-certified buildings, their value was increased by 5%.
- **Increased rent premiums** – According to a study sponsored by the Royal Institute of Chartered Surveyors, building owners can expect between 3% to 6%increases in rent premiums for certified eco-efficient buildings over their traditional counterparts.
- **Lower occupancy cost for tenants** – While higher rent prices can be expected for energy efficient buildings, this does not necessarily translate into higher occupancy costs. Lower energy usage, water consumption and healthier work environments all attribute to potential occupancy savings. There is also the potential for tenants and owners to split improvement costs over the term of the lease.
- **Fewer vacant buildings** – Occupancy rates are approximately 3% to 6% higher for certified spaces over comparable non-certified spaces, according to a research conducted by the University of Reading, UK.
- **Improved public relations and marketing value** – Energy efficiency and eco-efficient operations are becoming an important part of brand identity and has increased promotional value.
- **Reduced ownership risk** – Increased regulations on Greenhouse Gas emissions will have a probable impact on all energy-using sectors and society. These regulations will likely increase the cost of energy and have an impact on building operations. Therefore, the more efficient building operations are, the less impact these potential cost increases will have on building operations.

Building retrofits need to be implemented systematically. In order to complete such a project effectively and efficiently, there are a number of steps that should be taken to make sure that every improvement is measured.

The basic objectives of any building retrofit should include:

- Improve building performance by reducing energy consumption and associated operational expenses
- Improve building efficiency by reducing water consumption through operations management and fixture choices
- Improve indoor environmental comfort and quality for tenants
- Document and audit all improvements
- Divert construction waste from landfill.

A building retrofit can be conducted in depth, or it can focus just on the most significant areas of energy use and loss.

4.2 Standards

BRE Global is developing a new scheme for the assessment of non-domestic building refurbishment scheduled for launch in the summer of 2012. Further, LEED Standards for new construction can also be applied to major renovations.

4.3 Best practices

4.3.1 Data gathering and benchmarking

A preliminary step to any building retrofit is the establishment of the existing operating baseline. Some of these key steps, as defined by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), are:

- Whole Building Energy Use (WBEU) analysis based on historic utility bills for cost and comparison. This data is used to compare this facility to other similar facilities
- Comfort indexes – Compare the actual comfort conditions to the comfort requirements
- Energy indexes, energy demands divided by heated/conditioned area, allowing comparison with reference values of the indexes coming from regulation or similar buildings
- Actual energy demands.

4.3.2 Building audits

A building audit will identify ways to improve the overall building efficiency.

The main areas the audit should cover are:

- building and utility data, equipment analysis and energy bills;
- operating conditions and location of facility – seasonal factors;
- occupancy and operating schedule;
- evaluation of energy conservation measures currently in place;
- estimation of potential energy savings;
- identification of any customer specific requirements.

ASHRAE has defined three types of building energy audits, varying by rigor and detail:

Level I: walk-through survey

- Preliminary analysis to assess building energy efficiency and to identify simple and low-cost improvements.
- Based on visual verifications, study of installed equipment and operating data and detailed analysis of recorded energy consumption collected during the benchmarking phase.
- Simplest and quickest type of audit − Minimal interviews with building operators, a brief review of facility utility bills and other operating data, and a walk-through of the facility to become familiar with the building operation and to identify any glaring areas of energy waste or inefficiency.
- Quick estimates of implementation cost, potential operating cost savings, and simple payback periods are provided.
- A list of energy conservation measures (ECM) or energy conservation opportunities (ECOs) requiring further consideration also provided.

Level II: detailed survey and energy analysis

- Based on the results of the pre-audit (benchmarking and level I)
- Energy use survey to provide a comprehensive analysis of the facility
- Quantitative evaluation of the ECOs/ECMs
- Can involve on-site measurements and sophisticated computer-based simulation tools to evaluate precisely the selected energy retrofits
- Utility bills are collected for a 12- to 36-month period to allow the auditor to evaluate the facility's energy/demand rate structures and energy usage
- Additional metering of specific systems is often performed to supplement utility data
- In-depth interviews with facility managers are conducted to provide a better understanding of major energy consuming systems and to gain insight into short and longer term energy consumption patterns
- Detailed financial analysis for each recommendation including implementation costs, operating savings, and investment criteria.

Level III: detailed analysis of capital-intensive modifications, also known as an investment grade audit (IGA)

- Detailed analysis of capital improvements focusing on ECOs requiring rigorous engineering study
- Evaluate return on Investment (ROI)
- Complete engineering study to justify capital investment.

4.3.3 Other best practices

In addition to energy management, there are other areas that should be focused on for a building retrofit.

4.3.3.1 Interior building considerations

- Energy consumption should include emission and consumption reduction strategies, building automation systems and the use of renewable energy
- Water efficiency should be evaluated both leveraging opportunities for water efficient fixtures (low flow toilets and sinks) and efficient water chillers and leveraging recirculation of water, where appropriate

- Indoor environment fixtures – Adding such things as waste stream diversion (recycling), recycled content and low volatile organic compounds (VOCs) for furniture, thermal comfort levels utilizing efficient HVAC settings, energy efficient lighting, lighting sensors and timers, and maximization of daylight
- Janitorial productions – Use of biodegradable products for cleaning
- Painting – Use of low VOC paints for any new application
- Janitorial productions – Use of biodegradable products for cleaning.

4.3.3.2 Exterior building considerations

- Landscaping – Use only regional appropriate flora, or use of xeriscaping practices which eliminate and minimize the need for supplemental watering, and if watering is required, ensure sprinkling at optimal times of the day and employ the use of rain sensors to shut off automatic sprinkling in times of rain
- Employ a light coloured roofing substrate to minimize heat absorption and install solar panels to supplement grid energy use
- Install bike racks and provide easy access to bus or rail lines – Encourage employees to use alternative transportation options.

4.4 Metrics

Below are some of the key metrics to consider tracking efficiency measures, comparing before and after results:

- kWh consumption/savings – look at totals;
- gallons of water consumed/savings;
- total metric tons CO_2e;
- visible light transmittance;
- foot candles – daylight illumination.

5 Technical buildings and outside plant

This section gives an overview of sustainability considerations which can be taken into account for specialized buildings appropriate to the ICT industry, specifically data centers.

5.1 Overview

Data centers are typically very energy-intensive buildings, due to the ICT equipment located within. While the design of the IT infrastructure within a data center has a major impact on total energy usage, the principles of green building design can also be implemented within the building framework and surrounding area to maximize environmental benefits. A well designed building, which will house a data center, will allow for the design of the IT Infrastructure that maximizes energy efficiency. While other types of buildings may exist, there are no specific standards that have been formalized. The use of standard green building guidelines would be appropriate to those situations.

5.2 *Standards*

5.2.1 BREEAM New Construction: data centers

BREEAM data centers[18] are an assessment method and certification scheme that can be used at the design, construction, and refurbishment phases of the building's life cycle. The scheme is used to assess the environmental impact of unoccupied or occupied data center buildings.

Data centers are used to house computer systems and associated components, such as telecommunications and storage systems. These buildings tend to be heavy consumers of energy and, as they have grown in number, interest in applying BREEAM to assess their environmental impacts has also grown.

Launched in 2010, the BREEAM data centers scheme allows for the assessment of this specialized type of building using the standard BREEAM methodology. The scheme recognizes the data centers energy intensive nature, and the rewarding efforts to reduce this impact. This is balanced against the need to reduce other key environmental impacts. Associated with the construction and operation of buildings, BREEAM data centers assessments can be carried out on:

- new data center buildings;
- major refurbishment of existing data center buildings;
- fit-outs of existing data center buildings.

[18] www.breeam.org/page.jsp?id=157.

Figure 16: Weightings on BREEAM data assessments

BREEAM Section	Weighting (%)		
	New builds, extensions & major refurbishments		
Data Centre type e.g. Data hall with;	Large associated function areas	Small associated function areas	No associated function areas
Management	12	12	12
Health & Wellbeing	10	10	0
Energy	37	39.5	44.5
Transport	5	0	0
Water	8.5	9	10.5
Materials	7	7.5	8.5
Waste	4.5	5	5.5
Land Use & Ecology	6	6.5	7
Pollution	10	10.5	12
Innovation	10	10	10

BREEAM Section	Weighting (%)		
	Building fit-out only		
Data Centre type e.g. Data hall with;	Large associated function areas	Small associated function areas	No associated function areas
Management	12.5	12.5	12.5
Health & Wellbeing	10.5	10.5	0
Energy	39.5	42.5	48.5
Transport	5.5	0	0
Water	9	10	11
Materials	7.5	8	9
Waste	5	5	6
Land Use & Ecology	0	0	0
Pollution	10.5	11.5	13
Innovation	10	10	10

An additional 1% score can be added to a building's final BREEAM score for each Innovation credit achieved. The maximum number of Innovation credits that can be awarded for any one building assessed is 10; therefore, the maximum available score achieved for 'innovation' is 10%. Innovation credits can be awarded regardless of the final BREEAM rating, i.e. they are awardable at any BREEAM rating level.

There are three different ways in which a building can achieve an Innovation credit (all of which are summarized below). The first is by meeting exemplary performance criteria for an existing BREEAM issue:

Figure 17: BREEAM Innovation credit sources

Man 2 - Considerate Constructors
Hea 1 - Daylighting
Hea 14 - Office Space (BREEAM Retail & Industrial & Data Centres Schemes only)
Ene 1 - Reduction of CO_2 emissions
Ene 5 - Low or Zero Carbon Technologies
Wat 1 - Water Consumption
Wat 2 - Water Meter
Mat 1 - Materials Specification
Mat 5 - Responsible Sourcing of Materials
Wst 1 - Construction Site Waste Management

The second route is where the client/design team sets specific BREEAM performance targets/objectives and appoints a BREEAM Accredited Professional (AP) throughout the key project work stages to help deliver a building that meets the performance objectives and target BREEAM rating.

The final and third route is where an application is made to BRE Global by the BREEAM assessor to have a particular building feature, system or process recognized as 'innovative'. If the application is successful, an Innovation credit can be awarded.

5.3 Best practices

Case study: British Geological Survey data center, Nottingham, UK

The new computer suite at the British Geological Survey Campus at Keyworth in Nottingham19 is located within the courtyard of Blocks J, P, W and the new William Smith building on the campus.

The building is a data center in which existing data processing facilities are to be re-housed. The building is a direct replacement for the existing computer suite. It also provides space for future expansion of computing facilities. The building is unoccupied with control for the center operated from a nearby building. As such, none of the BREEAM Transport and Health and Well-being sections were applicable to the assessment.

The building will provide space for up to 52 server racks. The data center will process and store data produced by the British Geological Survey. The new building is intended to improve the efficiency of the technical facilities in terms of performance, energy efficiency and space standards. No demolition is required and a landscape scheme is proposed as an integral part of the development. The development will be linked to the existing campus and footpaths by a new corridor link and footpaths.

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[19] www.breeam.org/page.jsp?id=310.

The Natural Environment Research Council (NERC) and the British Geological Survey (BGS) required in the brief of the project that an Excellent rating should be achieved. This requirement followed the achievement of another BREEAM Excellent rating for another office building in the same campus and is part of the master plan for the whole site.

Key facts

- BREEAM rating: excellent;
- Score: 75.79%;
- Size: 172 m^2 (GIFA);
- Stage: design and procurement;
- BREEAM version: data centers 2010 (PILOT).

Overview of environmental features

- waste heat from process recovered and used to heat the nearby core store building;
- overall 22% CO_2 emissions reduction due to reuse of waste heat;
- highly efficient energy use: power use effectiveness 1.34 (1.20 when core store building and waste heat recovered included) (Gold Standard < 1.43);
- Turbocor chiller cooling systems;
- use of construction materials with a very low environmental impact (Green Guide A-rated walls, roof, floor finishes/coverings, and hard landscaping and boundary protection);
- responsibly-sourced low thermal insulation levels specified to optimize energy demand and heat recovery;
- energy efficient external lighting;
- sustainable procurement policy adopted by the Research Councils' Shared Service Center (RCUK SSC);
- extensive storm water management plan SWMP covering several projects on the campus;
- use of recycled aggregates;
- substantial increase in ecological value of the site.

The BREEAM assessment

- waste: (100%);
- land use and ecology: (90%);
- water: (85.71 %);
- management: (75%);
- materials: (66.67%);
- energy: (65.38%);
- innovation: (50%).

Building services

Heat recovery was identified as the most sustainable method of utilizing the energy generated by the building operation. Alternative uses for the recovered heat were reviewed and the extension to the core store (existing Block N) was identified as the most appropriate use due to the space heating requirements and similar construction time-scales of this building. The principle is to utilize the heat generated by the servers to provide space heating to a core store extension by an underfloor heating system. For example, heat that would be normally rejected through the dry coolers is to be utilized for low grade underfloor heating.

The core store extension has a large thermal mass and there is a substantial heating demand for approximately 32 weeks of the year.

The internal heat gains from the server are significant and require mechanical ventilation systems to maintain acceptable temperatures around the server racks. Chilled water cooling is provided to the data center from Turbocor water chillers. The IT load is 300 kW; however, the system has been designed to be capable of being expanded to serve a further 300 kW IT load.

Power usage effectiveness (PUE) values of 1.34 and 1.20 (with heat recovered excluded/included, respectively) could still be reduced further by increasing heat recovery reuse in other spaces.

To provide best practice system redundancy, resilience and part load control, the cooling demand is to be provided via a combination of systems: dual "V" configuration chilled water cooling coils and DX back-up close control down flow units. This system provides multiple redundancy paths.

Green strategy

Construction site

Managed in an environmental and socially considerate and accountable manner demonstrated by the Considerate Constructors scheme target of 36. The data center is part of a larger master development with waste materials segregated for all developments using a communal waste segregation provided on site. At least 65% by volume of construction waste generated will be diverted from landfill and recycled by an approved waste management contractor.

Energy

The unit of measurement PUE was used to better understand the possible impact of influencing the design and specification data center to result in a more sustainable data center. From the typical standard of 2, this data center achieved a PUE of 1.34 and therefore achieved the Gold Standard.

The low/zero carbon technologies (i.e. waste heat from building process) installed will result in a 22.2% reduction in CO_2 emissions.

All IT equipment will be sustainably procured.

Land use and ecology

Emphasis in this area includes:

– reuse of land (brownfield);

– mitigation and enhancement of ecological impact.

Project team details

- Client: Natural British Geological Survey
- Project manager: Natural Environment Research Council
- Architects: Pick Everard
- Cost consultants: Pick Everard

- Building services engineers: Pick Everard
- Structural engineers: Pick Everard
- Contractor: Hallam Contracts
- BREEAM assessor: Pick Everard
- Sustainability Consultant: Pick Everard
- Landscape architect: Munro & Whitten
- Ecological consultant: Middlemarch Environmental.

5.4 Metrics

As with other BREEAM ratings, data centers can receive a rating of:

- Outstanding
- Excellent
- Very Good
- Good
- Pass.

6 Life cycle

In terms of the physical environment, it is estimated that good design can reduce energy costs by 25%, and by reducing energy bills, the overall costs will also be lower. Design quality and sustainability are therefore indivisible. As per the HM Treasury's Green Book, good design will not always result in the lowest initial capital cost. However, when expressed as a discount value, higher initial investment can over the life of the building result in lower whole life costs (Great Britain, Treasury, 2003).

A life cycle assessment (LCA) can help avoid a narrow outlook on environmental, social and economic concerns by assessing a full range of impacts associated with all the stages of a process from cradle-to-grave (i.e. from extraction of raw materials through material processing, manufacturing, distribution, use, repair and maintenance, and disposal or recycling). Impacts taken into account include (among others) embodied energy, global warming potential, resource use, air pollution, water pollution, and waste.

In terms of green building, the last few years have seen a shift away from a prescriptive approach, which assumes that certain prescribed practices are better for the environment, toward a scientific evaluation of actual performance through LCA.

Although LCA is widely recognized as the best way to evaluate the environmental impacts of buildings (ISO 14040 provides a recognized LCA methodology), it is not yet a consistent requirement of green building rating systems and codes, despite the fact that embodied energy and other life cycle impacts are critical to the design of environmentally responsible buildings.

In North America, LCA is rewarded to some extent in the Green Globes® rating system, and is part of the new American National Standard based on Green Globes, ANSI/GBI 01-2010: Green Building Protocol for Commercial Buildings. LCA is also included as a pilot credit in the LEED system, though a decision has not been made as to whether it will be incorporated fully into the next major revision. The state of California also included LCA as a voluntary measure in its 2010 draft Green Building Standards Code.

Although LCA is often perceived as overly complex and time consuming for regular use by design professionals, research organizations such as BRE in the UK and the Athena Sustainable Materials Institute in North America are working to make it more accessible.

In the UK, the BRE Green Guide to Specifications offers ratings for 1 500 building materials based on LCA.

In North America, the ATHENA® EcoCalculator for Assemblies provides LCA results for several hundred common building based on data generated by its more complex parent software, the ATHENA® Impact Estimator for Buildings. (The EcoCalculator is available free at www.athenasmi.org.) Athena software tools are especially useful early in the design process when material choices have far-reaching implications for overall environmental impact. They allow designers to experiment with different material mixes to achieve the most effective combination.

A more product-oriented tool is the BEES® (Building for Environmental and Economic Sustainability) software which combines environmental measures with economic indicators to provide a final rating. Particularly useful at the specification and procurement stage of a project, BEES 4.0 includes data on 230 products (including generic and manufacturer brands) such as siding and sheathing.

7 Checklist

There are a number of checklists listed in this document, usually sourced from the standards, such as LEED and BREEAM, that a company may be seeking for its buildings. In addition to those checklists, here is a basic checklist that an ICT organization may use in the management of its sustainability performance with respect to its buildings:

Figure 18: Checklist for managing building performance in ICT companies

Does the company have a defined policy for sustainable buildings? Provide details.	
Does the company have defined goals and targets for sustainable buildings? Provide details.	
What percentage of company space is certified to a green building standard? Provide details on type and location.	
Does the policy require that company buildings meet green building standards for design and construction?	
Provide details of what standard and what level of certification is specified.	
Does the policy require that leased space meet green building standards for design and construction?	
Provide details of what standard and what level of certification is specified.	
Does the policy require that company space meet green building standards for operations and maintenance?	
Provide details of what standard and what level of certification is specified.	
Does the company have defined policies and procedures for suppliers related to ongoing operations that promote sustainability?	
Provide details.	

8 Conclusions

Overall, there are green building standards available for almost every type of building on a global basis and these standards are well developed and continuously being updated. These standards cover all phases of a building's life cycle from design through demolition. They are also available in a number of national standards and codes.

What is clear is that good sustainability performance is not simply about working in buildings that have been designed to be "green". Buildings that have been designed with sustainability standards in mind need to be operated and maintained using sustainability standards. Buildings that were not designed to meet sustainability standards when they were built can also be upgraded to meet sustainability standards that have been put in place for existing buildings.

Clearly, the investments that ICT companies have to make with certain types of facilities, such as data centers, has made the application of this area of work important for the sustainability performance of the company, but also drives its financial performance.

With respect to ICT usage in buildings to monitor and manage building systems, there is an opportunity to review the landscape and ensure that standards are in place and being used to ensure that equipment and systems from all manufacturers are compatible with each other.

This potential lack of compatibility may constrain building owners and operators from improving their systems when potential equipment purchases lack compatibility with current systems due to proprietary standards.

9 Glossary

ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BEES	Building for Environmental and Economic Sustainability
BGS	British Geological Survey
BiQ	Building Intelligence Quotient
BMS	Building Management Systems
BOMA BESt	Version of the Green Globes system operated in Canada for existing buildings by BOMA Canada
BRE	Building Research Establishment, UK
BREEAM	Building Research Establishment's Environmental Assessment Method
CABA	Continental Association for Building Automation
CASBEE	Comprehensive Assessment System for Built Environment Efficiency
CSA	Canadian Standards Association
DGNB	German Sustainable Building Council
EA	Energy and Atmosphere
ECM	Energy Conservation Measures
ECO	Energy Conservation Opportunities
EEO	Toronto's Energy Efficiency Office

FSC	Forest Stewardship Council
GB Tool	Green Building Tool
GBCA	Green Building Council of Australia
GBI	Green Building Initiative
GBP	Green Building Programme
GCC	Gulf Cooperation Council
GHG	Greenhouse Gas Emissions
GRIHA	Green Rating for Integrated Habitat Assessment
HVAC	Heating, Ventilation and Air Conditioning
ID	Innovation in Design
IEQ	Indoor Environmental Quality
IGA	Investment Grade Audit
IgCC	International green Construction Code
JRC	European Commission Directorate General Joint Research Council
LCA	Life Cycle Assessment
LEED	Leadership in Energy and Environmental Design standards for designing, building and operating more environmentally-friendly buildings
MR	Materials and Resources
MRO	Maintenance, Repair and Operations
NERC	Natural Environment Research Council
NHS	National Health Service
PUE	Power Usage Effectiveness
RP	Regional Priority
SS	Sustainable Sites
TGS	Toronto Green Standard
UPC	Abu Dhabi Urban Planning Council
USGBC	United States Green Building Council
VOC	Volatile organic compound
WBEU	Whole Building Energy Use
WE	Water Efficiency

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