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Comparative study by an expert panel of documents recognized for energy efficiency certification of buildings in Spain

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ABSTRACT

Approval of the European Directive 2002/91/EU was followed by its reformulation in Directive 2010/31/EU, with reference to the Energy Performance of Buildings (EPBD). The partial transposition of this norm in Spain took place through Royal Decree 235/2013, which describes the Basic Procedure for the Energy Performance Certification of Buildings and acknowledges four different documents to certify the energy simulation of buildings: (i) CALENER VYP as the general method, and (ii) CE3, CEX and CERMA, as simplified methods. This study analyzes and compares these documents through the qualified opinions of a panel of 105 multidisciplinary professionals of the sector that determined the strengths and weaknesses. To this end a survey was drawn up, including aspects as diverse as: the background and professional characteristics of the experts, the types of residences studied, the characteristics of the documents, the means of processing documents, and the final results in terms of reports and energy certifications. Data analysis shows that most technicians prefer using programs with a simple interface—namely, the CEX. Although all the documents recognized are equally valid for energy certification, when certain types of residence are involved, there may be as much as a 26% difference in the determination of CO_2 emissions. This translates into a higher or lower level in the final energy certification obtained for a building.

1. Introduction

The sectors of energy and construction are closely linked. A correct design and execution of a building, as well as the adequate use of its energy sources, are necessary to reach a zero energy house [1]. Renewable energies play a fundamental role, providing benefits such as economic savings, lesser CO_2 emissions, or an improved energy rating for a given construction [2]. In terms of functionality, energy simulation is a key tool for the energy-related assessment of a building [3]. It entails the use of computerized programs that can point out or predict any drawbacks deriving from construction characteristics and execution, as well as ways to remedy them.

In Spain, ratification of the European normative framework relative to the energy rating of buildings (European Directive 2002/91/EU [4], European Directive 2010/31/EU [5]), and its partial transposition through Royal Decree 235/2013 [6], Basic Procedure for the Energy Performance Certification of Buildings. Ministry of Industrial, Energy and Tourism meant the recognition of four software "documents" created for the energy simulation of buildings. CALENER VYP [7] applies a general method of reference with a higher level of detail, whereas CE3 [8], CEX [9] and CERMA [10] apply the simplified option of a prescriptive nature, whose indirect calculation is based on the general method. The simplified method is limited in that openings in the façade must constitute less than 60% of its total surface, and the percentage of skylights must be under 5% of the covered surface. Furthermore, excluded from the procedure are buildings whose enclosures consist of non-conventional constructive solutions.

All the above mentioned software documents are valid, as they are their results, which may rely on different parameters such as calculations, variables, means of data input, calculating engine, output report, etc. Consequently, the final results may be different both in CO_2 emissions and level of energy efficiency. Thus, the present contribution is a comparative analysis of the four documents mentioned above, based on a survey carried out with the active participation of professionals from the sector. Then, a horizontal comparison by means of a case study was performed to discern differences regarding the calculations of CO_2 emissions and the final energy rating of a residence.

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2. Materials and methods

In this section it has been defined the expert panel that carried out the survey about the documents recognized for the energy efficiency certification of buildings. The purpose of the survey is to analyze the strengths and weaknesses of each document, as well as to know the preferences of the experts. In addition, a standard building is defined as a model to develop the energy simulation with the different documents in order to compare the results obtained.

2.1. Documents recognized

The pertinent documents consulted were the CALENER VYP [7] (general procedure for buildings in project or terminated), and the CE3 [8], CEX [9] and CERMA [10], the latter three involving simplified procedures for existing buildings, described in the Royal Decree 235/2013 [6]. In addition, CERMA is valid to study new buildings in the design phase of the project [10], but for this study only the option of existing buildings will be analyzed.

2.2. Panel of experts

For the purposes of this study, we first generated an expert panel. This resource for data collection is commonly used in a wide range of fields, from medicine [11–14], to education [15,16], or biology [17], as well as construction [18].

The expert panel consisted of 105 technicians: 63 from the architecture sector and the other 42 from the engineering sector. They were identified through professional associations and universities in Spain. The experts have been selected attending to their professional relationship with the different documents, as well as considering their experience in energy performance certificates. All the experts of different professional associations interested in taking part have been represented. The participants are competent technicians that are qualified for elaborating reports on energy efficiency according to the Royal Decree 235/2013 [6].

An *ad hoc* questionnaire, shown in Table 1, was provided to the panel of experts. The structure of the survey and the items it contained were intended to determine the priority of the different experts when choosing one of the software tools of study, how they appraised it, and which strong points and weak points they encountered.

Data gathering through the surveys was carried out using Google Drive software, and the data obtained were statistically processed with predictive analytical software SPSS 20.0.0, licensed to the University of Granada.

2.3. Building type

A representative building was chosen in view of the predominating geometric and construction characteristics in Spain, a typology determined based on data from the National Statistical Institute of

Table 1
Structure of the ad hoc questionnaire given to the panel of experts.

	Question	Answer
Technician's background data	1.1. Degree	Architect; Architectural technician/Building engineer; Industrial engineer; Industrial technical engineer; Civil engineer; Technical engineer of public works; Others degrees (specify)
	1.2. Province	52 provinces
	1.3. Professional association	Yes/No (where)
	1.4. Sex	Man/Woman
	1.5. Age	18–99
Preferences	2.1. Geometric definition considered more accurate	Predefined types; surface and orientation; DXF blueprints
	2.2. Geometric definition used	Predefined types; Surface and orientation; DXF blueprints
	2.3. Preferences of document acknowledged by sectors	
	2.3.1. Interface	CALENER VIP; CE3; CEX; CERMA
	2.3.2. Input data	CALENER VIP; CE3; CEX; CERMA
	2.3.3. Final report	CALENER VIP; CE3; CEX; CERMA
	2.3.4. Material database	CALENER VIP; CE3; CEX; CERMA
	2.3.5. Calculating engine	CALENER VIP; CE3; CEX; CERMA
	2.3.6. Intuitive	CALENER VIP; CE3; CEX; CERMA
	2.3.7. Global	CALENER VIP; CE3; CEX; CERMA
	2.4. Other documents used	Yes/No (which one)
Times and surfaces	3.1. Single-family residence	
	3.1.1. Time per certification	Hours
	3.1.2. Average surface	m^2
	3.2. Multi-family residence	
	3.2.1. Time per certification	Hours
	3.2.2. Average surface	m^2
	3.3. Small teritiary sector	
	3.3.1. Time per certification	Hours
	3.3.2. Average surface	m^2
Qualification of document	4.1. CALENER	1–10
	4.2. CE3	1–10
	4.3. CEX	1–10
	4.4. CERMA	1–10
Recommendations for energy improvement suggested by the software	5.1. Insulation in opaque closures	CALENER VIP; CE3; CEX; CERMA
	5.2. Modification/substitution of openings	CALENER VIP; CE3; CEX; CERMA
	5.3. Installation/modification of solar protection	CALENER VIP; CE3; CEX; CERMA
	5.4. Improvements in systems, fuels, performance	CALENER VIP; CE3; CEX; CERMA
	5.5. Global	CALENER VIP; CE3; CEX; CERMA