Energy Efficiency of the Housing Stock in Portugal

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Context on Energy Efficiency of the Housing Stock of Portugal

There are about 3.5 million classic residential buildings and 5.9 million dwellings in Portugal (INE, 2011). The Portuguese residential building stock is old, with 15% of the buildings dating back to 1945 or earlier. Approximately 70% were built prior to 1990 (INE, 2011) when energy performance regulations for residential buildings were still not implemented in the country. Bearing structures are either stone or brick masonry (51%) or reinforced concrete (49%). Older buildings commonly have stone masonry and wooden roofs and floors (Magalhães and Freitas, 2017). The use of reinforced concrete in the bearing structure is more recent and is the common practice nowadays.

The first Portuguese energy performance of buildings (EPB) regulation was implemented in 1990. It was the first legal instrument to define energy performance requirements for new buildings and big retrofitting projects. This regulation was replaced by the 2006's Thermal Performance Buildings Characteristics Regulation (RCCTE), stemming from the European Directive 2002/91/CE, which set more demanding requirements concerning the building's thermal performance and introduced the Energy Certification System (SCE). In 2013, a new directive on building energy performance was issued (Directive 2010/31/EU), resulting in two new revised building's energy performance regulations in Portugal, Residential Buildings Energy Performance Regulation (REH) and Commercial and Service Buildings Energy Performance Regulation (RECS), as well as a revised SCE. A new directive on EPB, amending the previous

Source: EP-pedia Website

ones, was issued in 2018, which will result in the future revision of these regulations in Portugal. The implementation timeline of these instruments can be consulted in Figure 1.

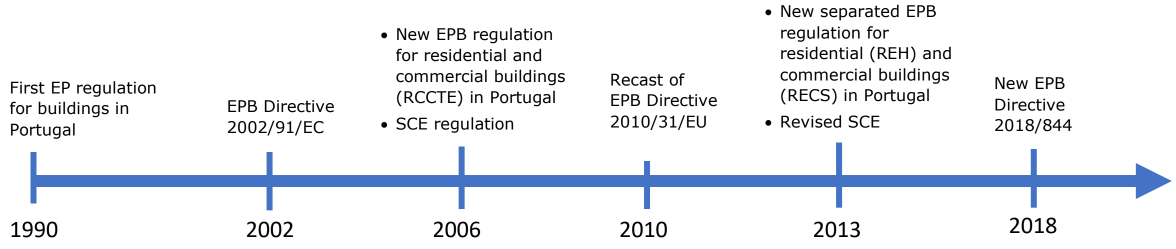

Figure 1 – Timeline of EPB directives and portuguese regulations

The building materials used influence the magnitude of the heat exchange between the exterior and interior of a building, usually represented by a heat transfer coefficient, the U-value. Better insulation has lower U-values. Alongside Spain, Portugal has registered consistently higher weighted mean U-values – and thus lower levels of thermal resistance and higher levels of heat loss – across building typologies for windows, pavement, walls and roof than most European countries (iNSPiRe, 2014; Anagnostopoulos and De Groote, 2016). Vasconcelos *et al.* (2011) point out the poor quality of Portuguese buildings, especially regarding thermal insulation, which results in dwellings that are cold and humid in the winter and too warm in the summer. About 29% of Portuguese residential buildings need some type of envelope intervention work, and 1.6% are severely degraded (INE, 2011). PCS/Quercus (2017) carried out an online survey on thermal comfort, finding that 37% of respondents claim not to have any insulation in their house.

Refurbishment costs represented 34% of the total spending of the Portuguese construction sector in 2014 (INE, 2015; Magalhães and Freitas, 2017). Additionally, according to Odyssee-Mure database (Odyssee-Mure, 2017), between 2000 and 2014 the energy efficiency of Portuguese households has improved by over 20%; though in 2019 Portugal still had the second highest percentage of population living in dwellings with a leaking roof, damp walls, floors or foundation, or rot in window frames or floor in the EU (24.4%) (Eurostat, 2021a). Renovation rates of residential buildings, considering light renovations, were as high as 2% per year between 1990 and 2005, which contribute to this energy efficiency improvement (Bernardo, 2015). Nevertheless, national statistics from the last 10 years show a very low deep renovation/reconstruction rate of buildings around 0.012% per year (INE, 2019) indicating a need for increased focus on energy efficiency improvement for buildings.

A total of 1,779,214 residential Energy Performance Certificates in Portugal has been issued to date (ADENE, 2021a). Of the homes that had a certificate issued between 2014 and 2020 (ADENE, 2021b), 11.9% have an A rating, the maximum

Source: EP-pedia Website

energy efficiency level, while 17.5% and 23% have the B and C ratings respectively. The majority of certificates in the analyzed sample, about 47.7%, are still rated D or lower. Figure 2 shows the number of Energy Performance Certificates for residential dwellings issued per year. The percentage of certificates issued between 2014 and 2020, per energy rating, is displayed in Figure 3.

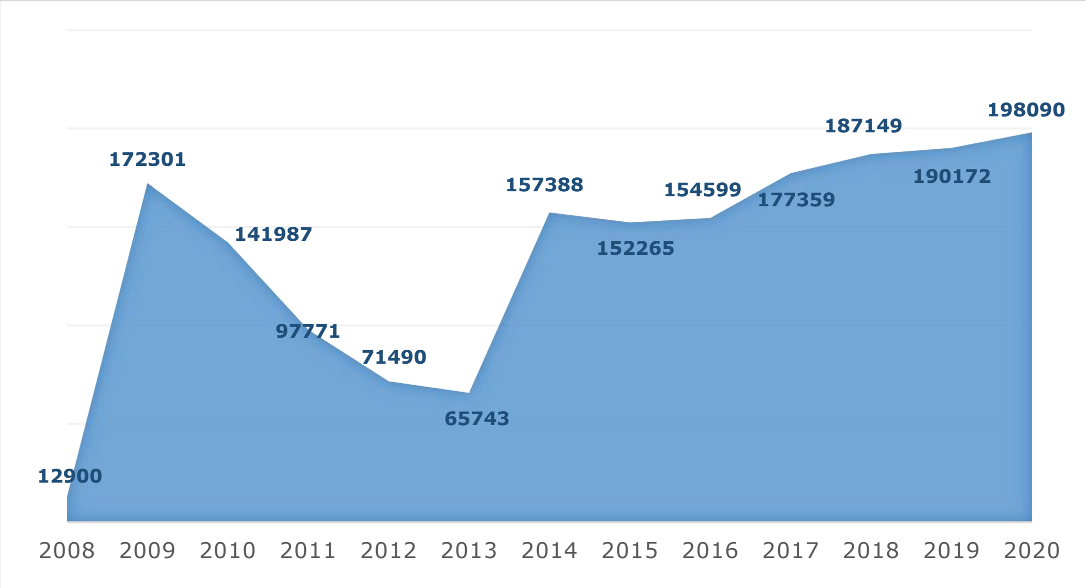

Figure 2 - Number of Energy Performance Certificates for dwellings in Portugal issued per year (Adapted from ADENE, 2021a)

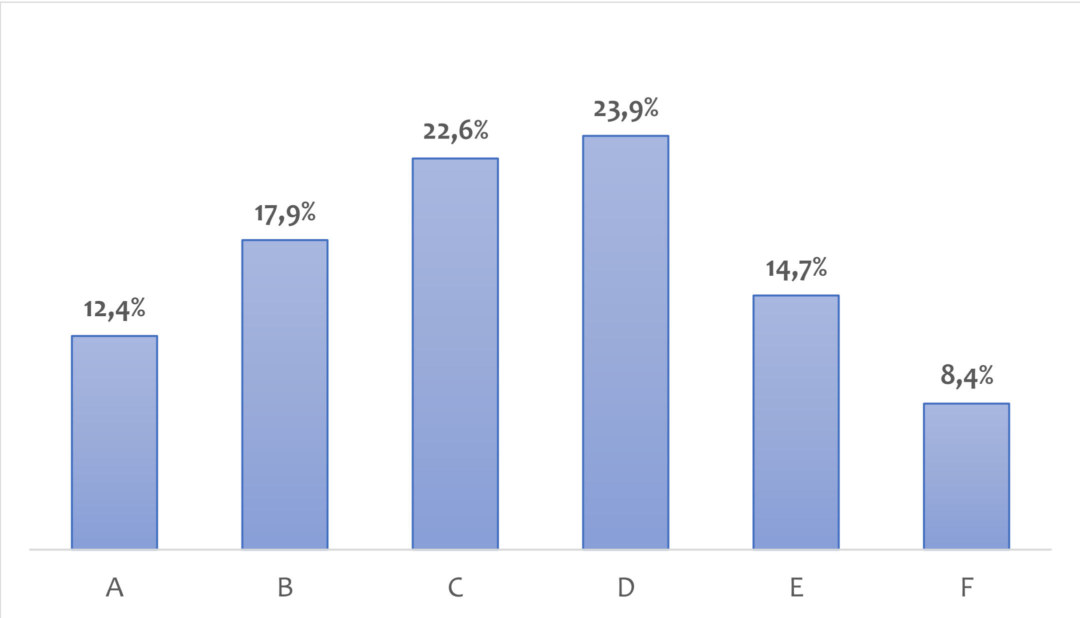

Figure 3 – Percentage of Energy Performance Certificates issued from 2014 to 2020 for dwellings in Portugal, per energy rating (Adapted from ADENE, 2021b)

It is relevant to point out that some of the older buildings have a historical and architectural value that, according to the legislation, has to be preserved; this is

Source: EP-pedia Website

frequently a constraint to the implementation of several thermal improvement measures (Magalhães and Freitas, 2017). In some regions of the country, the restrictions are even tighter, as the constructers must not only maintain the façade of the buildings, but also follow the traditional regional construction procedures and building materials.

While Portuguese homes are not energy efficient, they also have among the lowest energy consumption rates in the EU, both in aggregate and per capita. In 2019, Portugal had the second lowest final energy consumption per capita in the residential sector in the EU, with 11.8 GJ, behind only Malta (Eurostat, 2021b), although it has been increasing consistently since 1990, from a value of 6.5%, an increase of around 84% (PORDATA, 2021). According to DGEG (2021), from 2010 to 2017, residential energy consumption from oil products, diesel for heating, and LPG (Liquefied Petroleum Gas) decreased 38%, while natural gas and electricity consumption dropped respectively 16% and 13%. On the other hand, renewable energy consumption increased 11% over the same period, highlighting an effort towards decarbonization. For heating, the country also registered the second lowest share of final energy consumption for space heating in the households in 2018, 28.2%, considerably below the EU average of 63.6% and the value for other southern European countries such as Spain (43.1%), Italy (66.6%) and Greece (54.5%) (Eurostat, 2021c). In Portugal, the share of final energy consumption for space cooling stands at 0.6%, higher than the EU average of 0.3%, but lower than the aforementioned countries, which present shares of 1.0%, 0.7% and 3.6% for Spain, Italy, and Greece respectively (Eurostat, 2021c). Nevertheless, the ownership of decentralized, low-efficiency HVAC systems such as portable electric oil heaters and fireplaces is still very common in Portugal while households have low ownership rates of space cooling systems, at only 15.7% (INE, 2017). For cooling, the low ownership might explain the small consumption rates, whereas for heating, low use is a major factor behind low consumption levels, as ownership rates are close to 100% and most equipment has low efficiency (INE, 2017).

Perspective on Energy Efficiency of the Housing Stock in the policy debate of Portugal

Improving the energy efficiency of the housing stock is deemed a policy priority by the Portuguese government for decreasing energy poverty in the country, as stated in the National Energy and Climate Plan (Portuguese Republic, 2019a) and the Carbon Neutrality Roadmap for 2050 (Portuguese Republic, 2019b). The government has approved the Long-term Plan for the Renovation of Buildings (Portuguese Republic, 2021), which highlights the need for considerable investment for improving the building stock fabric to tackle energy poverty, as well as setting guidelines to achieve this goal. There are already several policy measures and schemes implemented with the goal of increasing energy efficiency of the building stock in Portugal. Under the National Action Plan for Energy Efficiency, the Energy Efficiency Fund launched a program called "Aviso 25", to finance up to 60% of energy efficiency measures for residential and service buildings, including the installation of efficient solar water heating systems. This is a non-repayable grant scheme, using finance from the Energy Efficiency Fund of 1.55M € for the residential sector, but it is not specifically targeted to energy-poor households. It prioritizes older buildings, which have the best opportunity for energy efficiency improvement (regarding the existing building envelope and lighting solutions, as well as the electricity consumption) and primary energy savings (NEEAP, 2020). This is a yearly recurring financing program but currently it has been discontinued.

Soft loan-based schemes for building renovation are currently implemented at a national level, such as *Casa Eficiente* (Portuguese Republic, 2020a) and IFFRU (Portuguese Republic, 2020b). All homeowners, and renters with permission from the owner, can apply to *Casa Eficiente*. This program supports projects that include works aimed at improving the environmental performance of dwellings. The interventions covered by the program aim to boost energy efficiency, the use of renewable energies, increased water efficiency and improved environmental performance. Interventions such as the application of thermal insulation in walls, replacement of frames, optimization of elevators, installation of solar photovoltaic panels, installation of solar thermal systems, acquisition of appliances of high energy and water efficiency can be covered. On other hand, IFFRU targets buildings 30 years old or older, and in a precarious conservation state, also supporting building envelope renovations, HVAC systems replacement and renewable energy systems installation, through soft loans.

Whilst most energy efficiency measures offered by the national regulatory authority and the state do not provide extra benefits to vulnerable consumers, Portuguese low-income homes may benefit through programmes promoting improvements in vulnerable households, disadvantaged communities and social neighbourhoods. These schemes are nationally funded, but regulated on the regional, municipal and social neighbourhood levels. In general, Portugal has provided several different avenues for home improvements of vulnerable households on the national level, with municipalities being able to apportion their budgets to measures they wish to promote within their territories (Kyprianou et al., 2019). Examples of these schemes are the "1º Direito" and "Reabilitar para Arrendar" at the national level, and "Reabilita+" and "Reaviva Sintra" at the municipal level; these target precarious buildings, aiming to improve housing

Source: EP-pedia Website

habitability and living conditions through grants and loans, since they particularly, in vulnerable neighbourhoods.

In September 2020, a new financing scheme designated "Support Programme for More Sustainable Buildings" was implemented, as part of the government's Economic and Social Stabilization Program, aiming to improve buildings' energy performance. This scheme has a budget of 4.5M € to provide non-refundable subsidies to energy efficiency projects, financing 70% of building fabric interventions, HVAC systems replacement and hydric efficiency (Portuguese Republic, 2020c).

Research Perspective on Energy Efficiency of the Housing Stock in Portugal

There are several studies focusing on the characterization and prediction of the energy performance and consumption of the Portuguese building stock, without focusing particularly on the impact of energy efficiency measures. Gouveia et al. (2015), Gouveia and Seixas (2016), Gouveia et al. (2017), and Gouveia et al. (2018) worked with smart meter data for analyzing electricity consumption profiles, space heating and cooling habits and for identifying energy-poor consumers in Portuguese dwellings in the city of Évora. Also using smart meter data, as well as surveys, Viegas et al. (2016) developed a methodology to classify electricity consumers. Moreover, Magalhães and Leal (2014) analyzed the national nominal energy needs for space heating and cooling and domestic hot water of energy performance certificates and compared it to the actual energy use. Vasconcelos et al. (2015) defined archetypal representative buildings of the Portuguese stock, also using energy performance certificate data. Fonseca and Panão (2017) and Panão and Brito (2018) estimated respectively the space heating and cooling energy demand and primary energy and the hourly electricity consumption for a sample of Portuguese residential buildings. Figueiredo et al. (2020) estimated the Portuguese building stock's residential electricity demand in 2050.

Another group of studies analyze energy efficiency measures and scenarios and their impact on energy needs and consumption. Palma et al. (2019) calculated the gap between theoretical energy consumption for thermal comfort and real energy consumption of the dwelling stock for all 3092 civil parishes in Portugal, considering different scenarios of indoor conditioned area and occupancy schedules. The reduction of the conditioned area and heating and cooling hours highlighted the civil parishes in the north and center inland regions as the ones with the higher gaps, potentially linked to energy poverty vulnerability in the population of those regions. Gouveia and Palma (2019) assessed the effect of energy efficiency measures by applying a bottom-up building typology approach to evaluate the impact of retrofitting interventions on the regional dwelling stock energy needs, also estimating heating and cooling energy performance gaps and the potential carbon dioxide emissions resulting from the gaps' potential offset by increased thermal comfort. The authors state that without improving efficiency, offsetting the gap would significantly increase carbon dioxide emissions. The authors identified the dwellings in the island of Madeira as being the most energy inefficient in Portugal, whereas the dwellings in the northern regions of Cávado and Terras de Trás-os-Montes present the better performing building fabric and elements. The roof was identified as the building element with the highest potential for energy needs reduction through retrofit. In the Long-term Strategy for Building Renovation (Portuguese Republic, 2021), the impact of energy retrofit and energy efficiency improvements to heating and cooling equipment on the primary energy consumption and thermal comfort of the households, as well as necessary investment cost were estimated, per type of building. While this entry primarily concerns residential buildings, the study found that the highest primary estimated energy savings are observed in public buildings for health and sports typologies and the greatest total estimated amount of energy that could be saved pertains to commercial building stock, followed by multifamily residential building stock from 1960 to 1980.

Palma et al. (2021) assessed the cost effectiveness of different energy retrofit scenarios for reducing the Portuguese dwelling stock energy needs for space heating and cooling, at regional level. Gouveia et al. (2021) using a positive energy district framework model showed an opportunity for historic districts to reduce their emissions and mitigate energy poverty. The historic district of Alfama, in the city of Lisbon (Portugal), was used as case study to show how energy efficiency measures in households may reduce energy needs, increasing thermal comfort while mitigating energy poverty. The potential annual energy demand reduction due to building retrofit was estimated at 82% and 19% for space heating and space cooling respectively.

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Source: EP-pedia Website

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