# SUSTAINABLE BUILDING EQUIPMENT: AN *EXCURSUS* THROUGH MAIN ENVIRONMENTAL PERFORMANCE RATING SYSTEMS. PART I: RESOURCE CONSUMPTIONS & ENVIRONMENTAL LOADINGS

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## ABSTRACT

Through the analysis of the main international environmental performance rating systems (BREEAM, LEED and GBTool) this work aims to show international design tendencies concerning sustainable building equipment requirements and to provide to designers and researchers a broad view of sustainable building equipment solutions. Hence a particular attention was paid to the assessment approach provided by these systems for each requirement, focussing on comparison of the building performance to a benchmark, compliance with qualitative indications or use of best technologies. Specifically this first part of the work focuses on the equipment requirements aiming to achieve less resource consumptions (minimization of energy and water use) and less environmental loadings (minimization of gases emissions due to energy consumptions, of the production of liquid wastes and of the impact on the site) during building construction, operation and management.

## KEYWORDS

Building equipment, sustainable, rating systems, energy, water, loadings.

## INTRODUCTION

A sustainable building equipment allows: the reduction of energy and water consumptions, the reduction of environmental loadings and the achievement of high levels of indoor environmental comfort for the occupants. Besides the building equipment has to be designed and managed as a high quality service that means being flexible, adaptable, easily controllable and maintainable. Rating systems, originally settled for assessing environmental performance of building projects on the basis of credits given to a set of performance criteria, can also be used from preliminary planning stages as useful guidelines and checklists for projects sustainability; among the other requirements many of these suggest explicitly or implicitly how to design, operate and manage a sustainable building equipment. Concerning the main rating systems, as BREEAM (British Research Establishment Environmental Assessment Method, version 1/93 for new office buildings), LEED Rating System (Leadership in Energy and Environmental Design Rating System, version 2.0 for new construction and major

renovations) and GBTool (Green Building Tool 2000, version for office buildings), in this work their sustainable issues pertinent to building equipment in new buildings design are compared, focussing on benchmarks, qualitative indications and best technologies. BREEAM was a world first and has since formed a basis for similar schemes in other countries: from the first version, launched in 1990 for new office buildings, it has been widely applied and adapted to many different kinds of buildings, ranging from residential to office and commercial buildings and continually updated to changing regulation requirements. BREEAM assessments are carried out by independent assessors licensed by BRE. LEED Rating System, developed under the USGBC (United States Green Building Council) is a self-assessing system designed for rating new and existing commercial, institutional and residential buildings; the version that the paper refers to is the second and has been followed by a third settled for assessing existing buildings. GBTool is an assessment framework for building projects developed under the Green Building Challenge, an international collaborative effort (made up of almost 20 participating countries) to set an international accepted framework for evaluating buildings environmental performances: many of the requirements can be adapted by national teams to the conditions of their own countries and regions.
This analysis, ranging from innovative wastewater technologies to non-polluting renewable energy technologies, offers a broad view of sustainable building equipment solutions and furthermore shows international planning tendencies. In particular this paper concentrate on the equipment requirements aiming to achieve less resource consumptions (in terms of less energy and water use) and less environmental loadings due to building construction, operation and management.

## RESOURCE CONSUMPTION

Among the four issues pertinent to building resource consumptions, in this paper energy and water are considered, since materials and land consumption aren't related and do not depend on building equipment.

### Energy

As regards the energy consumptions the three environmental performance rating systems concentrate on the comparison between the case study building performance and the benchmark, inferred from statistical data or from the performance of a reference building or from appropriate standards. GBTool assesses the annualised embodied energy consumption plus the annual primary delivered energy, normalised for net area and annual occupancy, of the building as a percentage of the benchmark value. In other words the method establish the extent to which the life cycle energy use of a building is less or greater than that of a reference building (i.e. a building of the same size and shape as the building being assessed, assuming a structural system, an envelope and a mechanical/electrical systems that would be typical for a conventional building in the region). Only two of the four aspects that the building life cycle energy use can be divided into are considered:

- Initial embodied energy, i.e. the energy required to produce the building;
- Operating energy, i.e. the energy required to operate the building (energy to condition –heat, cool and ventilate- to light the interior spaces, to power the equipments and other services);

while the recurring embodied energy, i.e. the energy required to maintain/refurbish the building over its life and the decommissioning energy, i.e. the energy required to demolish

and dispose the building at the end of its actual life aren't assessed.[1]
LEED suggests the comparison between the building performance and the benchmark value: it credits increasing levels of energy performance above a prerequisite standard. The requirement is to reduce energy cost for the building compared to the energy cost budget for regulated energy components described in ASHRAE/IESNA Standard 90.1-1999, as demonstrated by a whole energy simulation using an Energy Cost Budget Method. In the meantime, LEED considers as a fundamental prerequisite establishing a minimum level of energy efficiency: in fact it is considered compulsory to meet building energy efficiency and performance as required by ASHRAE/IESNA Standard 90.1-1999 or a local energy code, which ever is the more stringent. In addition to these two, it is required to supply a net fraction of the total energy costs in renewables for the building (through the employ of on-site renewable energy systems, using high temperature solar, geothermal, wind, biomass and biogas): the maximum number of credits is awarded if this fraction is equal to the 20 percent. Instead BREEAM focuses on the reduction of $CO_2$ emissions from building operation rather than on the consumption of delivered energy.

## Water

In order to reduce water consumptions the designers could compare the building performance to a benchmark, inferred from the performance of a reference building, or carry out some best technologies suitable for obtaining a good performance (the reduction of water consumptions both inside and outside the building or the increase of water consumption efficiency). GBTool suggests to benchmark the net annual consumption of water used for the building and related purposes against the performance of a conventional building that is similar to the building being assessed, in terms of function, population and operating schedule. The water consumption includes potable water used for toilet flushing and urinals, for sanitary uses, for occupant functions, for building equipment operations, for kitchen facilities and is measured in $m^3$ for kaph (number of thousand annual person hours of occupancy). BREEAM just impose to employ WC's with a maximum flushing capacity of 6 litres or less in order to obtain the credits. LEED provides a more complete approach to the subject, due to considering not only water consumption inside the building but also outside; it credits:

- the employ of strategies/technologies that use less water than the water use baseline calculated for the building (excluding irrigation) after meeting Energy Policy Act of 1992 fixture performance requirements, i.e. high water efficiency equipment, alternatives to potable water for sewage, recycled or storm water for HVAC process make up water;
- the use of high efficiency irrigation technologies, i.e. micro irrigation, moisture sensors, weather data based controllers, or the use of captured rain or recycled site water for irrigation needs;
- the reduction of the use of municipally provided potable water for building sewage conveyance, through the employ of innovative on site technologies as constructed wetlands, mechanical recirculating sand-filters or aerobic treatment systems.

[1] An assessment of recurring embodied energy would require a detailed analysis of the frequency and extent of the repair and replacement of all building materials and components as well as the energy required to produce them at the time of the replacement. Demolition energy represents a relatively small magnitude of life cycle energy use.

## ENVIRONMENTAL LOADINGS

As regards environmental loadings, the building equipment is responsible of the emissions due to energy consumptions, of the production of liquid wastes and of the impact of the building on the site and on adjacent properties.

### Emission of Green House Gases, ozone-depleting substances, gases leading to acidification

GBTool suggests for all the typologies of emissions -greenhouse gases (GHG), ozone depleting substances, gases leading to acidification- the comparison between the building performance and the benchmark values, inferred from the performance of a reference building. In particular, the emission of GHG are the sum of the total annualised embodied GHG emissions plus the annual operating GHG emissions, while the other two are only drawn from building operation. As GBTool BREEAM benchmarks the $CO_2$ production due to energy consumption of the building against precise standards, while LEED asks for qualitative requirements, as to engage in a two year contract to purchase power generated from renewable sources that meet the Centre for Resource Solutions (CRS) Green-E Requirements. The power that qualifies for this credit originates from solar, wind, geothermal, biomass or low-impact hydro sources. As regards the emissions leading to acidification, the last two methods suggest the use of technological solutions: LEED credits the employ of base building level HVAC and refrigeration equipment and fire suppression systems that do not contain HCFC's or Halon (while considering a compulsory prerequisite the zero use of CFC-based refrigerants in new base building HVAC systems and the CFC phase out conversion when reusing existing base building HVAC equipment) and BREEAM credits either the absence of air conditioning or the employ of refrigerant with low OPD (Ozone Depletion Potential) in air conditioning, the provision of refrigerant leak detection units and of suitable refrigerant recovery units and containers and the absence of Halon in fire suppression systems. BREEAM keeps crediting best technologies also for the reduction of emissions leading to acidification: in fact it awards the projects that specify boilers fitted with reduced $NO_x$ emitting burners and emitting $NO_x$ at a rate no higher than 200 mg/kWh of delivered energy.

### Liquid effluents

The matter of the reduction of liquid waste is handled both by GBTool and LEED with the suggestion of proper technological solutions: the first, with the assessment of the measures taken to reduce storm water flows (i.e. provision of on site storm water treatment using appropriately constructed and sized swales, sediment control ponds, pools and wetlands along drainage courses or infiltration basins) and sanitary waste flows (using composting toilets or biological sewage tertiary treatment system) to municipal system; the second, with the employ of constructed wetlands, storm water filtering systems, bio swales, bio-retention basins and vegetated filter strips for innovative storm water management.

### Impact on the site

The building equipment is also responsible for the impact of a building on site and on adjacent properties, in particular when considering the noise emissions affecting adjacent

properties, the thermal emissions to lake water or sub-surface aquifers and the light pollution. The first problem can be solved with the combination of noise reducing features of equipment and use of acoustic baffles or screens to reduce noise propagation outside the site boundaries during day and/or night, as suggested by GBTool, or by designing building services so that the rating level of the noise (measured outside the nearest exposed residential building) does not exceed some given limits, as suggested by BREEAM. Only LEED pays attention to the reduction of light trespass from the building site: the interior lighting and exterior, not exceeding Illuminating Engineering Society of North America (IESNA) foot-candle level requirements, must be designed such that zero direct-beam illumination leaves the building site the equipments. The last criterion subsists only for those buildings using ground source heat pumps: the designer ought to demonstrate that appropriate measures have been taken to maintain the thermal characteristics of lakes or sub-surface aquifers so they can be used by others.

## References


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