Building sustainability assessment: the case of hospital buildings

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ABSTRACT

The hospital project contains different aspects from the most common projects of residential, office or service buildings. Designing a hospital environment is based in a number of criteria related to the satisfaction and well being of the working team, the patient and the administrators. This kind of project has a strong social responsibility and impact on the city. Mostly due to various design requirements, these buildings are not designed and operated in a sustainable way. Based on this context it is important to study the best practices of a sustainable hospital design that should be taken into account in the design phase (to support the decision to adopt solutions that contribute to the building sustainability) and lifetime operation (supporting users and managers for the operation and equipment maintenance at an high level of efficiency). This paper will discuss the importance of the hospital buildings for the sustainable construction and will present some indicators that could support the sustainable design, operation and maintenance of a hospital building.

1. THE URGENCY FOR SUSTAINABILITY

1.1. The impacts of the Portuguese construction sector

The concept of sustainable development acts through diverse meanings and common activities to humanity that have an implicit mutual goal: a society that might persist throughout many generations with a flexible and whole vision which will allow it to maintain the social and physical system that sustains it. Cities can and should be an open field to sustainable guidelines since its scale complexity becomes an impact (positive or negative) on the environment as deep as its dimension.

On this scenario, the aim of construction industry is to achieve a product that fulfils the functionality requirements, being at the same time profitable, safe and durable throughout

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its life cycle. The product must be integrated in the natural system with the lowest negative environmental impact.

These principles are leading to a multi-criteria sustainable construction concept, which is based in many different scientific and technical areas and research fields. Bringing this concern to the humanization of hospitals brings up the question of what is a sustainable hospital and which are the best practices to create this type of buildings.

In Portugal, the construction in the sixties and seventies of the twentieth century was much less than the rest of Europe. This rhythm has intensified in the nineties and today the built environment is very similar to the European average. Between the late seventies and nineties, there were built over two million housing units and the growth of the housing units was higher in the nineties. The industry of this sector contributed for about 6% to GDP and employed about 10% of the workforce in the country (Piedade, 2003).

Meanwhile, the population has been steadily increasing. Between 2001 and 2011 the total population grew about 1.9%, from 10,336,000 residents to 10,555,853, while the number of dwellings and buildings increased 16.3% and 12.4% respectively. (INE 2011)

It should be noted that the construction of new housing has been to date the most important component, corresponding in 2003 to 83% of interventions in the built environment (INE, 2004). For this reason is justifiable the main focus of the different concerns and studies on residential buildings, since it corresponds to the biggest share of the construction. However, it is important to note that this significant increase in the building stock, was not reflected in a similar evolution neither on the environmental concerns nor in the search for efficiency in terms of energy consumption and materials. Therefore, these facts introduced an agenda for a more proactive approach on the environmental dimension to achieve a balance between this and the other two dimensions of sustainable development: society and economy.

In the national scene of the construction industry it is possible to clearly identify the problems and also a huge potential for improvement. Building with the least environmental impact as possible, respond to social demands and contribute to better economic management is the right path to follow. Nowadays this is challenging the construction sector and all its stakeholders, mainly the design teams. To achieve sustainability in this sector is essential to use good practices guided by indicators and performance targets, able to assess and balance the three main dimensions of Sustainable Development: environment, society and economy.

In Portugal, the issue of sustainability is still in its infancy. Mostly buildings present problems that result in thermal discomfort, visual and poor indoor air quality. This situation is linked, during the buildings' operation phase, with increased consumption of resources (energy and water) and situations that affect occupants' health and comfort. Although there is a big passivity of the occupants, for example, with respect to what happens in cold rooms in their homes, the same does not happens in respect to discomfort in the workplace and in public spaces. This is mainly due to the fact that only now people are beginning to be aware about their rights in relation to the building environment.

The conventional buildings are characterized by excessive use of natural resources, i.e. the use of large quantities of materials and the huge energy consumption. Consequently, this traditional model is responsible for producing large amounts of carbon dioxide and other harmful emissions to the different ecosystems. In this sense, there are already tools that promote more sustainable construction practices. However, there are still few mechanisms (e. g. taxes, credits and penalties) that facilitate and promote the practical application of the sustainable building concept. There are two distinct policies that governments can implement to control the adverse environmental impact continuously imposed to the planet by the construction, use and demolition of buildings (Bento, 2007): i) through rules and regulations and ii) through financial incentives for specific purposes.

Analysing the graph presented in Figure 1, it is possible to conclude that the peak of the general trend of production tends to coincide with an average environmental conscience. Additionally, the combined effect of the regulations and financial incentives is deviated from the trend of peak production for a larger and higher environmental awareness. Thus it is necessary that buildings are healthy, not forgetting that they seem like a small world that represents small-scale relations between it and the environment.

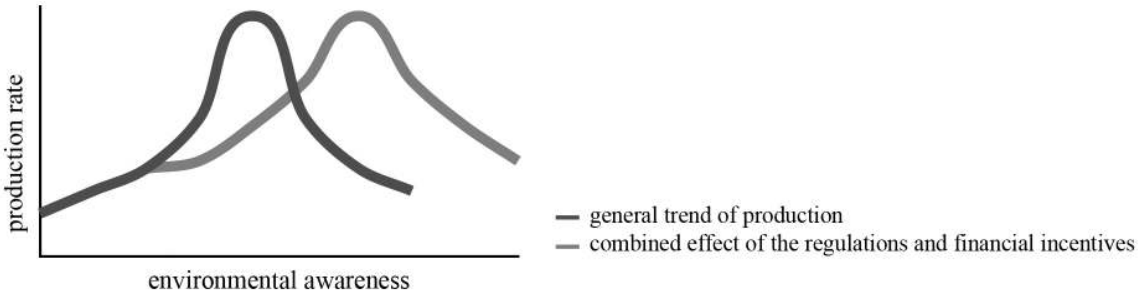


Figure 1 – Variation of environmental awareness as a function of production rate (Bento, 2007).

1.2. Sustainability in hospitals buildings

Michael Lerner (2000) formulated the following question: "*The question is whether healthcare professionals can begin to recognize the environmental consequences of our operations and put our own house in order*" (Robert & Guenther, 2006). This is not a trivial question, but the foundation of all other issues that may arise around this same concern (Robert & Guenther, 2006). Based on this principle, Figure 2 illustrates the relationship between human health, medical treatment and environmental pollution that directly affects the mission of the health care industry.

The hospital buildings, not because they are more abundant in the territory, but because they are large consumers of natural resources and energy, should be a major focus of study in the evaluation process of the buildings life cycle (Guenther, 2008). The activity implied to the healthcare industry, require a lot of energy for heating, refrigeration, etc.. On the other hand it is necessary to take into account the use of renewable and non-renewable resources, disposable products, toxic substances and the production of a large quantity of waste (Short & AL-Maiyah 2009).

The health sector has a strong influence on the economy of nations and their policies, incorporating a group of buildings where the quality of the indoor environment is quite significant. The impacts of this type of buildings are more significant than any other because they are directly related to human health (Guenther & Vittori, 2008). The operation of these equipments for 24 intensive hours, the high number of movement of persons, the existence of distinct work zones with different energy needs, the existence of different functions such as treatment, education, research, rehabilitation, health promotion and disease prevention, the need for the existence of systems strategic reserve of equipment for constant supply of energy, and size of facilities, are key points that differentiate these from other types of buildings and make it a specific case study (Dias, 2004; Bitencort, 2006).

The motivation and research opportunity of the abovementioned studies were based in the aim of studding design enhancements that can be introduced on this type of buildings to improve its life cycle's sustainability. Based on case studies of successful design approaches it is possible to conclude that the ability of evolution of these buildings is great.

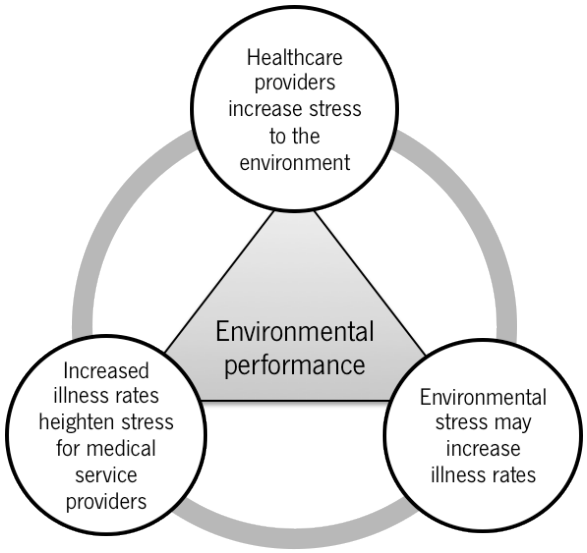


Figure 2 – Relationship between environmental performance and health care (Robert & Guenther, 2006).

On average, a hospital has energy consumption per square meter, ten times more than an office building with research laboratories (HSJ, 2009; INEGI, 2009) and consumes more electricity per year than any other existing building in a Portuguese city. These figures are due to the fact that these buildings act as authentic machines developed to maintain the patient's health and life. Additionally, they need to embrace all the innovations that arise in medicine (for example in the Hospital of S. João, in the period between 2007 and 2009 there was an increase of 8% in energy consumption due to the introduction of new equipment, ventilation systems and other works still in progress (HSJ, 2009)). Moreover, and according to the comparative analysis of some activity and budget reports from the Portuguese hospitals, it is possible to note that in most cases sustainability initiatives are reduced to the separation, treatment and possible waste recycling and, in exceptional cases, to the reduction of electricity and water consumption. At present, there are several studies about the sustainable development of hospitals. However, most of them are oriented for business management. Sustainable practices are not widespread mainly due to the fact that these buildings are exceptional. Additionally, the implementation of sustainable practices, normally related to the concept of reduction, is not always very well perceived by society and can generate some resistance.

Several studies and professionals agree that it is possible to work through the weaknesses of actions and measures, some of them simple and inexpensive, but capable of reducing the environmental impact. In order to introduce sustainable practices in the design of healthcare buildings, several countries have published guidelines to promote improved design approaches. Among them, it is possible to highlight recommendations for hospital projects that the Green Building Committee of the American Society of Healthcare Engineering (ASHE) published in 2002 (Robert & Guenther, 2006). This partnership between the American Hospital Associations and the United States Environmental Protection Agency, pointed out the principles of sustainable architecture that are intended to reduce waste and other impacts associated with hospitals (Robert & Guenther, 2006). The ASHE proposes an architectural development of these recommendations in order to develop buildings capable of improving the health concerns at three scales (Robert & Guenther, 2006):

- Protecting the immediate health of building occupants;
- Protecting the health of the surrounding community;
- Protecting the health of the larger global community,

2. HOSPITAL PROJECT

2.1. Place, form and function

The hospital project contains different aspects from the most common projects of residential buildings, offices or services. In common buildings, sometimes the user and the client are the same and when they are not, setting the requirements is not difficult since they are common to most inhabitants. In the case of hospital buildings this is not the reality and the project team is usually hired for the purpose of designing a building that includes different spaces and different users, such as doctors, nurses, patients, visitors, cleaning staff, administrators, and others. In this sense it is important to combine different spatial needs, which are always subject to constant changes throughout its period of use due to new features, innovations, needs expansion and new treatment methods (Figueiredo, 2008).

With the evolution of such buildings, it appears that the patient is increasingly occupying a central place of every concern and attention. Thus, there is contemporary in hospitals it is the patient as the final customer, dictating how should be thought of the life cycle of these structures (Figure 3).

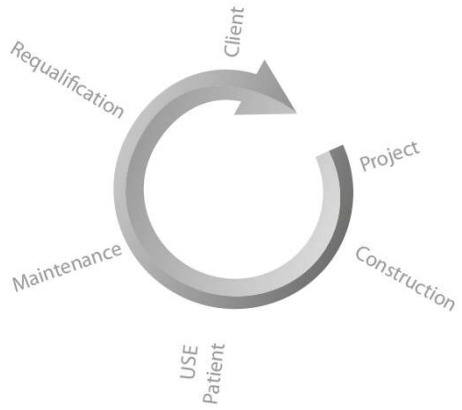


Figure 3 – Life cycle of hospital buildings (Figueiredo, 2008).

3. SUSTAINABILITY ASSESSMENT

3.1. Methodologies to support the design of sustainable buildings

The first major reason that led to the emergence of the need to evaluate the environmental performance of buildings was born with the realization that no country had the ability to say how sustainable it was a building, even when they believed that dominated the design concept and sustainable construction. Later researchers and government agencies understand that the certification systems would be the best method to demonstrate the sustainability performance of all types of constructions and buildings (Haapio & Viitaniemi, 2008). Nevertheless, the search for better methods and evaluation systems is still in the process. At the present there are still some uncertainties beyond the constant confusion about the meaning of sustainable construction, which binds, most often, only the reduction of energy or water consumption. Therefore, to clarify and emphasize the best design options, it became essential and urgent to integrate sustainability assessment experts in the design teams (Mateus & Bragança, 2006).

In what regard to assessment methods, most of them are based in a holistic sustainability approach, considering only the most representative sustainability parameters. Considering in the assessment all links between the natural and artificial environments would

lead to an extremely time consuming and inapplicable process (Mateus & Bragança, 2006). In the sustainability assessment, it is also essential to take into account the variety of intervening factors, such as: the type of buildings; their specific requirements; climatic and geological conditions of each region; the different construction processes; and the cultural and economic values of each region (Haapio & Viitaniemi, 2008).

On the other hand, the evaluation involves quantitative and qualitative indicators, which are not always correlated, and that have necessarily to express the same magnitude for any possibility of comparison (Mateus & Bragança 2011). After the establishment of sustainability indicators, difficulties arise for the adoption of different classification levels to be considered, in the definition of the benchmarks (best and conventional practices for each sustainability indicator) and in the aggregation method to be used. Nevertheless, these are key issues to assess the overall sustainability performance and to compare the performance of different buildings (Mateus &Bragança, 2011).

In Portugal, the delay on the implementation of sustainable design practices means that this situation can be examined in two ways: one that tends to cover the minimum required by law, and another that would tend to make the requirement higher in order to increase also the responsibility of the sustainable construction in the country. According to Mateus and Bragança (2006), the second option would make the leap to an urgent shift in mentality and building design. As a result of the abovementioned difficulties, currently there is not an internationally accepted building sustainability assessment tool or methodology. Nevertheless, analyzing the main objectives of existing methodologies, it is possible to distinguish three different types: support tools for the sustainable building design (Performance Based Design); tools for life-cycle analysis (LCA) of products and building materials; systems and tools for building sustainability assessment and certification (Mateus &Bragança, 2006). The tools to support the sustainable building design (Figure 4) are a good base of guidelines to support the design teams. With this approach it is possible to describe the best sustainability practices for a building through a hierarchy of performance levels, which, when considered in design phase, will lead to more sustainable buildings (Bragança et al., 2007).

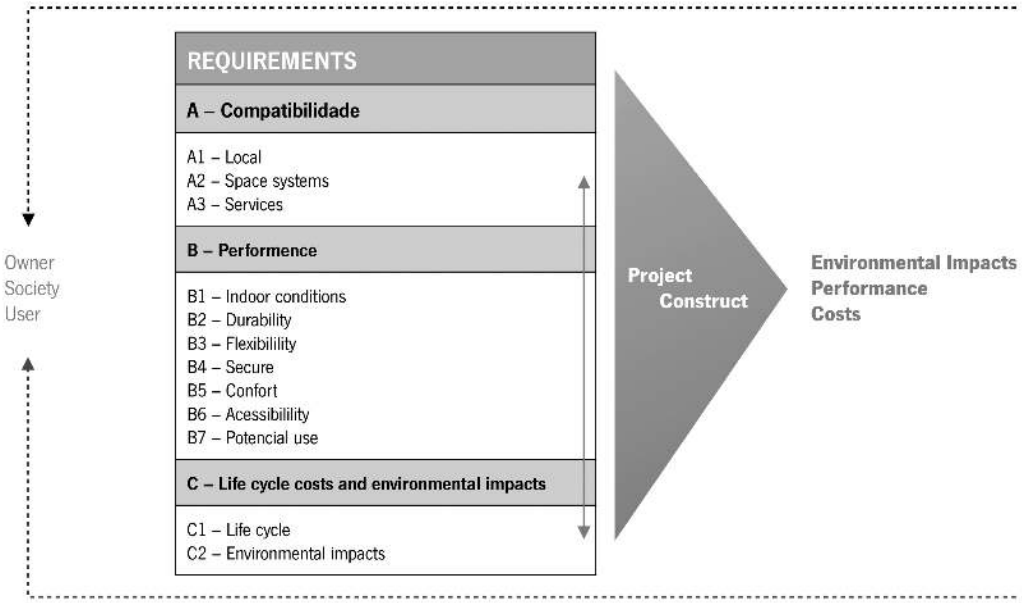


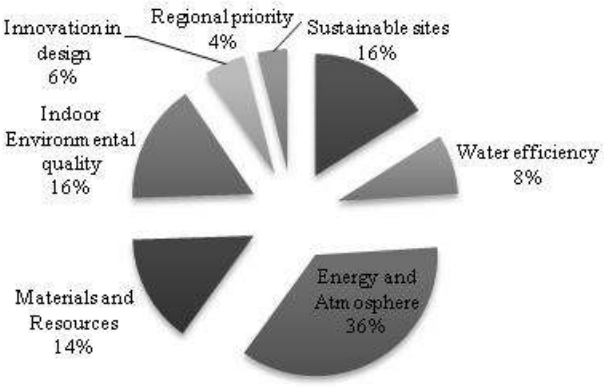
Figure 4 – Generic model of a support tool for the design of sustainable buildings (Bragança *et al*., 2007).

3.2. Sustainability assessment and certification of hospital buildings

There are some countries either developing or implementing sustainability assessment methodologies focused on hospital buildings. The first approach to be developed, in 2008, was the Building Research Establishment Environmental Assessment Method Healthcare (BREEAM Healthcare). The main objectives of this specific methodology are: improve the sustainability of buildings for healthcare; improve conditions for patients; enable economic progress; and improve the working conditions of the entire hospital team (Guenther, 2009).

Besides BREEAM Healthcare, other example is the Leadership in Energy & Environmental Design (LEED Healthcare), which final version was released in 2009. Figure 5 present the differences between these two methods at the level of the sustainability categories and respective weight in the overall sustainability level.

BREEAM for Healthcare



LEED for Healthcare

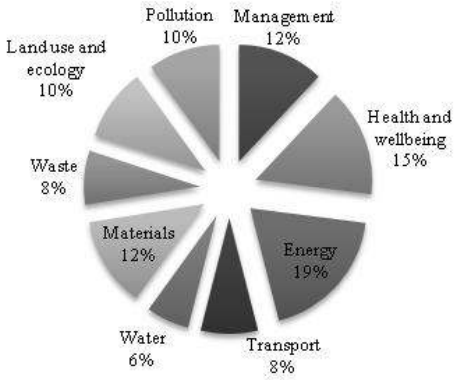


Figure 5 – Assessment categories of the methodologies BREEAM and LEED for Healthcare (www.breeam.org; www.usgbc.org).

The Boulder Community Foothills Hospital (BCFH) in Boulder, Colorado was the first hospital to achieve certification at the level of sustainable construction (Figure 6). The assessment is based in the LEED approach.

Figure 6 – Boulder Community Foothills Hospital (Verderber, 2010).

The Providence Newberg Medical Center (Figure 7) was the first hospital to receive the highest rating awarded by the LEED method (Gold), in the United States of America. Beyond this distinction, in 2007this hospital received the award for environmental leadership given by Hospitals for a Healthy Environmental (H2E) (Guenther & Vittori, 2008). Table 1 presents the design practices taken into account in the two abovementioned examples, which enabled a sustainability certification.

Figure 7 – Providence Newberg Medical Center (Verderber, 2010; Mahlum, 2011).

In Portugal, during 2008, the Ministry of Health developed a document that lists the recommendations and technical specifications for the hospital buildings, where there are recommendations for several issues, such as architecture, facilities and equipment for water supply and drainage, electrical and mechanical systems, centralized technical management, outdoor spaces, integrated management of solid waste, maintenance, etc.. Together with this document, there are other regulations that specify the requirements of each specific space at the level of lighting, indoor air quality, temperature and ventilation. Nevertheless, in which regards to the sustainable management of the hospitals there is not any document with the force of law or recommendation.

The sustainable design of hospital buildings will achieve competitive advantage strategies, as well as better economic and social efficiency. Thus, grouping the principles advocated by several authors, the goals that are intended primarily achieve with the sustainable design and construction of this kind of type of buildings are:

- Improve the quality of patient care;
- Reduce the time of patient recovery;
- Improve operational efficiency and productivity;
- Create increased facilities for users and surrounding communities;
- Contribute to the satisfaction and consequent fixation of employees and the experience positive patient (system performance evaluation of the complex);
- Develop quality and safe indoor and outdoor environments;
- Reduce operational risks associated with the project
- Increase the lifetime of the building;
- Reduce construction, operating and maintenance costs;
- Educate the understanding for the need to use a sustainability certification, allowing it to assess the pros and cons of introducing these design practices.

Table 2 presents the indicators that should be taken into account when it comes to implementing sustainable design practices in hospitals.

Table 1 – Design principles considered in the two case studies.

Dimensions	Design practices to improve the sustainable construction	Boulder Community	Providence Newberg
Environmental	Reduce site disturbance (use of local and regional materials)	•	•
	Use of high-reflectance, low-emissivity roofing	•	•
	Reduce the density of construction	•	
	Reduce the rate of net available land use	•	
	Reduce the consumption of non-renewable primary energy in operation phase	•	•
	Reduce the consumption of non-renewable primary energy in the construction phase		•

Table 1 (cont.) – Design principles considered in the two case studies.

Dimensions	Design practices to improve the sustainable construction	Boulder Community	Providence Newberg
Environmental	Reuse materials		•
	Use of materials with recycled content		•
	Use of organic-based products which are certified	•	•
	Recycling of construction waste	•	•
	Reduce water consumption in the building	•	•
	Use of native vegetation in green areas to reduce water consumption	•	•
Social	Maximize the use of indoors natural ventilation	•	•
	Maximize the use of natural light and shade	•	•
	Use the site potential to promote thermal comfort	•	•
	Maximize solar building orientation	•	•
	Use of materials with a low content of VOCs	•	•
	Maximize acoustic comfort	•	•
	Encourage the use of alternative transportation	•	•
	Maximize accessibility to activities spaces	•	•
	Availability of green spaces with easy access for users	•	•
	Maximize access to living areas, gym		•
	Maximize views to outdoor spaces	•	•
	Maximize flexibility and adaptability of indoor		•
Economic	Reduce operating costs related to energy consumption	•	•

Table 2 – Dimensions, categories and indicators to support the implementation of sustainable practices in building design hospital.

Dimensions	Categories	Indicators
Environmental	Climate change and outdoor air quality	Environmental impact associated with the life cycle of buildings
	Soil use and biodiversity	Urban density
		Reuse of previously built or contaminated soil
		Use of autochthonous plants
		Site Selection
		Heat island effect
	Energy	Non-renewable primary energy
		Renewable primary energy
		Energy produced locally
		Electricity

Table 2 (cont.) – Dimensions, categories and indicators to support the implementation of sustainable practices in building design hospital.

Dimensions	Categories	Indicators
Environmental	Materials and Solid Waste	Reuse of materials
		Use of recycled materials
		Use of certified materials
		Use of cement substitutes in concrete
		Use of local materials
		Coating materials
		Storage conditions of solid waste during the building's use phase
		Construction Waste
		Use of mercury
		Furniture
	Water	Water consumption
		Reuse and use of non-potable water
	Pollution	Reduction of CO2 emissions
		Monitoring of energy used for each order
		Monitoring the energy used by the user area
Social	Comfort and health of users	Efficiency of natural ventilation in indoor spaces
		Toxicity of finishing materials
		Thermal comfort
		Visual comfort
		Acoustic comfort
		Indoor air quality
		Indoor Environmental quality
		Design quality
		Local development
		Equipment
	Accessibility	Accessibility to public transport
		Low impact mobility
		Accessibility to amenities
		Space distribution
	Awareness and education for sustainability	Education of occupants
	Innovation	Innovation of the project design
Economic	Life cycle costs	Initial cost
		Operation costs

4. CONCLUSIONS

Due to various design requirements, healthcare buildings are not designed and operated to meet the sustainable development requirements. This paper pointed out that the main factor contributing for this reality is the absence of an effective method to support

design teams to consciously introduce sustainability on their projects. In addition, conventional design teams do not have the necessary skills that allow optimizing the life-cycle sustainability at the design phase and building managers are not aware about the measures that they should adopt for efficient operation.

This raises the importance to develop a methodology that includes the indicators discussed in this paper, to support the decisions of players in two phases: design (supporting the decision to adopt solutions that contribute to the sustainability of the building) and operation (user support for the operation and maintenance of equipment are executed with the highest efficiency level possible). For that purpose, future research on sustainability assessment of hospital buildings should be focused in finding the best parameters and assessment method for assessing the proposed indicators. At the end, it is necessary to develop a manual to guide the practical implementation of the methodology by conventional design teams.

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