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Architectural Design Evaluation Under Bioclimatic Issues

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Abstract

A well-known fact is that through an adequate architectural design we can reduce the demand for energy in buildings, increase energy efficiency and promote the use of renewable energy, in particular solar energy.
In this paper we will discuss the need for Architectural Design Evaluation Criteria aiming at describing and comparing different possibilities in this field thus enabling designers or prospective property buyers to balance and understand the response level of different solutions.
In the frame of a wider research project, several bioclimatic issues are being considered – urban planning, site location, building and plot position and form, room distribution, solar access, glazing, solar protection and shading, opaque envelope design, potential for passive heating, natural cooling and natural ventilation – in terms of energy consumption, thermal comfort, daylighting and air quality, in order to establish relevant evaluation criteria. The main objectives of the methodology under preparation and some examples of evaluation criteria will be presented. In the first step of this study, only residential buildings will be considered.
This work tries to address the need for an extensive but compatible with a practical use assessment, applying some simplifications but without losing the required precision. The methodology will be formatted in order to become a useful tool, both for building quality evaluation and for building certification.

1 Introduction

Sustainability in Architecture relates deeply into the relationship between the external environment and the internal one. Besides the selection of sustainable construction materials, the bioclimatic strategy allows a natural and dynamic interaction between people, their built environment and outdoor conditions and contributes greatly to the achievement of an important goal of sustainability – a more efficient use of energy.

In the context of the European Union, the development of national energy certification schemes is considered as an important strategy for achieving the Kyoto protocol. In what concerns buildings, the European Directive 2002/91/EC [3] on energy performance of buildings, entered into force on 4 January 2003, imposes that a building energy performance certificate should be made available to users.
EU Member States must now draw up and implement national schemes aiming to certificate energy performance of new buildings and also, progressively and in certain conditions, of existing buildings.
At the moment, Europe discusses the challenges and needs for a successful implementation of the Energy Performance Directive identifying, for instance, the most suitable calculation methods, innovative labeling methods and ways to promote the use of renewable energies.

2 Energy or environmental evaluation methods in Europe

In what concerns energy performance of buildings, from the most complex to the simplest, the existing evaluation methods can be grouped in three types: thermal dynamic simulation tools, simplified calculation methods and points-based methods. The last type is specially fitted to disseminate information and provide non-experts with an easy to use evaluation tool, very often adopting building energy labels.
Assessment methods are not harmonized in Europe. In this field remain high differences between the national code thresholds and also in the way building performance is presented. A common format could be very helpful.
In certain countries, such as Denmark, energy audits and certification have been an established practice since the 1970's and 1980's [2]. Other EU member states are taking now the first steps in that direction.
There are several evaluation methods included in codes like RT2000, in France [5] or EnEV, in German [1] and other methods that are labels and not codes, like "Passiv Haus" and "Plus Energie Haus", in German [1], the HQE ("Haute Qualité Environnementale"), in France [6], and BREEAM (BRE Environmental Assessment Method), in United Kingdom [4].

3 Application of evaluation methods to Southern European climates

Southern European climates are generally considered as mild climates. However, in spite of their mildness, there is still a need for heating in the coldest periods of the year. In summer, the need for cooling is quite significant and it is, apparently, increasing with new architectural solutions, especially in buildings where glazing is used largely. As a consequence of a higher level of the demand for comfort and also of some less energy conscious architectural options, the number of buildings with air-conditioning systems keeps growing.
The most known evaluation methods have been developed for northern or central European countries. For those countries, for instance, a passive cooling strategy, in summer, has not the same relevance as for southern countries. Even in winter or in mid-season, in Mediterranean climates excessive solar gains can result in indoor overheating if there is not enough thermal inertia and (or) ventilation.
Another issue to consider is the importance of internal gains, especially for high-insulated buildings. If an important internal heat load is produced, in summer, and there is a weak heat transmission towards the exterior, overheating can occur.
Issues like an appropriate solar protection, a sufficient thermal mass, a well-planned natural ventilation strategy and controlled internal gains must be necessarily considered for Southern European climates.

4 Methodology under preparation

4.1 Portuguese scenario

The amount of energy used for heating or cooling rooms, in Portuguese residential buildings, is not yet very significant in the global energy use but, in the last few years, it has been continuously increasing, both in winter and in summer.
In Portugal, it is recognized the need for a tutoring action pointed towards designers, regulating a better minimum thermal quality level of the building envelope and systems and offering demonstration examples of energy efficient buildings. More practical tools and references organized, for instance, through a labeling system, are needed.
Portuguese thermal code is in force since January 1991 and has been, very recently, the object of a revision process, almost concluded, to be in accordance with the new European directive.
A Design Quality Evaluation Method developed some years ago in FEUP, University of Porto [7], will be the basis for the structure of this work. This procedure was inspired by the French Method Qualitel and Swiss Method Sel and has evolved towards a full logical tree of successively subordinated objectives that the various spaces, building materials and components and technical installations of a dwelling must fulfil. In Fig. 1, we can see the first levels of objectives of this method. Fig. 2 shows the objectives and evaluation criteria under the environmental comfort objective.

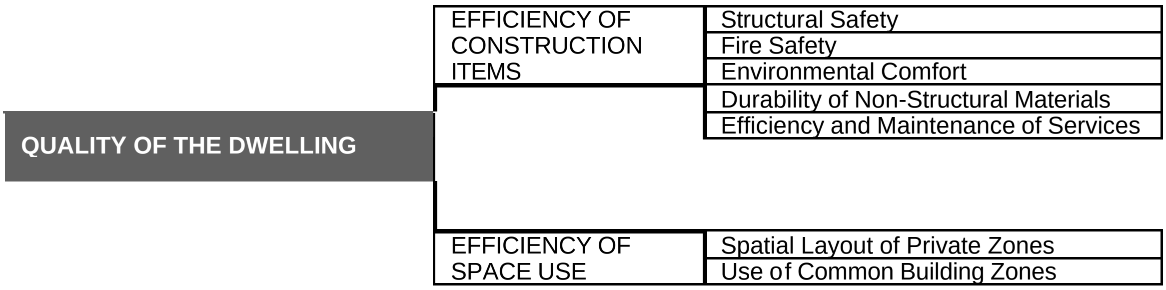

Figure 1: First levels of objectives

For each objective and sub-objective, one or several evaluation criteria have been established. The evaluation procedure results in the attribution of a mark, ranging from 0 (poor quality) up to 4 (very good quality). Weighting of the different objectives and evaluation criteria is then applied in order to obtain a final mark that classifies the global quality of the residential building under analysis.
In the present work, we will assume the sub-objective “Environmental Comfort” of the method (Fig. 2) as a starting point and the existing criteria will be adapted and new one added, in order to create a complete point-based method on bio-climatic issues, able to fulfil the requirements of an energy labeling process.

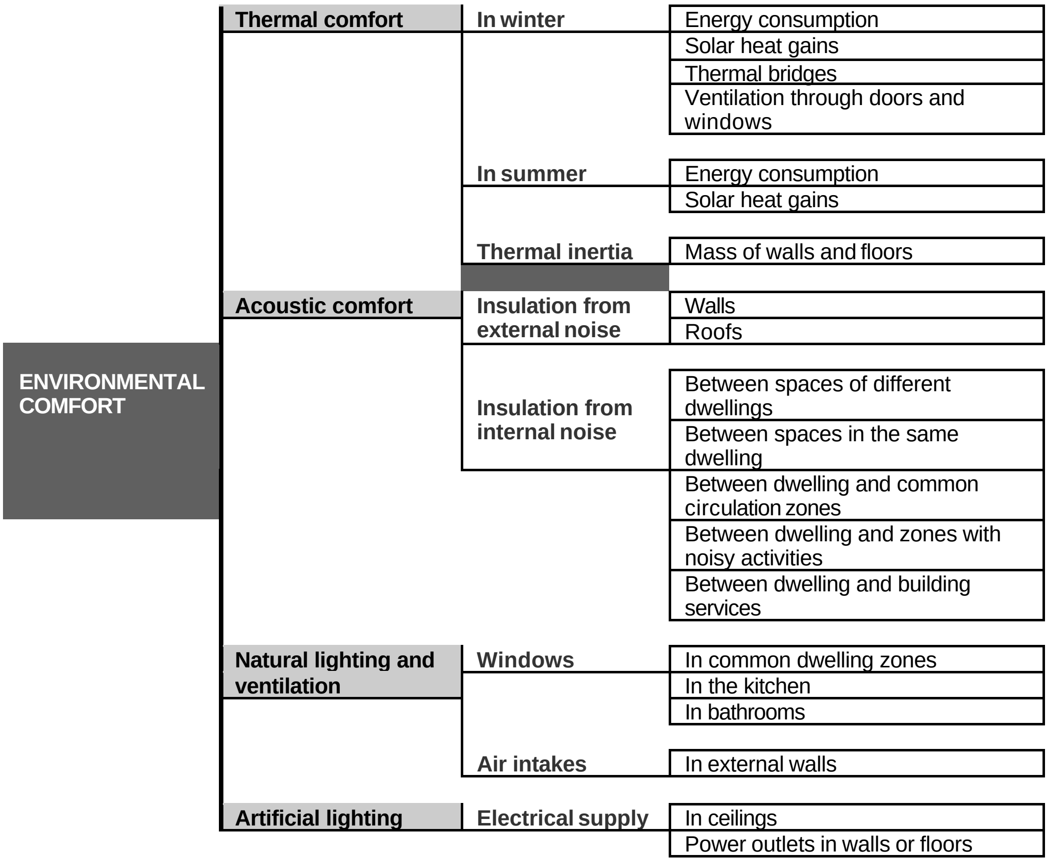

Figure 2: Objectives and evaluation criteria under Environmental Comfort

4.2 Relationship with the objectives of the main project

The creation of a point-based method in combination with an energy labeling process in FEUP, University of Porto, will be one of the tasks of a wider research project entitled “Energy Efficiency in Residential Buildings – from theory to practice. The application of bio-climatic architecture principles to the daily design practice”.

This research project aims to contribute to the practical application of the European Directive bringing the bioclimatic principles to daily design practice, through the collaboration between urban planners, architects and civil engineers.

Four main themes have been chosen, each one considered in the energy efficiency perspective: urban planning, thermal insulation, natural ventilation and passive solar systems. Various aspects of these four areas will be studied. The output of the project will be a guide with design recommendations and demo solutions for the specific Portuguese climatic conditions. As a complement, an application tool will be provided to all concerned professionals including the methodology under preparation.

4.3 Examples of evaluation criteria

Once the main issues are identified, the sensitivity of the energy performance to each chosen parameter must be evaluated. The scale to be used when rating each criterion must be in accordance with its relevance to energy consumption. In Table 1 it is given an example of what might be the rating of heating energy consumption, in winter. For this, an indirect indicator, T_b*, is used, representing the indoor temperature of the building if the allowable maximum heating load was used. This parameter can be calculated by a simplified method based on Portuguese thermal regulation.

Table 1: Indirect rating of heating energy consumption

Points	T_b*
4	$T_b^* \geq 18°$ C
3	$17°$ C $\leq T_b^* < 18°$ C
2	$16°$ C $\leq T_b^* < 17°$ C
1	$15°$ C $\leq T_b^* < 16°$ C
0	$T_b^* < 15°$ C

Another example, quite relevant to Southern countries is solar protection of openings. In Table 2, we present a possible rating of this criterion. S is the solar factor of the opening.

Table 2: Rating of solar protection of openings

Points	Solar protection of openings	
4	There are efficient external shading devices	$S \leq 0{,}10$
3		$0{,}10 \leq S \leq 0{,}25$
2	There are no external shading devices	$S \leq 0{,}10$
1		$0{,}10 \leq S \leq 0{,}50$
0	No solar protection (with $S \geq 0{,}50$)	

The final result of the method will be a specific score of points that will allow the classification of the building in a labeling system. This will be a useful tool for the implementation of building certification. Fig. 3 shows a possible format for building energy certificate.

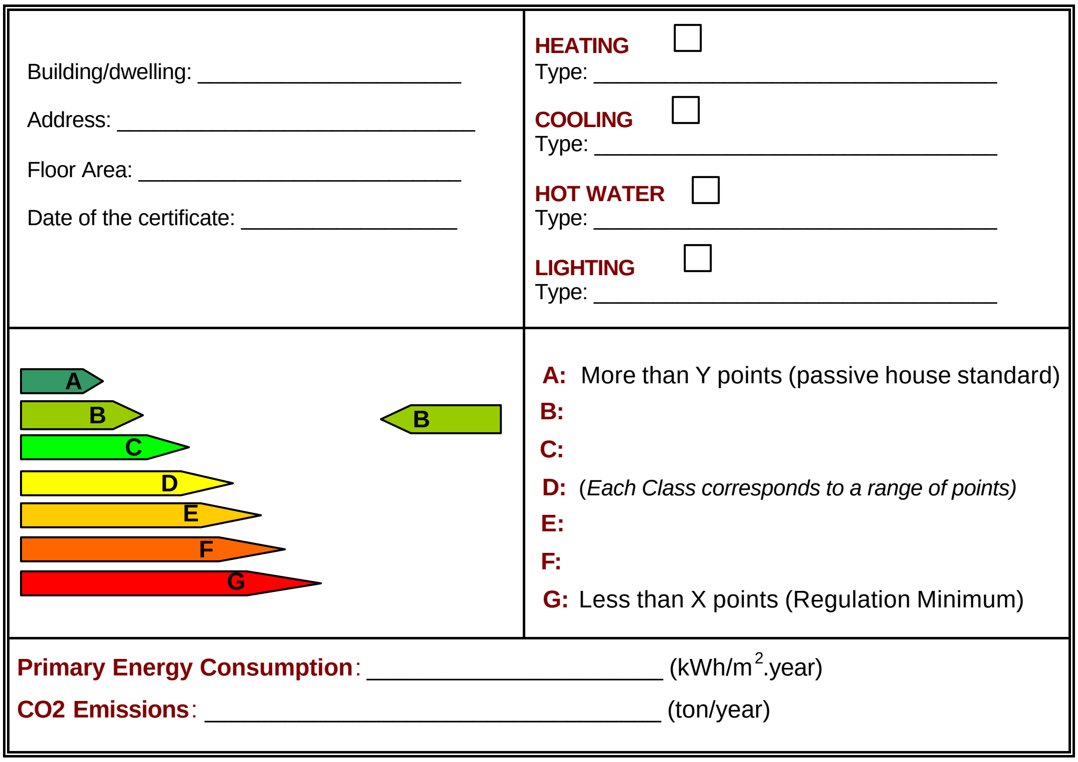

Figure 3: Example of a possible building energy certificate format

Based on the usual certificates for domestic appliances it is proposed, with [1], the definition of A to G classes, relating them with the score obtained with the evaluation method.

5 Conclusions

In this paper, a short introduction to the setting of an evaluation and labeling method for the energy performance of buildings was presented, with a special focus on Southern European climates. This kind of methods can be very useful for the implementation of European Directive 2002/91/EC [3] on the energy performance of buildings and for building certification schemes and are now being discussed and developed, all over Europe.

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