



Update of energy performance certificates in the residential sector and scenarios that consider the impact of automation, control and management systems: A case study of La Rioja



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HIGHLIGHTS

- A total of 9416 energy performance certificates in the residential sector were analyzed.
- Approximately 40% of the energy performance certificates were incorrect.
- The developed algorithms can be generalized for the remainder of Spain.
- Introducing BACS and TBM systems can reduce building energy consumption by up to 26.36%.

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ABSTRACT

Energy performance certificates are considered to be tools for knowledge and energy planning in the residential sector. Although energy performance certificates describe primary energy consumption and the associated emissions of a home or building, they do not consider the influence of building automation control systems (BACS) or technical building management (TBM) systems on these parameters. The European Standard EN 15232 remedies this shortcoming and evaluates the savings in primary energy and the reduction of CO₂ emissions that can be achieved by these systems. This study investigates the energy performance certificates registered in the Autonomous Community of La Rioja and considers the policy changes in the Technical Building Code (Código Técnico de la Edificación) and, specifically, the Basic Document for Energy Saving (Documento Básico de Ahorro de Energía) (CTE-DB-HE). Due to this regulatory change, we corrected the certificates and outlined different scenarios based on the implementation of these systems in this study. These scenarios show the potential distribution of energy performance certificates and the improvements in the ratings obtained.

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1. Introduction

In the European Union, the building sector has a final energy consumption of 448.4 Mtoe (40.62%) and associated emissions of 1253 MtCO₂ (35.75%). Residential buildings are responsible for 65.99% of the final energy consumption in the building sector [1]. Consequently, energy-saving measures applied to these buildings have a large potential for saving energy and reducing CO₂ emissions, offering multiple benefits to all of Europe [2].

The Energy Performance in Buildings Directive 2002/91/EC [3] introduced the requirement to provide an energy performance certificate when leasing or selling a building or dwelling. The directive also established a calculation methodology. This directive was

endorsed by Directive 2010/31/EU [4], which each Member State has implemented differently [5]. Directive 27/2012/EU [6] also established a common measurement framework for promoting energy efficiency that allows the Member States to achieve 20% savings in primary energy by 2020 within the European 20-20-20 goals.

In Spain, the transposition of the directive [3] was performed using the Technical Building Code (Código Técnico de la Edificación) [7], the Regulation of Thermal Installations in Buildings (Reglamento de Instalaciones Térmicas de los Edificios) [8] and the Royal Decree 47/2007 [9], which established the format of energy performance labeling for buildings and the calculation procedures for creating them. This regulation applies at the national level; however, Autonomous Communities are responsible for the assessment, control and registry of energy performance certificates.

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Nomenclature

BAC	building automation control	DHW	domestic hot water
BACS	building automation control systems	EPC	energy performance certificate
CIIyE	Department of Industry, Innovation and Employment (Consejería de Industria, Innovación y Empleo)	RITE	Regulation of Thermal Installations in Buildings (Reglamento de Instalaciones Térmicas de los Edificios)
CTE	Technical Building Code (Código Técnico de la Edificación)	SCADA	Supervisory Control And Data Acquisition
CTE-DB-HE	Basic Document for Energy Saving of the Technical Building Code (Documento Básico de Ahorro de Energía del Código Técnico de la Edificación)	TBM	technical building management

Using energy performance certificates, data are available for determining the primary energy consumption and the CO₂ emissions of the residential sector [10]. Focusing on the Southern European countries, studies were carried out in Cyprus [11], Greece [12–14], Italy [15,16], Spain [17], Portugal [18] and France [19].

Currently, official certification programs do not consider the influence of building automation control systems (BACS) or technical building management (TBM) systems on primary energy consumption and the associated CO₂ emissions. To mitigate this shortcoming, the European Standard EN 15232 [20] established a procedure for scoring energy performance certificates based on the European Standard EN 15217 [21] to be obtained by any legally established methods. Ippolito et al. [22] performed a case study that applied this regulation and verified its benefits.

Multiple studies have investigated the influence of the following management and control systems on energy saving: digital controllers [23]; SCADA [24,25] and web-based [26] monitoring systems; demand-side management [27–30]; decision support and energy management systems for residential applications [31]; integrated automation models of demand response, generation and storage systems in buildings [32]; plug & play building optimization and control systems [33]; predictive control techniques [34–36]; integrated analysis of big building automation systems data [37]; automatic energy consumption control systems [38] and integrated building automation systems [39]. In addition to finding savings through technological improvements, it is very important to learn and change the habits of people over the long term [40–42]. Energy savings ranging from 12% to 19% have been measured in office buildings using energy efficient climate control [43]; savings of 30% have been achieved through the optimization of system technique regulations [44].

On September 12, 2013, there was a major change in the Technical Building Code and, specifically, the Basic Document for Energy Savings (CTE-DB-HE) [45], that changed the climatic zone assignment method; this change allowed for voluntary application from September 13, 2013, until March 13, 2014, and became mandatory after March 14, 2014. It is therefore necessary to develop algorithms that can verify and classify energy performance certificates and can then standardize them. In this study, these processes are performed in Matlab. The algorithm selects valid certificates whose climate zones coincide with the climate zone assigned by the new standard. It is important to detect incorrect energy performance certificates in a fast and robust way [46,47]. Additionally, the energy performance certificate data quality is very important for describing and modeling the building stock [48].

The goal of this paper is to evaluate, according to EN 15232 [20], the impact of BACS and TBM systems on the standardized registration of energy performance certificates of the Autonomous Community of La Rioja, known as La Rioja. Based on the results of this study, we expect to gain a perspective on the evolution of energy efficiency ratings in terms of both primary energy

consumption and CO₂ emissions based on the implementation of BACS and TBM systems in the residential sector. Future trend scenarios will be outlined to verify the effectiveness of this implementation, as performed by Balaras et al. [49]. The results obtained may help countries to direct their efforts in energy planning and residential sector rehabilitation toward strengthening these systems due to the potential significant improvements in their building stock rating. At the user level, the results may help to raise awareness about improving energy performance certificates and the associated benefits [50].

After introducing the methodology with the developed algorithms, we apply it to the energy performance certificates of La Rioja and show the results for different implementation scenarios of BACS and TBM systems.

2. Methodology

2.1. Baseline data

The data regarding the registry of energy performance certificates of the Department of Industry, Innovation and Employment (Consejería de Industria, Innovación y Empleo – CIIyE) of the Government of La Rioja [51] were used in this study. Appendix A shows the energy performance certificate content. We studied a total of 10,534 certificates based on Royal Decree 235/2013 [52], which entered into effect between June 2013 and May 4, 2015. The information in these certificates was located in a Microsoft Excel file and was imported into Matlab for processing.

For this study, the following information from the energy performance certificates was used: certificate number, registration date, building type, climate zone, municipality code, primary energy consumption (in kWh/year and kWh/m² year) and rating, which was expressed by a letter from A to G, and CO₂ emissions (kgCO₂/year and kgCO₂/m²·year) and rating, which was also expressed with a letter from A to G.

Of 10,534 certificates, excluding those in the tertiary sector, 9416 certificates were for the residential sector. Of these, 444 corresponded to multi-family blocks (4.72%), 8269 to individual dwellings in multi-family blocks (87.81%), and 703 to single-family houses (7.47%).

The labels obtained for the primary energy consumption and CO₂ emissions for the energy performance certificates for each building type and climate zone are shown in Table 1.

2.2. Climate zone

In Spain, there are 15 climate zones, depending on the climate severity of the summer and winter seasons based on the CTE-DB-HE 2013 standard [45]; these zones are defined by a letter and a number: α3, A2, A3, A4, B2, B3, B4, C1, C2, C3, C4, D1, D2, D3

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