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# A systematic review of Building Performance Evaluation criterias (BPE)

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## ABSTRACT

The objective of this article is to provide, through a systematic review of the literature, focused on the quality control of buildings, a database to present the Building Performance Evaluation (BPE) most used criteria. Through this review, 782 articles were identified, of which 15 were selected considering the subject's adherence to the research and publication period. It was discussed the main information about the articles, their authors and journals. The performance criteria compiled by the analyzed articles used as basis: literature, questionnaires and interviews with users and professionals of the area, consultation with specialists in the segment and technical visits to buildings. With these identified criteria, it was possible to define 9 dimensions of analysis that are presented and discussed in this document.
**Keywords:** performance; evaluation; criteria; construction; systematic review.

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# Uma revisão sistemática dos critérios do Building Performance Evaluation (BPE)


## RESUMO

O objetivo deste artigo é fornecer, por meio de uma revisão sistemática da literatura focada no controle de qualidade das edificações, um banco de dados para apresentar os critérios mais utilizados pelo Building Performance Evaluation (BPE). Mediante a esta revisão, 782 artigos foram identificados, dos quais 15 foram selecionados considerando aderência do tema a pesquisa e período de publicação. As principais informações sobre os artigos, seus autores e revistas foram debatidas. Os critérios de desempenho compilados pelos artigos analisados utilizaram como base: a literatura, questionários e entrevistas com usuários e profissionais da área, consulta a especialistas do segmento e visitas técnicas as edificações. Com tais critérios identificados foi possível definir 9 dimensões de análise que são apresentadas e discutidas neste documento.

**Palavras chave:** desempenho; avaliação; critérios; construção; revisão sistemática.

# Una revisión sistemática de los criterios del Builiding Performance Evaluation (BPE)


## RESUMEN

El objetivo de este artículo es proporcionar, a través de una revisión sistemática de la literatura enfocada en el control de calidad de las edificaciones, una base de datos consistente para presentar los criterios más utilizados por el Building Performance Evaluation (BPE). Mediante esta revisión, 782 artículos fueron identificados, de los cuales 15 fueron seleccionados considerando adherencia del tema a la investigación y período de publicación. Las principales informaciones sobre los artículos, sus autores y revistas fueron debatidas. Los criterios de desempeño compilados por los artículos analizados utilizaron como base: la literatura, cuestionarios y entrevistas con usuarios y profesionales del área, consulta a especialistas del segmento y visitas técnicas a las edificaciones. Con estos criterios identificados fue posible definir 9 dimensiones de análisis que son presentadas y discutidas en este documento.

**Palabras clave:** desempeño; evaluación; criterios; construcción; revisión sistemática.

## 1. INTRODUCTION

A building is built with the aim of providing the human being with a pleasant and comfortable working environment, and protected against climatic inclement weather (Khalil et al., 2008). However, a building is the result of a project and planning built and managed based on specific standards established by governments, professionals and specialists who must meet not only the current technical requirements of each country, but also the expectations and aspirations established by the users (Ibem et al., 2013).

Based on this discussion, it is important to realize the importance of this research by considering that high population indexes is essential for more buildings to be built, but at the same time continue to meet the requirements established by the standards and by the final owners.

The performance of a building can be defined as its capacity to operate at maximum efficiency, fulfilling its function throughout its life cycle (Khalil et al 2016). To provide this maximum operation and to improve its efficiency, regular and continuous evaluation of building performance, called building performance evaluation (BPE), is essential. The BPE is a process of systematic comparison of the real performance of a building, that is, it relates the objectives of the client with the criteria of performance established by the specialists in order to measure the degree of satisfaction and performance of a building for those users (Preiser, 1994). This process aims to

improve the quality of management, design and construction by providing a more sustainable construction (Ibem et al., 2013); provide basic information on users' needs, preferences and satisfaction (Vischer, 2008) and provide feedback on the causes and effects of environmental issues related to buildings, thus informing the long-term planning and management of the life cycle of buildings (Meir et al., 2009). To do so, the BPE serves as a tool that adds value, assisting managers in decision making at strategic and operational levels during construction of a building (Khalil et al., 2008). However, for the application of the BPE it is necessary to define the evaluation criteria that can help in the process of measuring the performance of a building. According to Teicholz (2003), one can not improve what can not be measured. Measuring the performance of a building, according to Koleoso et al. (2013), is the safest way to improve the economic, physical and functional development of a building, ensuring that its objectives are met. Based on this assumption, this article aims to present a brief overview, through a systematic review of the literature, of the main academic studies that have studied and established performance criteria for the evaluation of buildings in order to assist in the expansion of this area of research focused on the control of quality of buildings.

## 2. MATERIALS AND METHODS:

This research adopted a systematic review approach proposed by Kitchenhamet et al. (2009) and followed three main steps (Figure 1): (1) Review planning; (2) Conduct of review; (3) Dissemination and reporting.

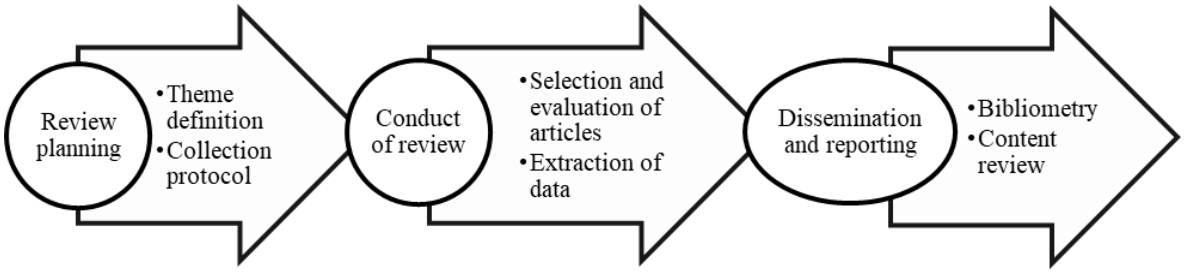


Figure 1. Process of applying the systematic review.
Adapted from Kitchenhamet et al., (2009)

The first phase of the research proposes to align the research theme and elaborate the collection protocol. The central theme established for research was to identify the criteria established in the literature for evaluating the performance of buildings. Based in this thematic, the collection protocol was elaborated, selecting 3 international databases: Web of Science, Scopus and Science Direct, and a Brazilian database, the CAPES. In each database, terms related with performance evaluation in construction had been tested. In the search *string* it had used the logical boolean operators AND, OR and the quotations marks for bigger precision of the research, until two terms were defined: *"building performance evaluation*" and "*building performance criteria*".
In the second phase of the research, the articles were selected based on the scope of the theme, that is, if the article had as its essence the definition of criteria for performance evaluation of buildings; the period of publication (2010-2017) and the search for articles of *Journals*, discarding articles of congresses. After this selection, a dynamic reading of the articles was performed and in this step, it was possible to obtain more articles by referential means cited by the authors. This process created a *looping* and stopped only when no articles were applied to the topic. The identified articles were organized in an Excel spreadsheet.
This technique of searching for new articles from those already selected is known as Snowball Sampling (ABN) and was reported by (Biernacki and Waldorf, 1981). Finally, in the third phase of the research it was possible to elaborate the articles bibliometry and content revision. In the first

one, we tried to measure the main aspects related to the articles, the authors and the magazines. The mechanism used to identify the citations of articles and the scores of journals was the platforms "*Scopus- Search for an author profile",* "*Scopus- Journal Metrics*" and "*Scimago Journal & Country Rank*". Based on all the keywords identified in the articles, the word cloud was created using the online software "*Word it out*". The objective of this stage was to understand the panorama of research in the world, identifying the main authors and journals. In the second stage, the proposal was to compile the information present in the articles, organizing them into four groups: (1) methods used to elaborate the performance criteria; (2) conducting the questionnaires used; (3) organization of the criteria identified in 9 dimensions and (4) preparation of a table compiling all the criteria identified in the established dimensions.

## 3. RESULTS AND DISCUSSION

Through the systematic review of the literature, the two selected keywords *«building performance evaluation*» and «*building performance criteria*» were inserted into the four selected databases: Web of Science, Scopus, Science Direct and CAPES. In the first round, 782 articles were identified. With this sample we selected articles from 2010-2017, peer-reviewed *Journal* and *Journal* articles, reducing the sample to 424. With these, a dynamic reading was performed, which is a reading of the main topics such as abstract, method and result, and it were chosen the articles that presented in their conception the elaboration of a BPE method and selection of criteria. Then, the technique of Snowball Sampling was applied until the end of the identification of articles adhering to the theme. Table 1 presents in detail the procedure performed up to the selected number of 15 articles.

Table 1. Conduct of research: selection of articles.

| | Data Base | Web of Science | Science Direct | Scopus | Capes | Total |
|---|---|---|---|---|---|---|
| Key Words | "building performance evaluation" | 67 | 195 | 4 | 370 | 636 |
| | "building performance criteria" | 27 | 19 | 2 | 98 | 146 |
| | Total search without filter and with duplicity | | | | | **782** |
| Filters | 1° Selection of the year (2010-2017)<br>2º *Journal* and *Journal* | 47 | 134 | 0 | 243 | **424** |
| | 3° Dynamic reading: article has elaboration of the BPE method and selection of evaluation criteria | 0 | 4* | 0 | 9* | 9 |
| | 4° Snowball (2010-2017) | 19 | | | | |
| | 5º Dynamic reading | 4 | | | | 3 |
| | 6º Snowball (2010-2017) | 4 | | | | |
| | 7º Dynamic reading | 4 | | | | 2 |
| | 8º Snowball (2010-2017) | 1 | | | | |
| | 9º Dynamic reading | 1 | | | | 1 |
| | Total adherent research | | | | | **15** |

*With the 15 articles selected, it was possible to perform bibliometric and content revision.

### 3.1 Bibliometric

In Table 2 it is possible to identify the authors name, the database where the article was identified, the name of the journals, their "DOI" registry and the country of origin. The journals that published the most works (from 2010 to July 2017) identifying criteria for performance evaluation in buildings were: United Kingdom (60%), followed by the Netherlands (13.33%), China, USA, Egypt and Lithuania (6.66%). It is noticed that more than 85% of the publishing magazines are from Nordic countries.

Table 2. Summary of onformation related to the 15 reviewed sources.

| Nº | Authors | Data Base | | | | | Journal | DOI | Journal origin (country) |
|---|---|---|---|---|---|---|---|---|---|
| | | Science direct | Scopus | Web of Science | Capes | Snow ball | | | |
| 1 | Gopikrishnan e Topkar (2017) | x | | | x | | *Housing and Building National Research Center* | dx.doi.org/10.1016/j.hbrcj.2015.08.004 | Egypt |
| 2 | Ibem et al (2013) | x | | | x | | *Frontiers of architectural research* | dx.doi.org/10.1016/j.foar.2013.02.001 | China |
| 3 | Khalil et al (2016) | | | | x | | *Ecological Indicators* | doi.org/10.1016/j.ecolind.2016.07.032 | Netherlands |
| 4 | Khan e Kotharkar (2012) | x | | | | | *Procedia - Social and Behavioral Sciences* | doi: 10.1016/j.sbspro.2012.08.052 | England |
| 5 | Steinke et al (2010) | | | | x | | *Health environments research & design journal* | | EUA |
| 6 | Nazeer e Silva 2016 | | | | x | | *Built Environment Project and Asset Management* | doi 10.1108/BEPAM-09-2014-0049 | England |
| 7 | Talib et al 2013 | x | | | | | *Facilities* | doi.org/10.1108/f-06-2012-0042 | England |
| 8 | Støre-Valen e Lohne 2016 | x | | | | | *Facilities* | doi 10.1108/F-12-2014-0103 | England |
| 9 | Mohit e Azim (2012) | | | | | x | *Procedia- Social and Behavioral Sciences* | doi: 10.1016/j.sbspro.2012.08.078 | England |
| 10 | Nik-Mat et al (2011) | | | | | x | *Procedia Engineering* | doi:10.1016/j.proeng.2011.11.174 | England |
| 11 | Hashim et al (2012) | | | | | x | *Procedia - Social and Behavioral Sciences* | doi: 10.1016/j.sbspro.2012.12.231 | England |
| 12 | Lavy et al (2010) | | | | | x | *Facilities* | doi.org/10.1108/02632771011057189 | England |
| 13 | Mohit e Nazyddah (2011) | | | | | x | *Journal of Housing and the Built Environment,* | doi 10.1007/s10901-011-9216-y | Netherlands |
| 14 | Lai e Man (2017) | | | | | x | *International Journal of Strategic Property Manag.* | doi:10.3846/1648715X.2016.1247304 | Lithuania |
| 15 | Elyna Myeda et al (2011) | | | | | x | *Journal of Facilities Management* | doi.org/10.1108/14725961111148090 | England |

However, it can be seen from Figure 2 that most research and research authors are concentrated in Western countries. Malaysia is the country with the largest number of researchers.


Figure 2. Information about the country of origin of the research and the authors.

Through the "*Scopus- Search for an author profile*" platform, it was possible to verify the most cited articles and the co-quotations made between them (Table 3). The article by (Steinke et al., 2016) was the most cited in the literature, followed by the article by (Mohit and Naydaah, 2011). Table 3 shows how many times the articles were cited in the literature in general, and where there were cases of citations between them.

Table 3. Citations and co-citations identified in the 15 revised articles.

| **Articles that have been cited** | **Gopikrishnan e Topkar (2017)** | **Ibem et al (2013)** | **Khalil et al (2016)** | **Khan e Kotharkar (2012)** | **Steinke et al (2010)** | **Nazeer e Silva (2016)** | **Talib et al (2013)** | **Støre-Valen e Lohne (2016)** | **Mohit e Azim (2012)** | **Nik-Mat et al (2011)** | **Hashim et al (2012)** | **Mohit e Nazyddah (2011)** | **Lavy et al (2010)** | **Lai e Man (2017)** | **Elyna Myeda et al (2011)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of citations in the literature | 0 | 6 | 2 | 0 | 15 | 0 | 0 | 1 | 1 | 1 | 0 | 8 | 0 | 1 | 0 |
| Steinke et al (2010) | | | | | | 1 | | 1 | | | | | | | |
| Lavy et al (2010) | | | | | 1 | 1 | | 1 | | 1 | | | | 1 | |
| Myeda et al (2011) | | | | | 1 | | | 1 | | | | | | 1 | |
| Nik-Mat et al (2011) | 1 | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mohit e Azim (2012) | 1 | | | | | | | | | | | | | | |
| Ibem et al (2013) | 1 | | | | | | | | | | | | | | |

The "*Scopus- Journal Metrics"* and "*Scimago Journal & Country Rank*" platforms made possible to know more about the magazines identified. The information presented in Table 4 refers to the number of publications for the years 2015-2016, the score of each journal according to its area of registration, its rank and its impact on the platform *Scopus* and *Scimago.*

Table 4. Journals Metrics

| **Journals** | **JCR (2017)** | **SJR 2015** | **SJR 2016** | **Cite Score** | **SRJ** | **H index** | **Total cites (2015)** | **Total cites (2016)** | **Documentos 2013/2015** | **Cite Score Rank** | **Nº artigos** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Frontiers of architectural research | - | 0,432 | 0,392 | 0,88 | 0,392 | 10 | 151 | 112 | 128 | 37/223 | 1 |
| Ecological Indicators | 3,983 | 1,481 | 1,308 | 4,07 | 1308 | 78 | 5039 | 5218 | 1286 | 20/291 | 1 |
| Built Environment Project and Asset Management | - | 0,243 | 0,317 | 1,07 | 0,317 | 8 | 53 | 75 | 71 | 93/245 | 1 |
| Facilities | - | 0,369 | 0,421 | 1,06 | 0,421 | 25 | 118 | 148 | 141 | 14/87 | 3 |
| Procedia Engineering | - | 0,238 | 0,282 | 0,74 | 0,282 | 31 | 6130 | 6732 | 9257 | 108/265 | 1 |
| Journal of Housing and the Built Environment | 1,329 | 0,649 | 0,866 | 1,16 | 0,866 | 31 | 132 | 142 | 120 | 30/134 | 1 |
| International Journal of Strategic Property Management | - | 0,561 | 0,293 | 0,92 | 0,293 | 19 | 117 | 82 | 90 | 161/347 | 1 |
| Procedia - Social and Behavioral Sciences | - | 0,159 | - | - | 0,159 | 29 | 185 | - | - | - | 3 |
| Journal of Facilities Management | - | - | - | - | | - | - | - | - | - | 1 |
| Housing and Building National Research Center | - | - | - | - | | - | - | - | - | - | 1 |
| Health environments research & design journal* | 1,387 | - | - | - | | - | - | - | - | - | 1 |

With the keywords identified in the 15 articles selected, it was possible to use the "Word it out" software to create the word cloud. The three words most highlighted by the articles were as follows: Performance, Building and Evaluation (Figure 3). This cloud of words gives an overview of what has been studied within these articles in relation to the evaluation of buildings, subjects such as: aid in the decision making of enterprises; improvement of the processes and physical conditions of buildings. The researched places: corporate sector (offices); education (schools and universities). What is being used as an instrument, such as questionnaires; post-occupation analysis, among others.


Figure 3. Keyword cloud

### 3.2 Content Review

The 15 works identified in the literature used several methods to elaborate the criteria for evaluating the performance of buildings. By consulting these articles, it was noticed that the review of the literature was the method used in all articles, that is, the authors sought to first explore the criteria already listed and identified in the literature and then spent, for the most part, exploring the criteria in practice. The criteria were tested, evaluated and validated through questionnaires (67%) made with users and / or construction professionals, such as engineers and architects. In 30% of the questionnaires applied, specialists of the area were consulted firstly, and then the users. In 20% of the used questionnaires only the specialists were consulted. In the questionnaires applied, the Likert scale was the instrument used in 50% of these.

The technical visit consisting of a visual analysis of the buildings and consultation of documents, such as design and technical data sheets, was the method used in 33% of the articles. It was not used in isolation, but always in conjunction with other methods. The interview was used in 27% of the articles, being carried out with users and / or professionals of the area. The AHP method (7%) was explored on a smaller scale, applied in the link with expert consultation. The full picture of the methods employed can be seen in Table 5.

Table 5. Methods used to identify the performance criteria.

| Nº | Methods | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Literature** | **Expert Consultation** | **Questionnaire** | **Likert Scale** | **Technical visit / observation** | **Interview** | **Method AHP** |
| 1 | x | x | x | x | | | |
| 2 | x | | x | x | x | | |
| 3 | x | x | | | | | x |
| 4 | x | | x | | x | x | |
| 5 | x | x | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6 | x | x | x | x | | | |
| 7 | x | | x | | | | |
| 8 | x | | | | | | |
| 9 | x | | x | x | | | |
| 10 | x | | x | | x | x | |
| 11 | x | | x | | x | x | |
| 12 | x | x | x | | | | |
| 13 | x | | x | x | | | |
| 14 | x | | | | | | |
| 15 | x | | | | x | x | |

The questionnaire was the second method most used by the authors to identify the criteria needed to evaluate a construction. Of these, 80% were applied, and 20% were not applied, that is, in the case of the 20%, the authors present the questionnaire as a reference and as an instrument to test the criteria but did not actually use it. In the questionnaires applied, in short, about 3,196 questionnaires were sent. Only the work of (Nik-Mat et al., 2011) sent 1,230 questionnaires. The response rate varied from 20.4% to 100% in the applied works. To select the respondents to the questionnaires, the most used criteria was the working time in the area, in the case of the specialists, and for the users, the dwelling time of the dwellings. The works organized the criteria into dimensions that were validated. In some cases, the criteria were reorganized and then validated by the authors (Table 6).

Table 6. Summary of applied questionnaires.

| **Nº** | **Dimensions and Performance Criteria** | **Sample size** | **Replies per article** | **Response rate (%)** | **Result** | **Applicability** |
|---|---|---|---|---|---|---|
| 1 | 13 dimensions with n criteria (not detailed) | | | | 13 dimensions | No applied |
| 2 | 5 dimensions with 27 criteria | 670 | 452 | 67,5% | 5 dimensions | Applied |
| 4 | 5 dimensions with 22 criteria | | | | 5 dimensions | No applied |
| 6 | 7 dimensions with 57 criteria | 37 specialists | 31 specialists | 83,80% | 7 dimensions | Applied |
| 7 | 3 dimensions with 58 criteria | 225 | 166 e 192 | 74%/85% | 3 dimensions with 11 criteria validated | Applied |
| 9 | 4 dimensions with 46 criteria | 100 | 100 | 100% | 4 dimensions | Applied |
| 10 | 3 dimensions with 17 criteria | 2 categories: users and construction team: 1230 | 252 | 20,40% | 3 dimensions | Applied / Not detailed |
| 11 | 7 dimensions with 34 criteria | 3 categories: users; external public and | | | 7 dimensions | Applied / Not detailed |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | construction team | | | | |
| 12 | 4 dimensions with 35 criteria | 11 industry representatives | 7 | 63,60% | 4 dimensions | Applied |
| 13 | 5 dimensions with 45 criteria | 3 categories: residents groups; individuals and residents in transit: 960 | 250 | 27,60% | 5 dimensions | Applied |

In full, each article provides a range of criteria that should be analyzed to evaluate the performance of a building. In some cases, the articles created dimensions to organize their criteria, in others, the articles presented the criteria without presenting a specific group. In this way, the authors of this paper organized the criteria identified in the articles in 9 dimensions established from the reading of the works (Table 7).

Table 7. Dimensions established to organize the performance evaluation criteria of a construction.

| **Authors** | **Dimensions to measure performance** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Functional** | **Technical / Maintenance** | **Environment (spaces / location)** | **Financial / Economic** | **Environmental** | **Image / Appearance** | **Neighborhood relation** | **Process** | **Leadership** | **Types of construction** |
| Gopikrishnan e Topkar (2017) | x | x | x | | | | | | | n/s |
| Ibem et al (2013) | x | x | x | x | | x | | | | habitation |
| Khalil et al (2016) | x | x | x | | | | | | | Education |
| Khan e Kotharkar (2012) | x | x | x | | | | x | | | Education |
| Steinke et al (2010) | x | x | x | x | | | | | | health |
| Nazeer e Silva 2016 | x | x | x | x | x | | | x | x | Education |
| Talib et al (2013) | x | x | x | | | | | | | health |
| Støre-Valen e Lohne (2016) | x | x | x | | x | | | | | n/s |
| Mohit e Azim (2012) | | x | x | | | x | x | | | Habitation |
| Nik-Mat et al (2011) | x | x | | | | x | | | | Habitation |
| Hashim et al (2012) | x | x | x | x | | x | | | | habitation |
| Lavy et al (2010) | x | x | x | x | | | | | | n/s |
| Mohit e Nazyddah (2011) | x | | x | | x | | x | | | habitation |
| Lai e Man (2017) | x | x | | x | x | | | | | commercial |
| Elyna Myeda et al (2011) | x | x | x | | | x | | | | commercial |

It can be seen from Table 7 that 20% of the articles are concerned with creating criteria that evaluate constructions in general. However, the other 80% show that it is important to establish specific criteria for each type of construction, in the case of housing, education, health and commerce.
The nine dimensions elaborated involve the analysis of aspects related to the functional condition of a building, such as: air condition, ambient (acoustic and thermal comfort), noise, fire protection, lighting, among others; the technical condition involves the structure of the building, plumbing and electrical services, for example. The environment dimension refers to the spaces (of the rooms) and location of the enterprise; the financial dimension involves expenses related to building (maintenance, light, water). The environmental dimension refers to the spending index on light, water and garbage collection; the image dimension involves the aesthetics and appearance of the buildings.
The dimension "relationship between neighborhood" presents the contact of the residents with the surroundings. The "processes" dimension involves the control and management of the services provided within an enterprise and finally the leadership dimension refers to the instructions established to the owners and employees in the construction occupation. The most used dimensions during the constructive evaluation refer to Functional (93%) and Technical (93%), followed by Environment (88%).
The evaluation criteria identified in the 15 articles studied and organized in 9 dimensions are presented below:

- Gopikrishnan and Topkar (2017): Thermal comfort; ventilation; visual comfort (natural lighting); fire safety, lightning, accidents in general; acoustic comfort; water control; control of air quality; control of drinking water and electricity services; building maintenance (fissures, leaks, infiltration, humidity, sewage); control of basic sanitation; control of internal and external finishes to the building; evaluation of spaces such as size of internal and external areas, accessibility to the connectivity of the building (networks), the surrounding roads, stairs and elevators internal to the building. Control of garbage collection and maintenance of building aesthetics.
- Ibem et al (2013): Visual control; thermal and acoustic; control of air quality; fire safety, insects, dangerous animals, moisture; building maintenance; control of electrical and sanitary services; evaluation of the internal spaces, the design of the building and its location (accessibility for residents); control of the costs with the building; control of the aesthetic appearance of the construction and materials used in construction.
- Khalil et al (2016): fire safety; thermal comfort; visual comfort (artificial and natural lighting); waste control; ventilation; acoustic comfort; assessment of structural stability; electrical and sanitary services; control of finishing materials; building cleaning control; evaluation of the size of the spaces and the circulation and evaluation of the signage of the environments in the building.
- Khan and Kotharkar (2012): fire safety; visual comfort; assessment of structural stability; control of sanitation services; evaluation of internal space sizes; evaluation of the flexibility of the internal environments and control of the aesthetics of the building.
- Steinke et al (2010): evaluation of how the building contributes to the quality of life of residents / employees; level of innovation and practicality of the building; level of expenditure (energy and water) and level of satisfaction of the residents / employees.
- Nazeer e Silva (2016): visual control (natural lighting); thermal comfort; control of safety equipment, internal hygiene of buildings; olfactory control of environments; evaluation of internal and external signaling of environments; acoustic control; ventilation; internal maintenance of the building; structural control; durability of materials; assessment of accessibility and flexibility of spaces by residents; accessibility that the building possesses to those with physical disabilities; evaluation of signage of the environments in the building; evaluation of costs related to building (financing and maintenance of the

building); waste control; assessment of existing resources to assist in waste management; control of building aesthetics; existing processes check the residents' knowledge regarding maintenance, use of resources; waste management; fire safety, among others and level of training that the users obtained to do proper maintenance of the building.

- Talib et al (2013): evaluation of how the construction contributes to the quality of life of residents / employees; control of the structural and electrical quality of the building; accessibility of spaces and evaluation of the quality of building design.
- Støre-Valen and Lohne (2016): Evaluation of the functionality, usability, flexibility of the building and the sustainable resources existing in the building.
- Mohit and Azim (2012): environment ventilation; accessibility of electricity services, such as quantity of power plugs; control of electrical and sanitation services; evaluation of the size of spaces; location of the building (accessibility to residents); parking leisure areas; control of waste collection and neighbor relationship (level of security, involvement with the neighborhood).
- Nik-Mat et al (2011): air quality control; visual control; security level of the building; control of cleaning, maintenance of internal and external building and accessibility of internal and external spaces (parking).
- Hashim et al (2012): thermal comfort, acoustic, visual, ventilation; comfort of the environment; control of building maintenance, materials used in construction; cleaning; evaluation of the size of the internal spaces of the building and its adaptability to the residents; costs related to building (maintenance, energy, waste, among others) and evaluation of the aesthetics of construction.
- Lavy et al (2010): evaluation of how the building brings a sense of comfort to the residents, considering level of safety and hygiene; thermal comfort, acoustic, visual (natural lighting), air quality; building maintenance; control of sanitary and electrical services; evaluation of the accessibility of the building for residents in terms of location, room space, parking and accessibility for the physically handicapped; evaluation of the costs of maintenance of buildings, energy, water); control of waste collection; control of the aesthetics of the building (finishing) and relation of involvement of the neighborhood with the building.
- Mohit and Nazyddah (2011): acoustic comfort; ventilation; accessibility of electricity services, such as quantity of power plug; fire safety; evaluation of the rooms (physical structure); assessment of accessibility of the building, such as presence of suitable corridors, stairs, elevators, parking; building access to community conveniences and control of waste collection.
- Lai and Man (2017): thermal comfort; visual; acoustic; air quality; satisfaction of users and / or professionals; security percentage of the building; building efficiency in relation to maintenance time; evaluation of preventive and corrective maintenance; building costs (maintenance, staffing, site insurance, among others) and control of energy consumption by building users.
- Elyna Myeda et al (2011): Visual comfort (lighting); air quality; building safety; control of the finishes (internal and external) of the building; general maintenance of the building; control of cleaning and electrical and sanitary services; evaluation of the accessibility of the building to the residents, such as stairs, elevators, spaces signaling, parking and control / maintenance of the landscaping and design of the building.

## 4. CONCLUSIONS

In this paper, a set of criteria established by authors for *building performance evaluation* (BPE) is presented in detail. The systematic review approach, together with the Snowball Sampling technique resulted in the identification of 15 articles. Both bibliometric and the content of these

articles were investigated. The United Kingdom is the country responsible for publishing the largest number of papers in this area, although most of the research conducted and the authors are from the eastern countries like Malaysia and India. The citations of the articles and the punctuation of the respective journals were also verified, realizing that there is a reasonable number of co-citations among the studied subjects.

In addition to the literature search by the BPE criteria, the articles also used practical methods, such as questionnaires, expert consultation, interviews and technical visits to buildings. The articles show a concern in the elaboration of specific criteria for each type of construction instead of establishing criteria for buildings in general. The criteria identified were grouped into 9 dimensions: functional, technical, environment, financial, environmental, physical image / appearance, neighborhood relation, process and leadership. The criteria most used to evaluate a building were the criteria listed in the functional and technical dimensions, such as: thermal comfort, visual (lighting), acoustic, fire safety, air quality, maintenance and cleaning of facilities (sanitary and electrical) of the building.

The authors hope that this research will help those who study the performance evaluation of constructions in order to facilitate the identification and more adequate selection of the studied criteria.

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