SUSTAINABLE BUILDING EQUIPMENT: AN *EXCURSUS* THROUGH MAIN ENVIRONMENTAL PERFORMANCE RATING SYSTEMS. PART II: INDOOR ENVIRONMENTAL QUALITY & QUALITY OF SERVICE

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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 the comparison of the building performance to a benchmark, on compliance with qualitative indications or use of best technologies. Specifically this second part of the work focuses on one hand on the equipment requirements aiming to achieve high levels of indoor environmental comfort for the occupants in terms of air quality and of thermal, visual and acoustical comfort; on the other hand on the requirements that an equipment must give to be an high quality service, that means being flexible and adaptable to changing requirements, easily controllable during the operation phase and capable of maintaining unchanged performance.

KEYWORDS

Building equipment, sustainable, rating systems, indoor, quality, service.

INTRODUCTION

The excursus through the main environmental rating systems (refer to the introduction to part I), 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 high levels of indoor environmental comfort for the occupants and on the requirements that enable building equipment to give an high quality service.

INDOOR ENVIRONMENTAL QUALITY

The building equipment has a great influence on indoor environmental quality, in terms of air quality and of thermal, visual and acoustical comfort.

Air Quality

Air quality pertains to aspects such as moisture and pollutant control inside the building, ventilation and fresh air delivery. As regards the moisture control inside the building qualitative requirements for the equipment prevail among the environmental performance rating systems analysed. In any case where a building HVAC system incorporates a chiller, humidifier, dehumidifier, heat exchanger, air washer or any other device introducing moisture into the building, GBTool gives the maximum score if:

- the cooling tower and the distribution system conforms to all the current recommendations and specifications for the prevention of Legionnaires Disease;
- the design and construction of the HVAC system is unlikely to accumulate standing water under all operating conditions;
- all air ducts are easily accessible for cleaning purpose;
- HVAC air handling systems is capable of maintaining indoor relative humidity of less than 55% in perimeter zones during the heating season in locations where exterior winter design temperatures are below 0°C.

BREEAM credits a design if it isn't provided with an air conditioning equipment, or if it isn't provided with a wet cooling tower or if air conditioning with wet cooling towers and evaporative condensers are designed to the specification described in CISBE TM13.
In order to minimize or eliminate indoor pollutant at source the three methods requirements for the equipment are equally shared among the three assessment typologies suggested (comparison to benchmark values, qualitative requirements, provision of best technologies). The pollutant control pertains to:

- the mineral fibre control in air plenums and in the HVAC distribution system;
- the location of outdoor air supply;
- the filtration performance in HVAC system;
- the airborne pollution migration between occupancies;
- the radon control (only in geological zones with known radon concentrations).

Only GBTool mentions the mineral fibre control, scoring the absence of asbestos containing materials or uncoated mineral duct liners in HVAC distribution system. Both GBTool and LEED ask for qualitative requirements in matter of airborne pollution migration between occupancies: the first gives the maximum score if the HVAC system is designed to provide future separate air supply and exhaust from all areas in the building that are likely to contain facilities generating pollutants such as cafeterias, graphic production areas or print rooms; the second credits the employ of areas with structural deck to deck partitions with separate outside exhausting, no recirculation and negative pressure where chemical use occurs (housekeeping areas and copying/print rooms). For the location of outdoor air supply GBTool benchmarks the distance of air intakes and exhaust against precise values (the maximum score is achieved whether air supply intakes for the building are located on the top floor or more than 15m above grade and more than 15m from exhaust or other sources of contaminated air) while LEED credits the employ of permanent entryway systems (grills, grates, etc.) to capture dirt, particulate, etc. from entering the building at all volume entryways. In order to control the migration of radon from radon-bearing soil to occupied spaces of the building, GBTool requires the presence of a separating zone between sub-grade areas and occupied areas pressurised and vented to the exterior, supplied with an alarm system connected to the main building management system.
For a suitable ventilation and fresh air delivery a project must be checked for the amount of outdoor air provided by the ventilation system, for the ventilation effectiveness, for the linkage between the HVAC systems and operable windows and for the filtration performance in HVAC systems. Both GBTool and BREEAM benchmark the total outdoor air provided by ventilation system against fixed values. GBTool handle the ventilation effectiveness in

occupant zone in detail, assessing whether the HVAC ventilation system supplies air directly to occupants, supply vents are capable of being easily relocated following major changes in office layout and occupants can easily control ventilation rates from their own workstations; instead LEED benchmarks air change effectiveness of the ventilation systems against the value of 0.9 according to ASHRAE 129-1997. GBTool considers pertinent to a sustainable equipment even the presence of a linkage between the HVAC systems and operable windows (so that the local HVAC zone shuts down when the window is open) and a good HVAC system filtration efficiency at 1.5 micron (assessed comparing the performance of the system with fixed values).

Thermal comfort

As regards the thermal comfort the three methods provide three quite different approaches, in which however qualitative requirements prevail: GBTool assesses both indoor air temperature and relative humidity in primary occupancies, comparing the performance values with specific benchmarks (respectively the percentage of occupied hours during the design year in which the air temperature is within comfort ranges and the percentage of relative humidity that may be maintained during the heating and the cooling season); LEED instead credits qualitatively the compliance of the HVAC system with ASHRAE standard 55-1992, including humidity control within established ranges per climate zones and the employ of a permanent temperature and humidity monitoring system (to provide operators control over thermal comfort performance and effectiveness of humidification and/or dehumidification systems in the building); BREEAM focuses on avoiding buildings overheating during the cooling season (requiring that a building design has been subjected to an assessment consistent with the CISBE Guide, volume A).

Visual comfort

For the visual comfort GBTool provides a mixed approach, between the performance comparison with benchmarks and the qualitative requirements: in fact it scores the level from ambient light fixtures comparing it with the industry norms, the possibility for the occupants of control over illumination levels and the absence of any glare conditions. BREEAM instead gives credits for specifying that best technologies are used (any fluorescent and other lamps with modulating/fluctuating output should be fitted with high frequency ballasts in all areas used for office work and for ensuring that CISBE Guidelines on horizontal illuminance are followed and that luminaries appropriate to the task to be undertaken are used).

Acoustical comfort

The rating systems deal also with the acoustical comfort, that comprises aspects such as the transmission of equipment noise to the occupancies and the noise attenuation between occupancies, mostly in a quantitative manner: in BREEAM noise levels within occupancies (building equipments noise contribute to increase them) are benchmarked against precise values, in GBTool all HVAC systems and equipment rooms are assessed comparing their Noise Criteria with fixed values and, besides, the measures/technologies adopted to isolate plumbing noise from the structure are evaluated.

QUALITY OF SERVICE

A building equipment, in order to be a service with high quality requirements and sustainable performance, has to be flexible and adaptable to changing requirements, easily controllable during the operation phase and capable of maintaining unchanged performance. Only GBTool deals with all these matters, for which qualitative requirements prevail.

Flexibility and adaptability

The flexibility and adaptability of the building technical systems is achieved by the adoption of design strategies which offer potential for adapting HVAC, lighting, cabling and telecom systems to changing occupant requirements and for facilitate future changes to a new type of energy supply. The maximum score is given when relocating all the systems listed above should be accomplished without repair or repainting of ceiling, walls or floors. The strategies to obtain such performance, for example the ease of adapting HVAC system for changing needs, is achieved by designing HVAC so that:

- it doesn't limit physical location or size of rooms;
- it is sufficiently diversified to accommodate operable windows;
- its flow of air is not affected by relocation of screens, walls, furniture;
- its adjustments and upgrades can be performed during fit-out or re-fit for a low cost;
- it can respond and effectively condition local spaces with little lead-time, all rooms are potentially serviced and it responds automatically to users actions.

The adaptability to future changes in type of energy supply is assessed by the extent to which the design of the building facilitates or hinders future changes to a new fuel source or to renewable energy technologies: in other words the maximum score is achieved whether adapting the building to a new fuel source or installing photovoltaics requires only minor adjustments to architectural, HVAC or electrical system.

Controllability of the systems

The controllability of the systems is assessed by the extent of design measures that ensure an appropriate control of major building systems: that means, according to GBTool, capability for partial operation of building technical systems, for control over heating and cooling systems and level of building automation appropriate to system complexity. Of these three criteria the first and the third are assessed basing on the compliance to qualitative requirements, while the second, credited by LEED in a quantitative manner, is assessed by means of the adoption of suitable technologies. The degree to which the building HVAC, lighting and control systems satisfy the need for part-floor and off hours service determine the capability for partial operation of building technical systems: if the control strategy for the passive, HVAC and lighting systems permits partial or off-hours service within all access corridors and in all workstation areas the maximum score is awarded. The strategies to achieve such performance include that:

- ventilation, temperature control, illumination and security systems could be switched on or off and adjusted floor by floor or by parts of a floor, either by the occupants or through occupancy sensors;
- air handling system is designed so that the ventilation for a part of one floor is met by fans that service no more than one floor;
- control is either by the building operator or an occupant group (from one office floor);
- no more than one hour lead time is required for changing operating hours or conditions.

The third criterion is assessed by the extent to which the level of sophistication of the building control strategy is consistent with the operational requirements of the building itself so that it can be easily understood and used by the operators and the occupants. The capability of personal control over the indoor environment is assessed differently by the two rating systems. To obtain the maximum score GBTool requires, in the dwelling units, that heating and cooling is controlled by separate thermostats for living and sleeping areas, thermostats are fully programmable and personal control over temperature, ventilation rates and local illumination levels is possible; for other type of occupancies that the building offers flexibility for each user while maintaining global indoor environment within acceptable limits. Instead LEED require to provide controls for each individual for airflow, temperature and lighting for 50% of the non perimeter, regularly occupied areas.

Maintenance of performance

The potential to maintain performance of building systems and critical performance parameters under abnormal conditions and the metering and monitoring of performance are the matters responsible for the maintenance of building equipment performance. The potential to maintain performance of building equipment is function of the accessibility and ease of maintenance of HVAC central and distribution system: GBTool evaluates the degree of accessibility for maintenance and replacement that, for the first, depends on the provision of sufficient space for central mechanical and electrical components and around them so that routine servicing is easy, while, for the second, on the presence of visible system gauges for monitoring, of signage to clearly indicate source and destination of specific sections of the delivery system, of accessible and easily demountable system sections and on minimization of duct run lengths and elbows. The ability to maintain critical performance parameters under abnormal conditions is assessed by the degree of building capability of maintaining full functionality under conditions outside of anticipated design conditions (temperature, rainfall, power and fuel supply): the provision of high building mass, the insulation of critical sections of the systems from flooding or storm damage, the redundancy in systems as back-up power, lighting or ventilation systems, in excess of regulatory requirements are the strategies to achieve such capability. Both GBTool and LEED provide requirements for the metering and monitoring of performance. GBTool scores the employ of sub-metering systems for major energy uses, of leak detection systems covering all main water and gas supplies and of measures to reduce refrigerant leakage. As regards the first subject the maximum score is awarded, in residential occupancies, whether a sub-metering of energy use is provided for all individual dwelling units and a reporting system is accessible by residents as well as the building manager and, in other occupancies, whether a comprehensive energy sub-metering system linked to a building management system is provided for all the occupancies and regular air quality tests are carried out and a reporting system is provided. Providing a leak detection system for all water and gas supply systems and a leak reporting system integrated with the Central Building Management System with alarm control is an additional way to guarantee a good performance in matter of safety and protection of architectural elements. For the measures to reduce refrigerant leakage the maximum score is awarded whether recognized standards have been followed for the provision both of refrigerant leak detection system for high risk parts of HVAC plant and of automatic pumps to drain refrigerants to storage tanks. LEED credits the equipment compliance with the installed equipment requirements for continuous metering as stated in DOE's IPMVP (International Performance Measurement and Verification Protocol) for the optimisation of building energy and water consumptions and the employ of a permanent CO_2 monitoring system (with feedback on space ventilation). The location of monitoring devices in areas of the building with high occupants densities and at

the ends of the longest runs of the distribution ductwork, the requirement in the commissioning plan and report of calibration of all the sensors within the system operation manual and of testing sensors and system operational and of adjustment initial set point (that maintain indoor CO_2 levels no higher than outdoor by more than 530 parts per million at any time) are the strategies to achieve a good CO_2 monitoring.

Pre-operation management

Building equipment sustainability depends on a well done pre-operations management: specifically on a correct performance tuning, by means of the inspection of all major systems prior to occupancy and of the management of the construction IAQ and on the correct building operation planning, in matter of provision of as-built drawings and documentation on building systems and of training of equipment operating and maintenance staff. All these items are assessed basing on qualitative requirements. Both GBTool and LEED agree on awarding those projects that provide a building commissioning (in order to verify and insure that the entire building is designed, constructed and calibrated to operate as intended) including: focused review of the design prior to the construction documents phase and of the construction documents when close to completion, review of contractors submittals of commissioned equipment, development of a system and energy management manual and of a contract for a post-occupancy review. The development of a IAQ Management Plan for the construction and pre-occupancy phases is required by LEED, asking to meet or exceed the minimum requirements of SMACNA (Sheet Metal and Air Conditioning National Contractors Association) and to replace all filtration media prior to occupancy. GBTool gives some good advice on as-built drawings and documentation on building systems: detailed operating instructions and checklists for normal operating procedures and control sequencing for all major equipment and systems, detailed checklists for all routine maintenance tasks, a schedule of routine maintenance activities for all major equipment and systems, drawings that show equipment, ductwork, piping and control point function and location for all HVAC, electrical, alarm and control systems, a listing of the current Energy Management Control System program (if any), manufacturer's performance data sheets and troubleshooting procedures, standard parts and lubrication product lists, and, eventually, contact information for maintenance personnel. Besides, a correct training of operating and maintenance staff is considered an important requirement and an additional score is awarded by GBTool whether all building operators will complete a comprehensive training course in efficient building operations and maintenance as a part of an established management program.

References

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