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Benchmarking Energy Use of Existing Hellenic Non-Residential Buildings

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Abstract

The total number of buildings in Greece amount to 4.1 million of which 20% are exclusive non-residential buildings that usually have high energy consumption due to specific building uses. The present work exploits data from energy performance certificates to derive relevant benchmarks. Recommended energy conservation measures are identified and analysed to identify the most common measures. Finally, a methodology is elaborated for deriving empirical adaptation factors to relate the normative calculated heating energy consumption with actual energy use, if available.

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Keywords: Energy Performance Certificates; Non-residential buildings; Benchmarks; Primary energy use; Carbon emissions; Energy conservation measures

1. Introduction

Buildings are among the largest energy end-use sectors in Europe, representing ~39% of the total final energy consumption and contributing ~35% of the total CO_2 emissions. Potential energy savings in the building sector by 2050 are estimated at 1,509 million tonnes of oil equivalent (Mtoe) as well as possible mitigation of 12.6 gigatonnes (Gt) of CO_2 emissions [1]. Non-residential buildings account for 25% of the European building stock and comprise a more complex sector compared to the residential sector, due to a number of factors like usage, energy intensity and construction techniques [2].

In Greece, the total number of buildings are ~4.1 million [3], of which 3.78 million are exclusive-use buildings and ~785,500 are non-residential (NR) buildings. Mixed-use buildings reach ~330,000 of which the ones with main

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NR use amount to 22.5%. The total floor area is estimated to 658 million m², of which 74% are located in residential buildings. Non-residential (NR) buildings have a total floor area of 159 million m² [4].

This paper presents an overview of Hellenic NR buildings' energy performance and commonly recommended energy conservation measures (ECMs), exploiting data from the energy performance certificates (EPC) of the national electronic registry (buildingcert). Over the period of January 2011 to the end of 2015, a total of about 650,000 EPCs have been issued for various building types, out of which 15% are for NR whole buildings or building units. With the exception of single-family houses, the vast majority of the EPCs were issued for building units. Detailed analysis is performed for office and school buildings.

The assessment is based on actual data (e.g. type of building, age, climate zone, total and heated area), as well as calculated data (e.g. energy class ranking, calculated and actual primary energy consumption, calculated and actual CO_2 emissions, fuel type, proposed ECMs). As a second step, a methodology is elaborated for deriving empirical adaptation factors to relate the normative calculated heating energy consumption with actual energy use. At the end of the analysis, the ECMs are grouped into three categories and the analysis is performed for identifying the most common refurbishment recommendations. First, interventions on building's thermal envelope aiming to minimize heating and cooling loads, while improving indoor environmental quality conditions. Second, interventions on building's systems aiming to increase their efficiency and minimize the fuel consumption. Third, interventions of integrating renewables and hybrid systems aiming to reduce the electricity consumption.

2. Data Analysis of NR buildings

A first rough quality control of the available data was performed at the beginning of the analysis. For example, EPCs were excluded if they corresponded to cases that did not have an obligation to issue an EPC (i.e. buildings with certain uses, buildings with total floor area smaller than 50m^2), issued by energy inspectors that have been penalized and their temporary license revoked, negative input values, heated area greater than total area or less than 20% of the total area or the 2.5% percentiles of the NR data in order to eliminate outliers, zero CO_2 emissions (using fuels other than biomass) and extreme values (i.e. calculated primary energy consumption less than 5 kWh/m^2 and greater than 8000 kWh/m^2).

The presentation and the assessment of the results in the following sections are based on two main classification parameters along the lines of the Hellenic TABULA residential typology [5]:

- building age, based on the year of building construction (T1: pre-1980; T2: in the period 1981-2000; T3: in the period 2001-2010; T4: post-2010); and
- building location, using the four climate zones (Zone A (ZA) in the south to Zone D (ZD) in the north) based on the heating degree days, in accordance to the national regulation on the energy performance in the building sector (KENAK) that transposed EPBD in Greece [6].

The analysis of the available data from the EPCs confirmed the poor energy performance of existing Hellenic buildings. NR buildings exhibit relatively better energy performance, ranked in energy classes (C, D or E) by 84%, while only 12% is ranked in the last two classes (F and G). Comparatively, residential buildings are mainly ranked in the last two energy classes (F and G) by 51%, while only 3% is ranked in energy classes B or higher, which agrees with the previously detailed analysis presented in [7]. In total, according to the national technical guidelines for KENAK, there are 60 different building uses, which can be grouped into 35 types (Table 1).

As expected, NR buildings are the most energy consuming. The average calculated primary energy consumption is about 80% greater than residential buildings. Educational buildings (e.g. kindergarten, primary/secondary school) and Private cram school / Conservatory have the lowest primary energy consumptions amongst the different building types, while indoor Sports Hall / Swimming pool, Pastry / Coffee shop and Restaurant have the highest due to their large volumes, latent loads, internal heat gains and other unique operational characteristics.

Table 1. Average heated area (m^2), calculated primary energy consumption (kWh/m^2) and CO_2 emissions (kg/m^2) per building type. For each type, the corresponding EPC population, as well as the percentage of whole buildings are also included.

Types of Buildings	EPCs	Heated area m^2	Primary energy kWh/m^2	CO_2 emissions kg/m^2	Whole buildings