

# Development of a sustainability assessment tool for office buildings

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**ABSTRACT:** The main objective of this work is to develop a sustainability assessment tool to assess the sustainability of office buildings in urban areas, according to the Portuguese environmental, social and economy contexts. This new approach is a contribution for the office buildings module of SBTool<sup>PT</sup> methodology. Since there is already a module suitable to assess the sustainability of residential buildings, this work is aimed to adapt the work developed so far to the context of office buildings. This paper starts with the analysis and discussion of the urgency to develop tools that could be used to support the design of sustainable office buildings. Afterwards the development of the proposed methodology is presented, discussing the parameters proposed to support the sustainable design and the sustainability assessment.

## 1. INTRODUCTION

### 1.1 *The urgency for a new developing model*

Nowadays, the world is facing several environmental, social and economic problems. These problems result essentially by the combination of three main factors: world population growth; resources consumption and pollution of air, soil and water.

The world population has been increasing in a scary way in the last decades. To better understand the rapid population growth, world population reached one billion people by the year 1804, increased to 2 billion in 1927, three billion in 1960, 4 billion in 1974, 5 billion in 1987 and finally reached 6 billion in 1999. The world population in 2010 has reached 6.850 billion people and is expected to reach the 8 billion in 2028 (UN, 2010). This major increase in world population combined with the lifestyle of today's society, which is beginning to be adopted by developing countries, is causing a great demand for the natural resources of the planet. This fact is being a major cause of the global crisis that the world is experiencing nowadays. If the entire world's population was living in a European lifestyle it would take two and a half planets to supply resources for the entire population (EU, 2009).

Global warming, a major cause of environmental problems, result mainly from the increased greenhouse gases emissions to the atmosphere. Some of the main gases are carbon dioxide, methane, nitrous oxide and fluorocarbons, which are derived mainly from burning fossil fuels. This phenomenon has caused severe consequences for the world's population as, among others: increasing the average level of the sea; climate changes; biodiversity loss; and desertification. For example, 12 of the 13 warmest years ever have occurred since 1995. In 2005, the average global temperature was 0.76 °C above the average temperature of the pre-industrial era and it is expected that by the end of this century the temperature will increase 1.8 to 4.0 °C. To understand the importance of preventing such a steady increase in temperature there are considerable scientific evidences showing that there is a risk of irreversible climate change and possibly catastrophic consequences, such as melting ice at the poles and corresponding rise in water level

of the sea, if the temperature rises 2 °C above the temperature of the pre-industrial era, i.e. about 1.2 °C above the current temperature (EU, 2009).

Energy is one of the most important factors in the quest for sustainable development. That is because the increase in energy consumption is a major factor leading to global warming. Energy consumption is the main responsible for emissions of greenhouse gases in the European Union (EU). It is also estimated that the construction sector accounts for about 35% of greenhouse gas emissions (EC, 2006). Thus, the efficient use of energy is certainly one of the most important ways to minimize the environmental problems; however, the demand for energy is increasing worldwide. The International Energy Agency predicts that the global energy demand will increase by more than 50% by 2030 if policies remain unchanged and more than 60% of this increase respects to developing countries. This will lead to a 52% increase in emissions of carbon dioxide (CO<sup>2</sup>), the main greenhouse gas (Nelson, 2010).

Protecting biodiversity is also seen as an important factor against the greenhouse effect, since the photosynthesis of plants provide an important natural mechanism for storing huge amounts of carbon.

At other field, according to the European Environment Agency, in 2005 Europe produced 1300 million tons of waste, equivalent to 3.5 tons of waste per capita and 518 kg of Municipal Solid Waste (MSW) per capita. According to data from the Portuguese Environmental Agency, in the same year Portugal produced 4.5 million tons of MSW, the equivalent to 450 kg of MSW/capita and 1.24 kg of MSW per capita per day (Lipor, 2009).

Water is also one of the essential elements for life on the planet. It is an invaluable resource for the continuity of human life, not only for drinking, but it is also essential for the production of other food resources. In fact, it takes a lot more water to produce food than for direct consumption. The needs of drinking water per person per day are 2 to 4 litres, but it is needed 2000 to 5000 litres of water daily to produce the food needed for one person (UN-Water, 2010).

## 1.2 *The relevance of the construction sector*

Worldwide the construction sector is responsible for consuming about 40% of raw materials and 55% of the extracted wood (Gaspar, 2009). The sector represents 40% of final energy consumption in Europe (Directive 31/2001/EU) and about 35% of emissions of greenhouse gases (Nelson, 2010). When it comes to waste, construction activities generate about 22% of all waste generated in Europe (APA, 2010).

According to the Portuguese Energy Balance of 2005, the buildings were responsible for the consumption of 5.8 Mtoe (million tons oil equivalent), representing about 30% of total primary energy consumption in the country and 62% of electricity consumption (Isolani, 2008). However, over 50% of this consumption can be reduced through energy efficiency measures (AD-ENE, 2009). For this reason, over the last decades emerged a number of Directives and Laws at European and national levels which aim at promoting both the reduction of energy consumption and the increase in share of renewable energies.

The economic and social impact of the sector is also enormous. Construction is directly and indirectly related to almost 10% of GDP at the European level, it directly employs 12 million EU citizens and indirectly 26 million workers are dependent on this sector (EP, 2010).

The building sector (residential & SME) produces also 17% of emissions of greenhouse gases. However, as mentioned above, the building sector accounts for about 40% of energy consumption. Thus, 40% of emissions in the energy sector are also related to the buildings, resulting in a total emission corresponding to this sector of approximately 28% (EU, 2009).

In 2002, the office buildings sector accounted for about 15% of final energy consumption in Europe and 12% of final energy consumption in Portugal (Pires, 2005). However, this sector's growth rate in average energy consumption is 12% (Decree Law 79/2006) and therefore, nowadays the rate of energy consumption that corresponds to this sector is higher than the values predicted for 2002. This sector, along with the residential property sector is among those who have the greatest potential for energy savings in Europe. The potential energy savings due to the offices sector is about 30% (EC, 2007).

### 1.3 *The role of the sustainability assessment tools*

Achieving sustainability in the building sector is only possible through a real methodological work. In order to be feasible, this work should be carried out during the preliminary phases of design. At this level sustainability assessment tools are playing an important role since they gather and report information for decision-making during the different phases of design, construction and use of a building. The sustainability scores or profiles based on indicators result from a process in which the relevant phenomena are identified, analyzed and valued.

There are currently many tools for assessing the sustainability of buildings. A sustainability assessment of a building should take into account the political, cultural, social and economic aspects of the site where it will be applied. Hence, given the subjectivity inherent in assessing sustainability, none of these methods is widely accepted (Mateus, 2009).

BREEAM was the first environmental assessment method for buildings. It was developed by researchers in the UK's BRE and the private sector in 1988. It is estimated that over 30% of buildings in the UK are assessed by this method. In order to allow assessments outside the United Kingdom there is nowadays the BREEAM International. LEED is an American rating system that was established in 1996 and is managed by the NGO U.S. Green Building Council. The expansion of this system to the outside of the United States is notorious as this system is being used in many countries around the world. HQE is a French association founded in 1996 that brings together professionals in the construction sector with the aim of improving the environmental quality of construction. The label replaces the HPE HQE - Haute Performance Énergétique existed since early 1990. The SBTool is a rating system for sustainable construction developed through the participation of more than 20 countries since 1996. This tool was developed and is updated by the International Initiative for a Sustainable Built Environment (iiSBE). SBTool was aimed to allow the assessment and internationally comparison of the environmental performance of buildings. CASBEE is a Japanese system of environmental assessment of buildings and was developed by the Japan Sustainable Building Consortium in 2002. DGNB System is a German environmental assessment tool that was developed by the German Sustainable Building Council in cooperation with the Federal Ministry of Transport, Building and Urban Affairs and released in 2009 to be used to support the sustainable design and to assess the sustainability of buildings.

Such tools are increasingly emerging as important solutions to decrease the impacts of the construction sector. As it was presented above, sustainability assessment of buildings is based in several goals that are much wider than the energy efficiency aims.

Although there are several definitions for a sustainable building, generally speaking, resources like energy, water, land, materials should be considered in a much more efficient way than in conventional buildings. These buildings are also designed and used in order to create healthier living conditions and more productive working environments, through the use of natural light and improved indoor environmental quality (Syphers et al, 2003). Therefore, sustainable building aims the proper balance between the three dimensions of the sustainable development: Environment, Society and Economy.

### 1.4 *Aim of this study*

The main objective of this work is to develop a sustainability assessment tool aimed to support the sustainable design and performance assessment of office buildings. This new approach is a contribution for the SBTool<sup>PT</sup>'s module of office buildings. SBTool<sup>PT</sup> is a Portuguese assessment system that results from the adaptation of the international SBTool to the national environmental, society and economy contexts. In the development of the SBTool<sup>PT</sup> it is considered the ongoing standardization works on the Technical Committee 350 (CEN/TC 350), "Sustainability of Construction Works".

The module of the SBTool<sup>PT</sup> developed so far is suitable to assess the sustainability of residential buildings (SBTool<sup>PT</sup>-H). Therefore this work is aimed to contribute for the adaption of the work developed so far to the context of office buildings.

This methodology, henceforward called MARS-S, has a structure and assessment method similar to SBTool<sup>PT</sup>. It was developed through a system based in a number of performance parameters, which allow comparing the performance of a building with two reference practices

(benchmarks) adapted to the Portuguese contexts: best practice and conventional practice. At the end, the global sustainability of a building is provided by using a single value that is obtained by the weighted normalized performance of the building at the level of each parameter. In order to provide a better support in the sustainable assessments, this methodology is also based in an evaluation guide. This guide has a similar structure to the one developed for the residential buildings.

## 2. DEVELOPMENT OF THE METHODOLOGY

### 2.1 *Main updates in the assessment structure*

Similar to the tool developed for residential buildings (SBTool<sup>PT</sup>-H), the evaluation methodology is based on the calculation of the normalized performance level of the building at the level of several indicators that are considered relevant for the sustainability of office buildings. This process in addition to turning dimensionless the value of the parameters considered in the assessment, converts the values between best and conventional practices into a scale bounded between 0 (worst value) and 1 (best value). Normalisation is done using the Diaz-Baltero equation (1).

$$\bar{P}_i = \frac{P_i - P_{i*}}{P_1^* - P_{i*}} \quad (1)$$

The global sustainability of a building is the weighted average of the performance that was obtained at the level of each parameter. This evaluation methodology is actually a comparison between the building and reference national practices and therefore it can be said that this is a relative evaluation of sustainability. Therefore this methodology was named Methodology for the Relative Sustainability Assessment of Service Buildings (MARS-S). MARS-S system has an assessment method sustained in the three dimensions of sustainability: environment, society and economy. Each of these dimensions is subdivided into categories which in turn are subdivided into parameters.

Table 1 lists the categories (global indicators) and parameters that are used in the methodology to assess residential buildings. It has a total of nine sustainability categories (summarizing the building performance at the level of some key-sustainability aspects) and 25 sustainability parameters within the three sustainability dimensions.

The methodology is supported by an evaluation guide and its framework includes:

- i) Quantification of performance of the building at the level of each parameter presented in a evaluation guide;
- ii) Normalization and aggregation of parameters;
- iii) Sustainable score calculation and global assessment.

The work carried out to adapt the methodology for residential buildings to office buildings is subdivided in four steps:

- i) Initially, the state of the art of existing methodologies to assess office buildings was studied. This task was focused in the international SBTool system and also considered the ongoing work on standardization bodies and other national and international *fora*;
- ii) The next phase was the detailed analysis of the SBTool<sup>PT</sup>-H methodology, examining the assessment methods of the various parameters in order to verify their compatibility and applicability in the case of office buildings. In this stage it was also considered whether new parameters are needed to address specific issues of office buildings that were not covered by the residential module. On the other hand, the structure of the methodology was also analysed and some recommendations for changes were made;
- iii) In a third step the needs of making adjustments on the system of weights was addressed. This step is of particularly importance since there are some changes both at the level of the number of parameters and structure of the methodology;
- iv) As a final step, it was developed an assessment guide to support the assessor. This

guide is aimed to promoting the assessment in a more quickly and effectively way.

Table 1. List of categories and sustainability indicators of the SBTool<sup>PT</sup>-H module.

Dimension	Categories	Sustainability indicators
Environment	C1 – Climate change and outdoor air quality	P1 – Construction materials’ embodied environmental impact
	C2 – Land use and biodiversity	P2 - Urban density
		P3 – Water permeability of the development
		P4 - Use of pre-developed land
		P5 – Use of local flora
C3 – Energy efficiency	P6 – Heat-island effect	
	P7 – Primary energy	
C4 – Materials and waste management	P8 – In-situ energy production from renewable	
	P9 – Reused materials and products	
	P10 – Use of materials with recycled content	
	P11 – Use of certified organic materials	
	P12 – Use of cement substitutes in concrete	
C5 – Water efficiency	P13 – Waste management during operation	
	P14 – Fresh water consumption	
Society	C6 – Occupant’s health and comfort	P15 – Reuse of grey and rainwater
		P16 – Natural ventilation efficiency
		P17 – Toxicity of finishing materials
		P18 – Thermal comfort
	P19 – Lighting comfort	
C7 – Accessibilities	P20 – Acoustic comfort	
	P21 – Accessibility to public transportations	
C8 – Awareness and education for sustainability	P22 – Accessibility to urban amenities	
	P23 – Education of occupants	
Economy	C9 – Life-cycle costs	P24 – Capital cost
		P25 – Operation cost

For each indicator there is a specific assessment methodology according to the building life-cycle phase that is under assessment. Moreover it covers the two Portuguese thermal regulations that an office building must fulfil. This approach is different from the residential module since it is not only focused on the design phase. Therefore, the developed approach could be used in the assessment of new buildings or rehabilitation operations and in the stage of preliminary design, design, construction and operation phases. These different stages are the same as those used in the global methodology SBTool (iiSBE, 2010). Table 2 presents the results of the abovementioned steps.

## 2.2 Brief presentation of the indicators, assessment procedure and benchmarks

In this section the changes made at the level of the indicators, assessment procedure and benchmarks will be highlighted. This process compares the residential module of the SBTool<sup>PT</sup> methodology with the proposed methodology for the relative sustainability assessment of office buildings (MARS-S). This section covers only those proposed indicators (PI) where some changes were made.

### *PI1 – Life cycle environmental impacts*

The MARS-S’s indicator “PI1 – Life cycle environmental impacts” resulted from a deep analysis of the calculation method used in the SBTool<sup>PT</sup>-H’s indicator “P1– Construction materials’ embodied environmental impact” in order to determine some characteristics that could lead an assessor to make some calculation mistakes.

Thus, keeping the original base, some improvements were made to the calculation method to correct these problems and also to facilitate the implementation of this parameter that was quite

complex. These changes reduced not only the number of variables and tables of this parameter but also its complexity and calculation time, above all enabling greater clarity in the results.

Table 2. List of categories and sustainability indicators of the proposed methodology to assess the sustainability of office buildings (MARS-S)

Dimension	Categories	Sustainability Proposed Indicators
Environment	C1 – Climate change and outdoor air quality	PI1 – Life cycle environmental impacts
		PI2 – Replacement of cement in concrete
	C2 – Biodiversity and land use	PI3 – Heat-island effect
		PI4 – Net area index
		PI5 – Previously contaminated or built areas
C3 – Energy	PI6 – Native plants	
	PI7 – Certified organic products	
C4 – Materials and solid waste	PI8 – Energy consumption	
	PI9 – Renewable energy	
Society	C5 – Water	PI10 – Reuse of materials
		PI11 – Materials with recycled content
	C6 – Users health and comfort	PI12 – Solid waste separation
		PI13 – Water consumption
		PI14 – Fresh water consumption reduction
C7 – Accessibility	PI15 – Waterproofing index	
	PI16 – Indoor air quality	
C8 – Awareness and education for sustainability	PI17 – Thermal comfort	
	PI18 – Visual comfort	
Economy	C9 – Life cycle costs	PI19 – Acoustic comfort
		PI20 – Accessibility to public transportation
		PI21 – Accessibility to amenities
		PI22 – Sustainable management of the Building
		PI23 – Life cycle costs

#### *PI2 – Replacement of cement in concrete*

The indicator “PI2 – Replacement of cement in concrete” is very similar to the indicator “PI12 – Use of cement substitutes in concrete”, however, as the use of cement has a major influence on global warming, climate change and outdoor air quality, it is proposed to move this parameter to “Category 1 – Climate change and outdoor air quality”, although this parameter is related to materials selection.

In what concerns the benchmarks, it is proposed an update changing the best practice from 30% to 40%. This figure is referred as an optimal dosage for the use of cement substitutes in concrete (Camões, 2005).

#### *PI3 – Heat-island effect*

The indicator parameter “PI3 – Heat-island effect” is similar to SBTool<sup>PT</sup>-H’s P6. However, as the heat-island effect is more related to global warming, tropospheric ozone and outdoor air quality than to biodiversity, it was decided to move this parameter to “Category 1 – Climate change and outdoor air quality”.

#### *PI5 – Previously contaminated or built areas*

The indicator “PI5 – Previously contaminated or built areas” is similar to SBTool<sup>PT</sup>-H’s indicator “PI4 – Use of pre-developed land”. In this parameter, the conventional practice benchmark was changed from 0% to 30%. This value was obtained by taking into account recent studies (INE, 2009) that indicates a percentage of 30% for rehabilitation works in Portugal. In the rehabilitation works there are always occupied pre-built or pre-contaminated areas. This change, be-

sides being a value more representative of conventional practice, is more negative for new buildings on Greenfield sites, giving a clear incentive to reduce the occupation of areas with important ecological value.

#### *PI7 – Certified organic products*

The indicator “PI7 – Certified organic products” is similar to SBTool<sup>PT</sup>-H’s indicator “P11 – Use of certified organic materials”. Taking into account that this indicator is focused on the protection of biodiversity by promoting the reduction of deforestation and illegal logging, it was decided to change this parameter to the Category 2: "Biodiversity and Land Use."

#### *PI8 – Energy consumption*

The indicator “PI8 – Energy consumption” is similar to SBTool<sup>PT</sup>-H’s indicator P7 – Primary energy. Nevertheless, to adapt the calculation method of this parameter to evaluate commercial buildings, it was necessary to define a new calculation method that enables assessment of the office buildings that are covered by different energy building regulations. Another change was made to evaluate the performance of the building without accounting the in-situ energy produced through renewable sources. Reasoning for this is that if a building produces a considerable amount of energy from renewable sources, it is possible to get a low value for the global primary energy needs and to get a good score at this parameter, using energy inefficient solutions. Additionally, this building would be doubly benefited by getting a good grade in the parameter that refers to renewable energy (SBTool<sup>PT</sup>-H’s P8).

#### *PI11 – Materials with recycled content*

The indicator “PI11 – Materials with recycled content” is similar to SBTool<sup>PT</sup>-H’s indicator “P10 – Use of materials with recycled content”. A new calculation method was developed that assesses the percentage of cost of materials and products with recycled content bigger than the conventional practice. Since this indicator is assessed using a new parameter it was necessary to establish new benchmarks. In Portugal the practice of selecting materials with high recycled content is not a common practice and therefore it was decided to consider as standard practice a value of 0%. With this value, it is possible to reward those designers who prescribe a small percentage of cost of materials with recycled content, which turns out to be an encouragement to this practice. The best practice for this parameter was set at 10%. This value is shown in a study by WRAP (WRAP, 2010) as an increasingly requirement sought by owners.

#### *PI13 – Water consumption*

The indicator “PI13 – Water consumption” is similar to SBTool<sup>PT</sup>-H’s indicator “P14– Fresh water consumption”. In order to adapt the assessment method of this parameter to office buildings, it was defined a new calculation method, since these buildings can have various types of uses and therefore considerable variation in water consumption. Furthermore, it was taken into account that in office and commercial buildings is usual the use of automatic irrigation systems in gardens.

#### *PI15 – Waterproofing index*

The indicator “PI15 – Waterproofing index” is similar to parameter SBTool<sup>PT</sup>’s P3. Nevertheless, since there is no objective relationship between the waterproofing index and its influence on biodiversity, it was decided to change this parameter to Category 5: "Water." To adapt the assessment method of this parameter for office buildings, a study was made covering different municipalities in all the districts of Portugal. This processes allowed setting new benchmarks for this type of buildings. As a result, the waterproofing index for the standard practice is 70% and the best practice 35%. A reference was added to account waterproofed areas from which runoff water is collected in tanks intended for the use of rainwater. These areas were considered 100% permeable.

#### *PI16 – Indoor air quality*

The indicator “PI16 – Indoor air quality” results from the fusion of two SBTool<sup>PT</sup>’s indicators: “P16 – Natural ventilation efficiency” and “P17 – Toxicity of finishing materials”. To adapt this parameter to office buildings some changes were made in the calculation method. For this pur-

pose, was taken into account that office buildings the conventional practice uses mechanical ventilation. The change made in the calculation method is also due to the fact that in office buildings covered by the Portuguese thermal regulation for residential and office buildings (RCCTE and RSECE, respectively), it is necessary to perform air quality audits by measuring the concentration of various pollutants. This is the best method for assessing the quality of air. Thus, the method for evaluating this parameter was separated according to the building design of and the applicable regulation. Thus, for buildings covered by the RSECE and in operation phase, air quality is assessed by measuring the in-situ concentrations of pollutants. For buildings covered by RCCTE or RSECE in the phases of preliminary design, design or construction, the assessment is made taking into account the predicted air quality, as a function of two factors: the ventilation rate of the building and the selection of finishing materials with low Volatile Organic Compounds (VOC).

#### *PI17 – Thermal comfort*

The indicator “PI17 – Thermal comfort” is similar to SBTool<sup>PT</sup>-H’s indicator P18. In the adaptation of this parameter to office buildings it was necessary to introduce some adjustments in the calculation method. Most of these adjustments are due to the fact that in this type of buildings the cooling systems are commonly used in summer. Therefore there were no changes in the calculation method for the heating season, but there were changes in the calculating method for the cooling season. To define the new benchmarks, it was used the values from the standard EN15251 for each type of space. Conventional practices were related to the comfort class III and best practices to class I.

#### *PI18 – Visual comfort*

The indicator “PI18 – Visual comfort” is equivalent to SBTool<sup>PT</sup>-H’s indicator “P19 – Lighting comfort”. Nevertheless, the assessment method of this parameter has changed from daylight factor to illuminance levels. This change had not only in mind the need for adaptation for office buildings, but was also an improvement in order to measure more correctly the comfort of users depending on the lighting. Thus, the performance of a building in this parameter is obtained through the level of the annual weighted average of the daily lighting of the building. This value is obtained after determining the annual daily average levels of illumination in different compartments of the building, adding the portions relating to natural and artificial light, depending on the operating hours of building and average daily number of annual hours of sunlight. Since major changes were made in the calculation method, new benchmarks were adopted using the recommended values for each type of space and use that are recommended in the standard EN12464-1.

#### *PI23 – Life cycle costs*

The indicator “PI23 – Life cycle costs” results from the fusion of two SBTool<sup>PT</sup>-H’s indicators: “P24 – Capital costs” and “P25 – Operation costs”. The adaptation of the methodology for evaluating these indicators for office buildings was carried out simultaneously, since both indicators were merged into a single indicator that evaluates the economic performance of the building throughout its life-cycle. This change considers that in office buildings the owner of the building is often the same entity that uses the building. Thus, it makes more sense to carry out a joint assessment that considers the real contribution of each phase for the life-cycle costs of a building.

### 3. CONCLUSIONS

This work successfully achieved its main objectives. The developed sustainability assessment tool is well suited to office buildings and several modifications to the existing module for the residential buildings of the SBTool<sup>PT</sup> were proposed, improving and correcting some of its weaknesses.

The development of the methodology took into consideration the applicability of various parameters in different phases of building design, as well as its scope in terms of regulations, so it



is an important contribution in the approach of the calculation methods of various parameters in order to make their evaluation more comprehensive and objective.

The proposed methodology also took into account the diversity of uses that offices and commercial buildings may have, adapting the calculation method of some parameters by increasing their flexibility. However the objectivity remained unchanged and, whenever possible, the processes were improved in order to facilitate their applicability.

There were also some changes in some parameters through its change to categories that represent in a more realistic way their real impact on the sustainability of buildings. Important updates were also made in the benchmarks of most parameters.

Finally, this work was done probably at the stage of human history in which man is more open to be sensitized towards sustainability, because previous generations sensitization was based on the awareness to prevent future generations to suffer serious problems and nowadays, the problems have begun to emerge and the effects of the unsustainability of our current society is already felt by the citizens.

The sustainable building rating tool that is being developed intends to contribute positively to the sustainable construction in Portugal through the definition of a list of goals and aims, easily understandable by all intervenient in construction market and compatible with the Portuguese construction technology background. Nevertheless there is still one important step to fulfil before applying the methodology: validation of the list of indicators and parameters through case studies. Although the list of indicators and parameters is partially based in the framework for assessment of integrated building performance (CEN/TC 350), further work includes its validation in Portugal through thematic interviews and surveys to experts in each dimension of the sustainable development.

The uptake of sustainable building design is in its infancy. Even with the actual limitations linked to the different methods available, the widespread of assessment methods is gradually gaining more market in the construction sector. Globally, the urgency to turn the economic growth toward sustainable development will require more efforts in the construction sector, too.

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