ENVIRONMENTAL CERTIFICATION FOR HABITATIONS: COMPARISON BETWEEN LEED FOR HOMES, AQUA PROCESS AND "SELO CASA AZUL"

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Introduction

With the need of changes in the construction industry, in order to adapt to sustainability agendas, evaluation methods of environmental impact in edifications were developed. Because, without the determination of parameters and goals there is no way to verify the compliance with sustainability issues to which the countries are subjected.

Many countries have already developed methodologies for assessment and environmental certification of buildings, also known as green seals. Among these are: Building Research Establishment Evaluation Method (BRE) in England, Leadership in Energy & Environmental Design (LEED) in the United States, the Sustainable Building Challenge (SBC) which belongs to a consortium of several countries, High Quality Environment (HQE) of France and the Assessment System of Environmental Efficiency for Construction (CASBEE) of Japan.

Since the reality of these countries is quite distinct from the Brazilian one, it is necessary to rely on studies that prove the employability of these tools in Brazil. Azevedo (2008) concluded that the mechanisms established by developing countries require an evolutionary structure. Bueno (2010, p. 115) proposes that adjustments must be made regarding the geographic, climatic, cultural and normative issues, but also says "(...) that the studied tools demonstrate a series of evaluative items fully applicable to residential buildings in the Brazilian scenario and others that still require adjustments".

The importance of the environmental seal is mainly to improve the quality of built environments and, especially, in order to minimize the impacts to the environment. Therefore, this article aims to elect the most appropriate environmental certification system to

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residential buildings in Brazil, among the three pre-selected ones. The hypothesis is that a green seal designed for a specific locality and reality has better performance. The systems here analyzed and compared are among the most known and used in the country, being (a) a foreign method, LEED for Homes; (b) an adaptation of the French system, AQUA Process; (c) the first Brazilian methodology, "Selo Casa Azul".

Brazil keeps the 4th position in the world ranking of LEED projects, behind only of the United States, China and United Arab Emirates (GBC Brazil, 2012). The AQUA Process has certified, until November 2012, 63 buildings (FCAV, 2012) and the "Selo Casa Azul" was granted to large works of social housing, such as the "Paraisópolis" complex and the "Chapéu Mangueira and Babilônia" complex (CEF, 2012).

For the comparative analysis of the three mentioned green seals a technique named Hierarchic Analysis has been used, a method that assists the deciding process through a decision matrix, with the determination of weights for the evaluation criteria.

In the field of civil engineering, the potential of hierarchical analysis has been little explored, however examples of studies that used this tool as a decision instrument can be cited, such as: 1 - Marchezetti et al. (2011), in the treatment of household waste; 2 - Silva and Souza (2011), in the selection of collectors-compactor trucks of solid waste; 3 - Lisboa and Waisman (2006) and Zayed et al. (2008) in decisions related to the area of roads project; 4 - Pan (2008), in the selection of construction methods of bridges; 5 - Lai et al. (2008), in the public works project; 6 - Pereira, Medeiros and Levy (2012) and Mattana et al. (2012) in studies on recycling of construction waste for the manufacture of concrete and mortar.

The environmental impact of buildings

Many are the implications and impacts generated by buildings around the world. At least a fourth part of CO_2 emissions is in construction and edification operations in Brazil, with exception of the forest fires parcel. The CO_2 is the most important by-product of construction materials production, including the used resources, the effects caused by the extraction of raw materials and their processing operation. It is important to know that buildings constructed in reinforced concrete structure or structural steel require similar amounts of energy and result in similar levels of CO_2 (TAVARES, 2006).

Considering the performance of buildings and even of towns is relevant taking into account their useful life. The buildings tend to last over 50 years and the road and rail infrastructures even more than 100 years. Besides, it is important to remember that they are major consumers of resources. According to Edwards (2008), most of the arable land in the world, 80%, is used in construction instead of agriculture. Besides, the construction of durable edifications can mean less need for investments with its recovery over the years as well as a high useful life, saving natural resources destined to the demolishment and reconstruction process of a given building at the end of its service life (MEDEIROS et al., 2011). In Brazil, real state has a high added value and may take almost 70% of family income for its acquisition (IPEA, 2008). Considering that the function of dwelling is to provide shelter and comfort for the man, it is certain that those who best fulfil their

role will be more valued by the real estate market. Besides, Olgyay (2006) highlights the importance of the edification to provide comfort associated with low maintenance cost, reducing the need for mechanical conditioning through the use of natural resources. In this regard it is worth noting that, in the evaluation of a building in a period of 50 years, the operational costs are five times higher than design and construction (EDWARDS, 2008). In this sense, Table 1 illustrates the economic impact that maintenance and repair services can have in the country's economy, where it is verified that some European countries spend around 50% of what they invest in constructions and maintenance and repair services (UEDA e TAKEWAKA, 2007). In Brazil, statistical data such as these do not exist, but data in Table 1 serves as an indication of how much maintenance and repair of buildings can cost for a nation.

Returning to the issue of sustainability, in addition to the adaptations of the international evaluation systems, there are national standardization initiatives, such as ISO 14000, and many sustainable materials and technologies of proven effectiveness. An example of this is the consolidation of the "*Casa Eficiente*" project, "(...) showcase of cutting-edge energy efficiency and environmental comfort technologies for residential buildings" (ELETROSUL, 2004).

The intention of environmental seals certification is that the market itself will boost environmental improvement, either for their commitment to the issue, either by marketing issues, such as competitiveness. And, in some countries, the certification "(...) *is no longer merely a market strategy and has become a condition for building legalization*." (PICCOLI et al., 2010, p. 70).

Table 1 - Expenditures for maintenance and repair in developed countries (UEDA and TAKEWAKA, 2007)

Country	Spending on new constructions	Spending with repair and maintenance	Total Spending with construction
France	85.6 Billions of Euros (52%)	79.6 Billions of Euros (48%)	165.2 Billions of Euros (100%)
Germany	99.7 Billions of Euros (50%)	99.0 Billions of Euros (50%)	198.7 Billions of Euros (100%)
Italy	58.6 Billions of Euros (43%)	76.8 Billions of Euros (57%)	135.4 Billions of Euros (100%)
United Kingdom	60.Billions of Pounds (50%)	61.2 Billions of Pounds (50%)	121.9 Billions of Pounds (100%)

Note: all data refers to year 2004, except for Italy which refers to 2002.

The cited authors state that, in 2007, it has been created in the country the first system of environmental certification, the Technical Referential of Certification: buildings in the service sector, system of High Environmental Quality (AQUA), based on the French system NF Bâtiments Tertiaires - Démarche HQE®. It must also be highlighted the initiatives of the National Program of Energetic Efficiency in Edifications (PROCEL EDIFICA) and the "*Selo Casa Azul*" of "*Caixa Econômica Federal*".

Piccoli et al. (2010) criticize the Brazilian normalization techniques related to civil construction, whose concerns are the "how" the product is built and not about its performance. The negative effect of these characteristics of the vast majority of national standards is the difficulty of certification of new constructive systems that, being innovative, do not have a specific standard. Standards based on performance criteria set minimum values of efficiency of the constructive system, being fully possible to create new construction systems, provided that the minimum limits to the user's satisfaction are met.

In order to overcome the conservative view of traditional standards, the technical standard NBR 15575 was developed, "Residential buildings up to five floors: performance". This standard aims to ensure users the performance of constructive systems and not to determine how they must be built, so that different construction systems, traditional or new, can concur as options for use in buildings without building companies being out of the standard. For this, each new constructive system has to undergo a battery of tests to be certified and approved for general use.

This standard was published in May 2008, however, it went through a process of adaptation of the building companies and texts review and entered into force as of March 2013 (ABNT, 2008).

One of the government initiatives for the sustainability agenda was the creation of the 1st energy efficiency law, Law nº 10.295, which establishes the National Policy for Conservation and Rational Use of Energy. This, regulated by Decree nº 4.059 of October 2001, establishes the creation of "maximum levels of energy consumption and minimum ones of energetic efficiency" and the need of "technical indicators and specific regulations" also for buildings (CARLO; LAMBERTS, 2010).

The fact is that the importance of reducing the environmental impact of buildings is a global trend, driven by government requirements or even by market strategies. For one reason or another, certification using green seal systems are increasingly in evidence and must be judiciously compared in order to produce the necessary knowledge in terms of deciding which option is most appropriate for use in Brazil.

LEED for Homes

The LEED certification system was created by the United States Green Building Council (USGBC), in 1998. It is a method of classification based on matching, weighting of credits (depending on the environmental impact and human health) and regionalization. The energetic efficiency and reduction of CO_2 emissions are items considered of greater importance in this evaluation system. The seal certifies buildings from a list of prerequisites and credits, and has four levels: Certified, Silver, Gold and Platinum (USGBC, 2012).

The LEED for Homes, created in 2008 specifically for residential buildings, aims at saving energy, water and, consequently, the economy of financial resources. Besides, it advocates that the certified house provides a healthier environment. USGBC claims that "green" and efficient buildings sell more and faster than those without these concepts. The LEED for Homes differential is the fact that the final amount of credits is a established from a relation between the area and the number of rooms. This is because that analogy indicates the amount of occupants of the housing unit. The categories of this seal can be visualized in Table 1 (USGBC, 2012).

Table 1 - LEED for Homes categories

LEED for Homes categories
1. *Innovation & Design Process*
2. *Location & Linkages*
3. *Sustainable Sites*
4. *Water Efficiency*
5. *Energy & Atmosphere*
6. *Materials & Resources*
7. *Indoor Environmental Quality*
8. *Awareness & Education*

Source: adapted from USGBC 2012

The Green Building Council Brazil is developing a seal for Sustainable Homes, The Referential SBC Brazil House®, designed specifically for the Brazilian residential market. One of the goals is to disseminate sustainable parameters in habitation and "(...) which seek economic viability, creation of healthier environments, reduction of natural resources extractions from the environment and awareness about the residential sector demand" (GBC Brazil, 2012).

AQUA Process

The Technical French Benchmark Certification *Bâtiments Tertiaires - Démarche HQE®*, developed by Certivéa, was adequate for the Brazilian context through a cooperative agreement with the Vanzolini Foundation in 2007. "The High Environmental Quality ("AQUA") is defined as being a management process to achieve the environmental quality of a new venture or involving rehabilitation" (FCAV, 2007).

The AQUA Process evaluates the environmental performance of a construction by its architectural and technical nature, as well as by its management. It is structured in two main tools: the Enterprise Management System (EMS) and the Environmental Quality of the Building (EQB). Under the view of this green label, the building management allows defining aspects of the building that will achieve and maintain the levels of environmental quality (FCAV, 2007).

Table 2 - Categories of the AQUA Process

Categories of the AQUA Process	
Eco construction	Relation of the buiding with its surroundings
	Integrated choice of products, systems and construction processes
	Construction site with low environmental impact
Management	Energy management
	Water management
	Management of use waste and occupancy of the building
	Maintenance - permanence of the environmental performance of the building
Comfort	Hygrothermal comfort
	Acoustic comfort
	Visual comfort
	Olfactory comfort
Health	Environmental sanitary quality
	Air sanitary quality
	Water sanitary quality

Source. Adapted from FCAV, 2007

The levels that an edification can obtain by the AQUA Process are related to the Environmental Quality of the Building. The combined performance can be Good, Superior or Excellent (FCAV, 2007).

"Selo Casa Azul" (BLUE HOUSE SEAL)

"Selo Casa Azul" is a social environmental classification of residential developments of "*Caixa Econômica Federal*". It is the first certification system created for the reality of Brazilian housing construction. It was developed by a multidisciplinary team in partnership with the Polytechnic School of the University of São Paulo, Federal University of Santa Catarina and University of Campinas.

The intent is to encourage the rational use of natural resources, reduce the cost of maintaining the buildings and the monthly expenses with users, as well as to raise awareness about the benefits of sustainable constructions. The seal applies to housing projects funded by "*Caixa Econômica Federal*" and its membership is voluntary.

In this seals methodology the "efficient solutions applied to the construction, use, occupation and maintenance of buildings" are evaluated. The verification is made at the moment of the technical availability analysis of the project and the gradation levels that can be achieved are: Bronze, Silver and Gold.

To qualify for the "*Casa Azul*" seal, 53 criteria are analyzed, divided into 6 categories, as presented in Table 3.

Table 3 – "*Casa Azul*" seal categories

"Casa Azul" seal categories
1. Urban quality
2. Design and comfort
3. Energy efficiency
4. Conservation of material resources
5. Water management
6. Social practices

Source: adapted from CERF, 2012

Hierarchical analysis

The Analytic Hierarchic Process, AHP, is a method of multi-criteria decision aid, proposed by Saaty in the 70s. This methodology addresses complex problems in simplified ways and allows the use of quantitative and qualitative criteria in the same analysis. This method is based in an unit responsible by decision making, that can consists of a single individual or a group of them, called decision makers (COSTA, 2002).

To understand the problem, the elements involved are organized in hierarchical levels, grouped in specific layers. The analysis is built as a schema that relates goal, criteria and alternatives. The alternatives are the action strategies that can be adapted to the problem and are evaluated by criteria. The criteria are properties or alternative variables, used to determine which one is the most appropriate to achieve the objective (COSTA, 2002).

The resume presented in Table 4 clarifies the AHP process.

Table 4 - AHP summary

Summary of the Analytic Hierarchy Process				
	1st stage	**Process**		
	Selection of alternatives	Alternatives are the options of solutions to reach the goal and that will be compared with the AHP method		
	2nd stage	**Process**		
	Definition of criteria and sub-criteria	In order to select the alternatives, they are compared by factors which are relevant to their performance. Those criteria are chosen by the decision maker. When one factor is very broad, it may be analyzed by sub-criteria, for a more detailed evaluation		
	3rd stage	**Process**		
	Data collection	In this stage are collected the data of each alternative referring to the established criteria. Those information are normally obtained by means of a literature review		
	4th stage	**Process**	**Example**	
	Attribution of weights	In this moment the decision maker will evaluate which criteria and sub-criteria have more influence in the performance of alternatives. This procedure is performed comparing the variables with each other and thus, verifying which one is more important in the result. For this, scales like the one of this paper are used.	Same importance More important Much more important Less important Much less important	1.0 2.0 3.0 0.5 0.3
	5th stage	**Process**	**Example**	
	Definition of point scale	Definition of point scale Being in possession of all data, the decision maker will establish a point scale. If there are qualitative criteria and/or sub-criteria, they will receive numerical values (see example). The variables quantitatively measured have their values compared directly.	Excellent Optimum Good Acceptable Bad	4.0 3.0 2.0 1.0 0.0
	6th stage	**Process**		
	Decision Matrix	The comparison of alternatives is performed in a decision matrix. In this matrix are assigned the valuables of the variables of each alternative. If there are values in different scales, they must be standardized. This procedure is performed dividing the value of each weight by the higher number, resulting in a scale from 0 to 1. The standardized data are multiplied by the relative weight, resulting in their participation in the performance. In the AHP method, it starts by the sub-criteria decision matrix (if they exist). The values that will be included in the criteria matrix, will follow the same mentioned logic.		

The comparative analysis performed in this study makes use of this methodology to compare three systems of environmental certification, which are the process alternatives. The criteria evaluated in this study were based in investigations performed, mainly by Bueno (2010), and researches on the references of each seal. From those same sources the data variables were taken.

Methodology

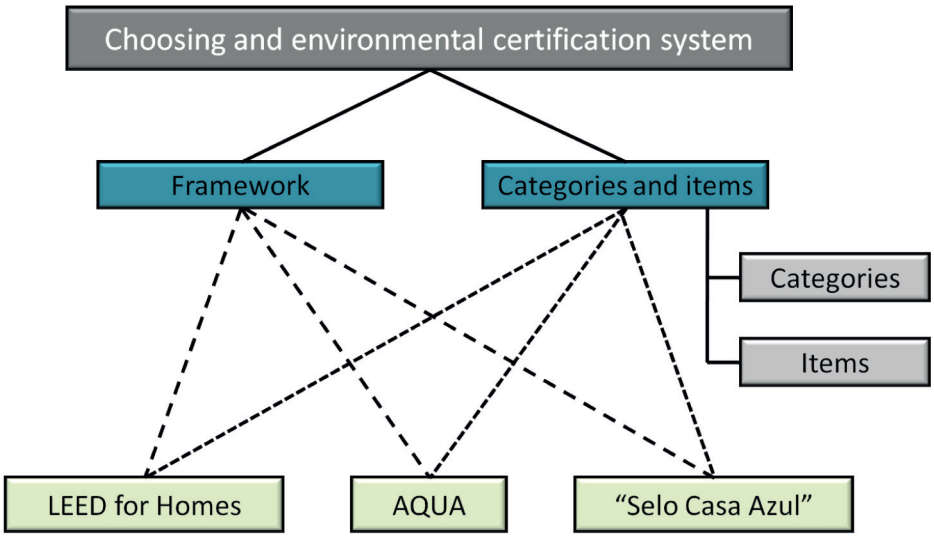
For evaluating the pre-selected system alternatives of environmental certification (LEED for Homes, AQUA and "*Casa Azul*" seal) the AHP method was used. For this

study two criteria were established: (a) Framework and (b) Categories and items. The judgment "Beaconing" is based on the study of Bueno (2010). The cited author made a study detailing the LEED for Homes System and AQUA. In this investigation, Bueno (2010) evaluated the following factors: (a) applicability in the Brazilian context; (b) relevance to the determination of environmental performance.

Thus, the " Framework " represents the percentage of items of each seal in accordance with the cited factors, according to investigation of the author.

The criterion "Categories and Items" is divided into two sub-criteria and refers to the division into categories of each green seal, as shown in Tables 1, 2 and 3, and their evaluation items. Categories were evaluated qualitatively, by verifying their relevance to evaluate the environmental performance of buildings, in a scale from excellent until bad. The items were analyzed in a quantitative way, considering their number to evaluate an edification proposed in each seal. The scheme of hierarchical analysis assembled detailing criteria, sub-criteria and choice options to the present study is shown in Figure 1.

Figure 1. Hierarchical analysis scheme



As it has been determined by the AHP method, the process begins with the setting of weights for each criterion to be evaluated. To define the importance of Framework and Categories and Items, a research has been performed with 3 professors and 11 master students of the Engineering Construction Program (PPGECC) in the University of Parana (UFPR). This group of individuals defined the criteria weights. This procedure was performed as an interview, first with an explanation about the study and about the evaluation items. The concepts for each criterion could vary from 1 to 9, and the sum of the two resulted 10. The 14 responses were tabulated and summed generating the relative importance according to Table 1.

Table 1 - Criteria Weight

Weights defined in the survey of master's degree students and professors of PPGECC in UFPR	Individual01	Individual02	Individual03	Individual04	Individual05	Individual06	Individual07	Individual08	Individual09	Individual10	Individual11	Individual12	Individual13	Individual14	Row total	Relative Importance
Framework	5	7	5	6	5	7	6	2	3	2	3	2	6	5	64	0.457
Categories and Items	5	3	5	4	5	3	4	8	7	8	7	8	4	5	76	0.543
													TOTAL		140	1.000

The weights of sub-criteria (Categories and items) were defined by a range of importance deliberated by the authors of this study. The scale and the calculation matrix of relative importance are shown in Table 2. Comparing one criterion to another, by the scale indicated in Table 2, it is possible to define which has the highest relative importance during the definition of the alternatives' performance.

Table 2 - Sub-criteria weights

Scale		Categories	Items	**Line total**	**Relative importance**
Equal	1.0				
Most important	2.0				
Much more important	3.0				
Less important	0.5				
Much less important	0.3				
Categories		1.0	2.0	3.0	0.667
Items		0.5	1.0	1.5	0.333
			TOTAL	4.5	1.000

Results

With the matrixes of relative importance defined, the elaboration of the decision matrix for evaluating alternatives was made. According to Saaty's method sequence, the sub-criteria were first measured. As mentioned, Categories refer to the same ones that each Green seal evaluates in the certification process. The scale used regards the qualitative values, from excellent to poor, as indicated in Table 3. Notes for the set of categories used by each system were given based on applicability and relevance.

The evaluation of Items used for certification was made quantitatively. The values listed in Table 3 for this sub-criteria refers to the number of items that can be scored in each seal. In the hierarchical analysis method, in the case were there are values in different

scales, those must be normalized, in order to obtain results in the range from 0 to 1 for all the parameters under evaluation. This enables the comparison of "categories" and "items" results in the decision matrix. Mathematically, the normalization consists in dividing the values of each row of the block "attributed values" in Table 3 by its highest value, as represented in the block "normalized values" in Table 3. The "sub-criteria note" block was obtained by the multiplication of the variable weight by the respective normalized values. Finally, the line "Total" in Table 3 is the sum of values of columns contained in the block "sub-criteria note".

Table 3 - Sub-criteria decision matrix

	Assigned values			Normalized values				Criteria notes		
Categories scales Excellent 4 Very Good 3 Good 2 Acceptable 1 Poor 0	"*Casa Azul*" seal	AQUA	LEED for Homes	"*Casa Azul*" seal	AQUA	LEED for Homes	Variable weight(%)	"*Casa Azul*" seal	AQUA	LEED for Homes
Categories	2	3	2	0.67	1,00	0,67	66.7	44.5	66.7	44.5
Items	53	35	36	1.00	0.66	0.68	33.3	33.3	22.0	22.6
						TOTAL	100	77.8	88.7	67.1

The result of the sub-criteria decision matrix (Table 3) shows a score of 88.7 for the AQUA process, followed by 77.8 by "*Casa Azul*" seal and 67.1 for LEED for Homes. It is demonstrated, therefore, that the AQUA process has better performance than the others considering only its set of categories and items.

The next step was the elaboration of a criteria decision matrix. Table 4 shows the results of sub-criteria and Framework evaluation. Based in Bueno's research (2010) it was possible to define the notes of this criterion. The author defined which criteria in the AQUA process and in the LEED for Homes do not attend the mentioned requisites. The same evaluation was made for "*Casa Azul*" seal by the authors of this paper. The calculation was performed by dividing the number of fail criteria, i.e., that do not meet the requisites, by the total of criteria.

According to Bueno (2010), from the 35 items of the AQUA process, 4 were disapproved (11.4%) and from the 36 of the LEED for Homes process, 15 did not meet the requisites (41.7%). The "*Casa Azul*" seal, which has 53 items, had 5 failures (9.4%). In Table 4 the values of variables "Beaconing" and "Categories and Items" are shown. Those values are represented by the block "assigned values" in Table 4, after undergoing a process of standardization, which consists in inverting the values, i.e., make the division of 1 by the respective number. As an example, dividing 1 by 9.4 in the case of "*Casa Azul*" seal, resulting in a value of 0.106. The reason to do this manoeuvre lies on the fact that the hierarchical analysis only works if all data have the trend of the higher the value is, the better.

Table 4 also contains the normalized values, relative weights and hierarchical analysis results, according to the same procedure used in calculations of Table 3.

Comparing the environmental certification systems using the Hierarchic Analysis method, the "*Casa Azul*" seal of "*Caixa Econômica Federal*" had the highest score, 93.3 in a scale from 0 to 100. Following is the AQUA process with 92.0 and, with the lower score, LEED for Homes with 51.4.

The result shows that the LEED for Homes system is not the most suitable one for the conditions in Brazil, mainly because it is an evaluation system designed for other countries and employed in Brazil without having undergone adaptations for the national reality.

Table 4 - Criteria decision matrix

	Assigned values			Normalized values				Note of criteria		
Framework scale / Percentage of failed criteria, according to Bueno (2010), being the highest % the worst score	*Casa Azul* seal	AQUA	LEED for Homes	*Casa Azul* seal	AQUA	LEED for Homes	Variable weight (%)	*Casa Azul* seal	AQUA	LEED for Homes
Framework	0.106	0.088	0.02	1.00	0.83	0.23	45.7	45.7	37.7	10.3
Categories and items	77.8	88.7	67.1	0.88	1.00	0.76	54.3	47.6	54.3	41.1
						TOTAL	100	93.3	92.0	51.4

Conclusion

The result of the comparison between the green seals analyzed in this study confirms the hypothesis that the one developed for a specific reality and location has better performance. The system of environmental certification "*Casa Azul*" seal had the higher final grade, having been developed to be applied in Brazil. In second place, with an almost irrelevant difference, is the AQUA process, adaptation of a foreigner system for the Brazilian reality. The LEED for Homes seal, that is used as it was conceived for the North American context, appears with the lower performance. The result seems consistent and indicates that the adaptation of the AQUA seal to the Brazilian reality was properly done and the transference of a certification system for the scenario of one country to another with different characteristics is not the most recommended way, its adaptation being essential.

The hierarchical analysis technique showed to be appropriate to refine the choice of a system of environmental certification. The positive point is that the methodology is fully open to the inclusion of other criteria, so that the decision matrix can be enhanced with the evaluation of theoretical and practical knowledge. Thus, the refinement of the

AHP process presented in this study is fully possible, and desirable, with the evolution of knowledge.

The contribution of this work emphasized the importance of green building seals, as these tend to stimulate sustainable actions in civil construction. However, as the market is being supplied with a range of environmental certifications, it becomes necessary to create means to perform systematic comparisons for choosing between the available options and AHP proved to be a useful tool for both.

As an improvement of the work proposed here, the addition of the following criteria is suggested: seal cost, economy of resources reached in buildings certified and applicability (easiness/difficulty to obtain a seal). This data could be obtained through researches with the ones involved in the certification process and by means of a Post Occupancy Evaluation of certified buildings.

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ENVIRONMENTAL CERTIFICATION FOR HABITATIONS: COMPARISON BETWEEN LEED FOR HOMES, AQUA PROCESS AND "SELO CASA AZUL"

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Abstract: In order to encourage changes in the construction industry for meeting the sustainability agendas, in several countries certification of building system have been developed. Mainly focused on issues related to natural resources and environmental impacts, these tools are also denominated green building seals. In order to identify the certification of better performance to be used in residential edifications in Brazil, a comparative analysis has been used. Three certification systems were selected, as they are the more usual in the country, which were LEED for Homes, the AQUA Process and the "Selo Casa Azul". For the investigation the Analytic Hierarchic Process (AHP) tool has been used, which allows the evaluation of multiple criteria, with data that can be both qualitative and quantitative. This study demonstrated that the seal developed for the Brazilian reality, "Selo Casa Azul", has the best performance to evaluate the habitable edifications in the country.

Keywords: *Green building program. Comparative analysis. LEED for Homes. Case AQUA Process. Selo Casa Azul.*

Resumo: Visando incentivar mudanças no setor da construção civil para adequação às agendas de sustentabilidade, foram desenvolvidos, em vários países, sistemas de certificação ambiental de edificações. Voltadas principalmente para questões relativas ao consumo de recursos naturais e impactos ao meio ambiente; essas ferramentas também são denominadas selos verdes para edifícios. Com o intuito de identificar a certificação de melhor desempenho a ser utilizada para edificações residenciais no Brasil, usou-se uma análise comparativa. Foram selecionados três sistemas de certificação, por se tratarem dos mais usuais no país, sendo eles o LEED *for Homes*, o Processo AQUA e o Selo Casa Azul. Para a investigação utilizou-se da ferramenta Análise Hierárquica (*Analytic Hierarchic Process*, AHP), que permite a avaliação de múltiplos critérios, com dados que podem ser tanto qualitativos como

quantitativos. Este estudo demonstrou que o selo desenvolvido para a realidade brasileira, Selo Casa Azul, tem melhor desempenho para avaliar as edificações habitacionais do país.

Palavras-chave: Certificação ambiental; Análise comparativa; LEED *for Homes*; Processo AQUA; Selo Casa Azul.

Resumen: Para incentivar cambios en la industria de la construcción para adaptarse a las agendas de sustentabilidad, fueron desarrollados sistemas de certificación ambiental para edificaciones. Direccionados para asuntos relacionados al consumo de recursos naturales e impactos al medio, estas herramientas son denominadas sellos verdes. Para identificar la certificación de mejor desempeño a ser utilizada en edificaciones residenciales en Brasil, se procedió a realizar un análisis comparativo. Fueron seleccionados tres sistemas de certificación bajo el criterio de ser los más usados en el país, siendo estos el LEED *for Homes*, el Proceso AQUA y el Sello Casa Azul. Se utilizó la herramienta denominado *Analytic Hierarchic Process* (AHP). El AHP permite la evaluación de criterios múltiples, donde los datos pueden ser tanto cualitativos como cuantitativos. Este estudio demostró que el sistema de certificación desarrollado para la realidad brasileña, Sello Casa Azul, tiene mejor desempeño para evaluar los edificios de vivienda del país.

Palabra clave: Certificación Ambiental; Análisis comparativo; LEED for Homes. Proceso de AQUA; Sello Casa Azul.