

Energy poverty in Portugal: Combining vulnerability mapping with household interviews

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ARTICLE INFO

Article history:

Received 8 March 2019

Revised 2 August 2019

Accepted 7 September 2019

Available online 7 September 2019

Keywords:

Energy poverty

Fuel poverty

Energy vulnerability index

Households

Interviews

Cold

Heat

ABSTRACT

Energy poverty seriously affects living conditions and health. In spite of its mild climate, Portugal has been pointed out as one of the most vulnerable countries in the European Union. Due to the multidimensionality of energy poverty, attention needs to be paid to specific factors contributing to it in different contexts. This paper contributes to a better understanding of energy poverty by providing results from a study combining the use of an energy poverty vulnerability index and mapping - based on a detailed quantitative analysis of all 3092 civil parishes -, with interviews conducted with 100 households in ten hotspots across the country. The sample of interviewees includes both rural and urban dwellers, several family types, and individuals of different ages, social and economic status, and living in different types of buildings. Results show the extent, but also variability, of vulnerability to energy poverty throughout the country. Findings also show that households may consider normal and acceptable to feel both cold and hot at home, either in winter or in summer. This can hinder the social recognition of the energy poverty problem and the need to tackle its negative consequences on the well-being and health of the population.

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1. Introduction

Research has shown significant geographic differences in the distribution and configuration of energy poverty. These regional inequalities are related to locally specific drivers of energy poverty [9,11,50]. However, until recently most of research on energy poverty had been limited to a small number of countries. Even in some of the countries that cross-comparative analysis showed to be most vulnerable to energy poverty, there had been lack of knowledge and public recognition of the problem. That has been the case of Portugal.

The country has been pointed out as being among the most vulnerable countries to energy poverty in the European Union [8,12,27,50] according to several indicators generally used to assess energy poverty. Using a composite indicator of energy poverty, Thomson & Snell [50] estimated that Portuguese households living in energy poverty range from 15.3 to 23.4% of the total. Also, regarding excess winter mortality, which has been considered an indicator of energy poverty due to the negative impacts on health of living in inadequately heated environments [35,54], Portugal

has presented one of the highest rates in Europe [21,26]. However, until recently the problem has been overlooked by national decision-makers, and research conducted is just beginning (e.g. [4,23,24,33]).

This paper builds on previous research conducted in the country [22,49], as well as on the fast-growing literature on energy poverty, to shed further light on the specificities of the Portuguese context. In order to do so, the paper combines environmental and social science research in a two-fold attempt: to identify the vulnerability to energy poverty of the different regions across the country and to explore the understandings and everyday life practices of households to cope with it. The methods developed in the research consisted of (1) calculating an energy poverty vulnerability index at civil parish scale (the smallest administrative scale) in order to map its geographical distribution; and, (2) conducting in-depth interviews in a diversity of households from ten different locations in order to explore their perceptions, understandings and practices of coping with energy poverty.

In the literature on energy consumption in vulnerable or low-income households, several concepts have emerged, including fuel poverty, energy poverty, energy deprivation or energy vulnerability. The concept of energy poverty has gained prominence due to increasing political recognition of the problem at the European

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Union level. A generally accepted definition has been to consider energy poverty as occurring when households experience inadequate levels of energy services in the home [10,51]. While initially the concept of fuel poverty (see [7]) used in the United Kingdom and Ireland reduced the problem to a lack of affordable energy for heating, it has since evolved toward a more nuanced view, including other energy services such as cooling, lighting, cooking or the use of home appliances [9]. However, most of scholarly attention has been given to heating since it usually consists of the larger share of energy expenditure in European households. As research [49] showed the relevance of paying attention to vulnerability regarding cooling, particularly in Southern European countries, this paper aims to advance the knowledge on the vulnerability of households to both heating and cooling. In doing so, the paper endeavors to present energy poverty in Portugal as being rooted in socioeconomic, material and cultural dimensions of society. We consider this in relation to growing interest in the literature about how spatial processes shape energy systems and influence their capacity for transformation [13]. This perspective is useful for understanding how the interactions between natural, technical and cultural phenomena in Portugal came to such particular assemblage, which substantially differs from other European countries, and albeit a privileged geographical setting (with one of the most favorable climates in Europe), is among the most vulnerable to cold and heat at home.

From this point of view, the case of Portugal has configured what we consider a landscape of energy poverty. The notion of landscape – especially when understood as both a material and social dynamic process embedded into a located and situated reality [36] – contributes to understand the way energy poverty is embedded into a particular society, territories or local communities. By emphasizing the spatial dimension of energy poverty, different scales emerge [9, 11, 13]. In this paper, different scales are articulated through an analysis of national dynamics over space, the mapping of variations in vulnerability to energy poverty across regions and civil parishes, and, at a micro-level of analysis, how households cope with cold and heat at home in their everyday lives. Thus, the paper starts by presenting the main climatic, socioeconomic and technical factors, whose particular assemblage explains the vulnerability to energy poverty in the country. This is followed by a presentation of the two-fold methodological approach developed – namely the use of an index of vulnerability to energy poverty and the sociological field study. In the results section, the findings obtained through the index are used to map energy vulnerability across the country, identifying the most vulnerable regions, and then the results of the interviews conducted with households in ten of the most exposed civil parishes are used to qualitatively characterize the perceptions, understandings and practices of coping with energy poverty. The paper concludes by presenting some recommendations for designing policies and strategies to tackle energy poverty.

2. The case of Portugal

Portugal is located in the Iberian Peninsula, in the southwest region of Europe. It has a population of 10.3 million inhabitants [40] and an area of 92 226 km² [15]. Portugal has a predominantly temperate climate, except for a small southern inland region which has a steppe and oceanic climate. The country's annual average temperature ranges between 8 °C in winter period to 22 °C during the summer [31].

By the beginning of 1970s, socioeconomic conditions were rather different from those in most of Western Europe, due to the predominance of a traditional rural model, and delayed and tentative industrialization. High levels of illiteracy remained (26% in 1970), and the growth of the middle class was hampered by deep

social inequalities [42]. After the transition to democracy in 1974, and especially with the accession to the EU (1986), there was considerable socioeconomic development, including the expansion of social welfare policies. However, the financial and economic crisis in 2007/8, which led to an international bailout for Portugal (2011–14) and intense austerity policies, had the effect of deepening the already existing social inequalities [16]. In 2013–14 the index of population at risk of poverty or social exclusion increased rapidly compared to the EU28 average, reaching 25% of the population [43]. In 2017, the country had one of the highest rates of income inequality in the EU, with a GINI index of 34.3%, above the European average (30.3%) [20]. Gradually, the restitution of social protection levels and decreasing unemployment rate have contributed to a decline in poverty risk, which reached 17.3% in 2018. Poverty risk affects mostly people over 64 years old, the unemployed and single parent families [29].

Concerning housing, the welfare system in Portugal can be considered rudimentary, as government expenditure in this sector is very limited compared to other welfare sectors. Housing tenure is mostly characterized by owner-occupancy, with home-ownership reaching 72% (often with heavy mortgages), private rental being 20% and social rental (generally owned by municipalities or municipal housing organizations) limited to 3% of total dwelling stock in 2012 [2]. In 2017 the percentage of people affected by severe housing deprivation conditions was 4.0% [29].

The Portuguese residential building stock is composed of approximately 3.5 million classic residential buildings, which lodge about 5.9 million dwellings [28]. Most of the residential buildings are old, approximately 15% date back from before 1945 and about 70% were built prior to 1990 [28], before any building energy performance regulations were implemented in the country. The use of stone masonry and wooden roofs and floors was predominant in older buildings [34], whilst the use of reinforced concrete in the bearing structure is the common practice nowadays. Most buildings have a poor energy performance, with about 75% registering an energy performance certificate (EPC) rate below or equal to C (ranging from A+ to F) [1]. Vasconcelos et al. [52] also point out the poor quality of Portuguese buildings, especially regarding thermal insulation, as dwellings are cold and humid in the winter and too warm in the summer. Moreover, about 29% of the Portuguese residential buildings need intervention work, and 1.6% are severely degraded [28]. There were 6612 non-classical dwellings in Portugal in 2011, approximately 0.11% of the dwelling stock, which do not have appropriate living conditions. Since 2017 there is a program (IFRRU 2020) aimed at supporting (through loans) investments in the renovation of buildings and energy efficiency measures complementary to those interventions. However, by the end of 2018 only 265 applications had been submitted and 71 contracts had been signed [41]. As observed by Bartiaux et al. [5] regarding a program aimed at subsidizing the installation of solar water heating panels in 2009–10, middle- and lower-class households hardly have access to these subsidies due to lack of information and the complexity of applications, among other factors.

About 89% of the dwellings have at least one space heating system, while a space cooling device can only be found in 11% of the dwellings [28]. In 2010, considering the dwellings that have one HVAC system, the portable electric heater was the most frequently used heating system (61.2%), followed by the open fireplace (24%). Only approximately 10% have any form of central heating. For space cooling, the cooling fan has the highest ownership rate (69.5%). The heat pump is also a common choice for space cooling provision (26%) [30]. Consequently, space heating final energy is provided mainly by electricity (14%), biomass (68%) and heating diesel (14%), whilst electricity is the only energy source of space cooling provision [30]. Space heating and cooling energy consumption represented only 22.0% and 0.64% of all residential

final energy consumption in the country in 2013, a significantly lower percentage than the other European countries [37].

In 2017, according to the EU SILC [20] survey among all 28 European member-states, Portugal had the 5th highest rate of inability to maintain dwellings adequately warm during the winter (20.4%) and had the second highest rate of population living in dwellings with a leaking roof, damp walls, floors or foundation, or rot in window frames or floor (25.5%) [20]. In 2012, 35.7% of the population claimed to be living in a not comfortably cool dwelling in the summer, the 2nd highest rate in the EU [20]. Also, only 5.6% of the population were identified to have arrears on utility bills, a percentage below the EU levels [20]. This is probably due to the very high use of open fireplaces, since part of the biomass used is left out from the statistics. The results of a national survey conducted by PCS/Quercus [39] also point to a potential thermal comfort issue in the population. About 74% of all respondents considered their dwelling to be cold during the winter, 24% of the people considered their houses to be too hot during the summer, and only 1% reported that their house provides thermal comfort. Most respondents (>80%) also felt the need to significantly increase their energy consumption to maintain adequate temperatures in their dwelling [39].

The price of electricity for households has been increasing in the last decade and since 2012 has been higher than the EU28 average [20]. According to an analysis of price levels for European households using purchasing power parities, in 2017 the price level index for electricity, gas and other fuels in Portugal was the third highest among EU countries [19]. Not long ago, the government established social tariffs for electricity (in 2010) and natural gas (in 2011) as a measure to assist vulnerable households paying their bills. Since 2016, this measure is automatically awarded to families with low incomes (up to 5808 euros annually), receiving other social support benefits and with a maximum of 6.9 kVA of installed power per month. About 12.9% and 0.6% of households have benefited from this tariff for electricity and natural gas respectively [18]. However, this has been insufficient, and the low incomes, coupled with the high energy prices, result in an increased vulnerability of the population to energy poverty. In late 2018, a pilot phase was initiated in 10 municipalities to extend the applicability of social tariffs to liquefied petroleum gas (LPG), since the vast majority of population (around 75%) use butane gas bottles for water heating, cooking and, to a lesser degree, space heating [30].

3. Methods

The methodologic approach of this study was divided into two major steps, as follows: 1 – energy poverty vulnerability index (EPVI) calculation and mapping at a regional scale, for both space heating and cooling in all Portuguese civil parishes (mainland and islands); 2 – household interviews conducted in ten locations with different climate and socioeconomic characteristics, which were selected among the areas most vulnerable to energy poverty according to the EPVI. Herein we only evaluate the mainland regions. Each step of the methodology is further described in the next sections.

3.1. Energy poverty vulnerability index development and mapping

The development of the energy poverty vulnerability index (EPVI) is described in the work developed by Gouveia et al. [22]. The EPVI is an aggregated assessment of the dwelling stock's energy performance, households' energy consumption, and the ability of the population to implement alleviation measures, defined by a set of socioeconomic indicators.

To evaluate the energy performance of the dwelling stock, the energy performance gap - i.e. the percental difference between

the theoretical and real final energy consumption for space heating and cooling - was estimated through the replication of Palma (2019) approach. A bottom-up building typology approach was used to estimate the theoretical final energy consumption of the dwelling stock. Firstly, the useful energy demand of all 176 building typologies was calculated using a steady-state method based on the national residential building's energy performance regulation [32]. An optimal inside temperature of 18 °C and 25 °C, respectively in the heating and cooling seasons, for the whole useful area of the dwelling and whole season duration, were considered.

The theoretical final energy consumption per civil parish was then estimated using heating and cooling equipment ownership rate and distribution [30], typical climatization systems' efficiencies, and the number of occupied main residence dwellings per building typology [28]. The real final energy consumption per civil parish was calculated using municipal statistics on total final energy consumption per energy carrier, and representative municipal energy matrixes. The energy performance gaps were standardized into a sub-index ranging from 1 (minimum gap) to 20 (maximum gap).

The ability to implement alleviation measures was assessed by analyzing a set of selected socioeconomic indicators. After a thorough process of literature review, several indicators were identified as being related to householders' financial capacity, motivation, awareness, and access to information on energy efficiency measures. The selected indicators were the following: 1) share of population with age equal or lower than 4 years old (in %); 2) share of population aged 65 and over (in %); 3) average monthly income per capita (in €); 4) share of dwellings' owned by the occupant (in %); 5) share of the population with a university degree (in %); 6) unemployment rate (in %); and 7) building state of conservation (qualitative). Each indicator was standardized to an ability classification value between 1 (minimum ability) and 5 (maximum ability), according to a "step" segmented linear function. The indicators were finally weighted according to the feedback of 13 energy poverty specialists, resulting in a sub-index also ranging from 0 (lowest ability) to 20 (highest ability).

The EPVI for heating and cooling was computed through a linear equal-weighted average value between the ability to implement alleviation measures sub-index subtracted to 20 (the inverse value of the sub-index) and respectively the heating and cooling energy performance gap sub-index. The three most vulnerable civil parishes to the heating and cooling seasons simultaneously in each region were identified. The percentage of social housing, non-classic dwellings and households receiving social energy tariff were also considered in the selection and included as benchmarking indicators of the EPVI results.

3.2. Household interviews

The second stage of the research consisted of a sociological field study designed to qualitatively explore the diversity of practices households adopt to cope with energy poverty. For that purpose, ten civil parishes were selected amongst the most vulnerable to energy poverty according to the index previously developed. The selection of these ten locations was sided with the 26 municipalities that had been selected for a previous project (ClimAdaPT.Local, see [46]). Those parishes had been carefully selected in order to represent the social, economic and climate diversity of the national territory. Besides that, the contact with representatives of local authorities that took place in the course of the previous project were taken into account, given it would facilitate our access to intermediaries who could help identifying potentially vulnerable households to energy poverty. The selection of the ten parishes also considered contrasting locations regarding climate and urban or rural character. The identification of possible interviewees was likely to

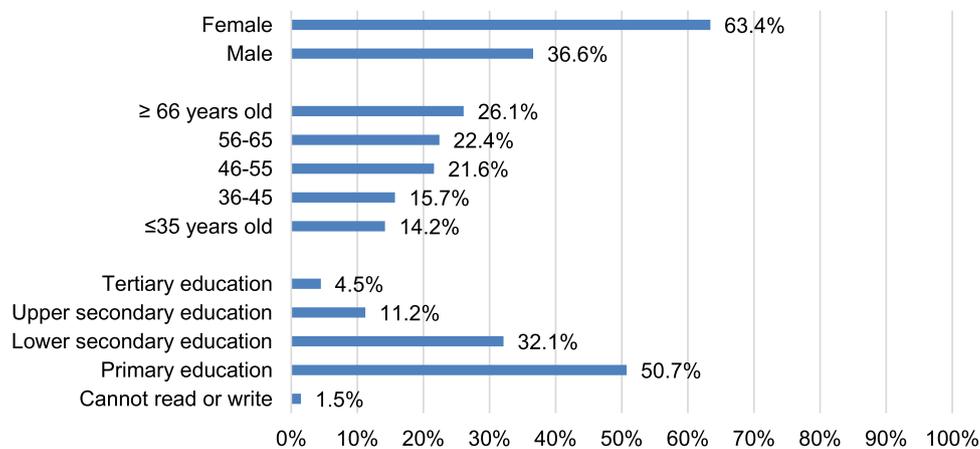


Fig. 1. Gender, age and educational level of the interviewees ($n = 134$).

be a difficult task due to the householders' probable lack of interest in talking about such sensitive topic. To ensure that potential interviewees matched a diversity of profiles and experiences of households vulnerable to energy poverty, the intermediaries in each location were asked to identify households in contrasting situations regarding respondent age, gender and economic status (retired, unemployed, working, etc.), household composition, type of building (house, apartment), housing tenure (own, rented, social housing tenant), and age of building.

The chosen method was in-depth semi-structured interview, as it presents several advantages for producing knowledge about how interviewees experience the world [14]. The interview provides a context that facilitates disclosure, and although it was guided by a series of key questions, unforeseen issues and information could arise. All interviews, except three, were conducted at the household's residence, which allowed to observe some aspects of the building, as well as inside the home. Often the interviewees spontaneously invited the interviewers for a dwelling tour, which provided the opportunity to further understand the specific background of the interviewees' statements. Notes from the observations were written down, thus contributing to a deeper understanding of the interviewees' discourses by placing individuals within a wide context.

The key questions were constructed based on the literature on energy poverty. The topics included material dimensions, as well as competences and meanings, which contribute to shape households' patterns of practices [48], such as: (1) characteristics of the dwelling (year of building completion, number of rooms, sun exposure, type of tenure, presence of leak, damp or rot, among others); (2) history of works carried out in the dwelling/building; (3) available equipment (including heating and cooling systems); (4) satisfaction regarding the dwelling, thermal comfort at home, and doings to cope with cold and heat at home, among other topics. The interviewees were also asked about the social characteristics of their household (number of people, kinship relations, age, gender, occupation and educational levels).

As often happens in research on households, it was more difficult to find men than women who would agree to be interviewed, which explains the predominance of women in the sample. This overrepresentation of women is of less importance since the sample of interviewees was not intended to be representative, as what was sought was a range of different experiences that could be explored in depth. Although interview appointments were arranged with a single member of the household, in some cases a second member also participated in the interview. For this reason, even if a total of 100 interviews were conducted, ten in each location, the number of interviewees is 134. The field work was car-

ried out between February and May 2018. The interviews lasted 40 min on average. Informed consent was obtained before each interview, and interviewees were reassured regarding confidentiality, anonymity and the protection of their data. Households are anonymously identified by the number of the interview. The main sociodemographic characteristics of the interviewees are presented in Fig. 1.

The interviews were recorded, transcribed and then analyzed using QSR NVivo software. The transcripts were coded by identifying themes and assigning variables to text passages. The themes arose both from the theoretical framework and directly from the data, as the software allowed to check and re-check the categorization of the texts. Only one coder coded all interviews.

4. Mapping: main results

The results concerning the energy performance gap sub-index emphasize the inefficiency of the Portuguese dwelling stock, as the final energy needed for regulated defined thermal comfort conditions is invariably superior to the final energy consumption for both heating and cooling. In a scale from 0 to 20, the average civil parish heating and cooling energy performance sub-indices are respectively 16.5 and 18.8.

About 97.5% of all civil parishes present a heating energy gap sub-index higher than 11 and approximately 93% have a cooling energy performance sub-index greater than 17, which evidences the magnitude and comprehensiveness of this issue. The frequency of civil parishes with high heating-related vulnerability is greater in the north and central inland of the country, due to the severity of the climate (higher number of heating degree-days), greater average dwelling area and use of inefficient heating systems such as open fireplaces. The majority of less vulnerable civil parishes are located in the suburbs and metropolitan area of Lisbon and the region of Algarve, due to the milder climate, greater number of newer buildings (with better energy performance) and higher consumptions, potentially due to more significant economic affluence.

The cooling EPG sub-index results are very high throughout the whole country but are particularly high in the north inland, despite the milder summer climate in this region. This is mainly due to very residual consumption levels. The cooling EPG sub-index values are higher compared to heating because of the current low ownership rates of cooling systems (only 11%), as the Portuguese often opt for mixed ventilation systems or to simply ventilate their dwellings naturally [55].

Regarding the ability to implement energy poverty alleviation measures, the average sub-index stands at 12.5 and about 87% of the civil parishes have a sub-index level superior to 11. The civil

NUT2	NUT3	Municipality	Civil Parish	Population	Typology	EPVI Heating	EPVI Cooling	Social energy tariff (%)	Social Housing (%)	Non-classical dwellings (%)
Alentejo	Baixo Alentejo	Ferreira do Alentejo	União das Freguesias de Ferreira do Alentejo e Canhestros	5140	Rural	12.1	13.1	16.9	0.0	1.2
Área Metropolitana de Lisboa	Área Metropolitana de Lisboa	Cascais	Alcabideche	42162	Urban	11.8	12.3	17.3	3.3	0.4
Área Metropolitana de Lisboa	Área Metropolitana de Lisboa	Lisboa	Ajuda	15617	Urban	10.7	12.2	14.5	9.4	0.1
Centro	Beiras e Serra da Estrela	Seia	Loriga	1053	Rural	11.9	13.9	24.4	0.1	0.0
Norte	Ave	Guimarães	Barco	1510	Rural	14.1	14.6	22.8	2.8	0.0
Norte	Ave	Guimarães	Fermentões	5707	Urban	11.7	13.2	22.8	2.8	0.0
Norte	Terras de Trás-os-Montes	Bragança	Salsas	389	Rural	14.0	14.5	24.2	1.9	0.0
Norte	Área Metropolitana do Porto	Porto	Campanhã	32659	Urban	11.8	12.8	18.0	13.8	0.6
Centro	Região de Coimbra	Figueira da Foz	São Pedro	2910	Urban	11.1	13.6	2.3	2.2	0.2
Algarve	Algarve	Olhão	Quelfes	17246	Urban	11.0	12.5	22.2	4.4	0.3

Fig. 2. Information on the ten selected civil parishes.

parishes with a higher sub-index (>12.4) are more frequent in all the western coastline region, especially in the urban areas of Lisbon, Porto, Coimbra, and Leiria. This higher ability is related to a lower rate of elderly people, higher average monthly income and higher proportion of people with a university degree. On the other hand, the inland civil parishes, especially in rural regions, present the lowest sub-indexes, resulting from higher percentages rates of elderly people, with lower levels of education and income, and significant unemployment rates. In the north inland, the poorer building conservation state also contributes to low sub-indexes.

Resulting from the combination of these two sub-indexes, the EPVIs for space heating of all civil parishes of the country range between 4.7 and 14.7, with an average of approximately 12.0. In the case of space cooling, the EPVI values of the civil parishes vary between 9.7 and 15.8, with the average standing at 13.2. About 37% and 85% of the civil parishes have a heating and cooling EPVI higher than 12. These results highlight the prevalence of energy poverty vulnerability all over the country. More details about the regional diversities of all the indicators used and a full overview of the country results can be found in Gouveia et al. [22]. The heating and cooling EPVI of the ten selected civil parishes, as well as further information and maps are displayed in Fig. 2 and Annex A.

5. Perceptions of thermal comfort and practices of coping with cold and heat at home

In this section the results from the interviews conducted at the second stage of the project are presented in order to complement the analysis based on the energy poverty vulnerability index (EPVI) with a sociological field study. This is done by focusing on two dimensions: first, the perceptions of thermal comfort reported by the interviewees, which give insights on the real settings of households' everyday life, as well as their understandings of the energy performance of their dwelling; and second, the practices of coping with cold and heat at home, in addition to the explanations put forward by the interviewees not to do otherwise, which offer a qualitative analysis complementary to the quantitative approach on

households' ability to implement energy poverty alleviation measures.

Regarding the households' perceptions of temperatures at their homes, only 16 (out of 100 interviews) did not acknowledge thermal discomfort in any season. More than half of them (56) said that their homes are simultaneously cold or very cold in winter and hot or very hot in summer. A higher number of households claimed to be satisfied with the thermal environment of their homes in summer (36, against 24 claiming to be satisfied in winter). Although our sample is not representative of the population and cannot be generalized, these numbers show how widespread is thermal discomfort among the interviewed households. The results also point to the intensity of discomfort felt by the households, since many of them claimed their dwelling is *very cold* (35) or *very hot* (34). Table 1 illustrates these results in more detail.

Individual subjectivity in the assessment of thermal comfort was clear, for example, when interviewees claimed to feel comfortable indoors while the interviewer was feeling cold (even if wearing a coat) or when interviewees admitted that other members of the household feel the cold at home more often than themselves. Indeed, the perception of thermal comfort may vary according to several factors. Beyond the "classical" variables most used in the literature on thermal comfort (such as air temperature, humidity, individuals' clothing or level of activity), this sensation is influenced by "cultural and behavioral aspects, age, gender, space layout, possibility of control over the environment, user's thermal history and individual preferences" ([44]: 195). Sociological research on energy use has emphasized how the notion of comfort is socially construed. The perception of what is an adequate or acceptable temperature indoors has evolved throughout history and different contexts, reflecting the expectations, "needs" and cultural conventions of people, even though building science has sought to specify a universal optimum temperature [17,47].

Some of the interviews conducted suggest that households that have experienced living on low incomes for a long time may underestimate thermal discomfort. Especially regarding cold, some interviewees claimed that they are "used to it", that they have "enough clothing" or that acclimatization (i.e. adapting oneself to

Table 1
Households' perceptions of temperatures at home in winter and summer (n=100).

		In Winter		
		Very cold	Cold	Mild
In Summer	Very hot	19	11	4
	Hot	7	19	4
	Mild	9	11	16

the weather by using only clothing or blankets) is the healthiest. In fact, they could not afford to warm their home or to pay for a dwelling with better conditions, and the awareness of these constraints seems to contribute to an attitude of acceptance or resignation (as also observed by [3]). That is the case, for example, of a 63-year old widow with primary education, living in a small rented house with damp, leaks and cracks that she claims is both very cold in the winter and hot in the summer – but that is better than the one where she lived previously:

"I have to [feel comfortable at home]! I have to! I cannot find another house for the price of this one. I just have to [feel comfortable]." (E76)

The quality of buildings in the sample was generally low or even very low, with several interviewees claiming that their house has leaks that allow rainwater enter inside. Most of the houses needed some intervention work – from structural problems to lack of insulation. No more than 22 out of 100 houses had been built after 1990 (when the first regulation on the energy performance of buildings was issued). Only 26 households did not have leakages or damp in any of the rooms, and 31 of the homes had developed some sort of cracks through which cold air could come inside.

These cases indicate that households may have low expectations regarding the possibility of having a warm environment indoors. In addition, the fact that other households they know and have known throughout their lives also experience similar conditions contributes to consider that it is "normal" to feel cold at home. In contrast, for someone who had experienced living in a warm home earlier, thermal discomfort may seem less acceptable. That is the case of a 45-year old single mother with upper secondary education who lived her childhood in a heated home in France (when her parents were immigrants there), and whose sister, whom she often visits, currently lives in a dwelling with a central heating system:

"If electricity was cheaper I would [use heating equipment], obviously! Of course I would! I would love to have central heating, like other people do. (...) This way [without heating], one even gets sick from living like this." (E66)

The expectations regarding thermal comfort may vary among household members. This may happen more often in households with two different generations, conducting to a certain degree of conflict between (most often) parents concerned with the cost of electricity (and socialized in a lower energy demanding way of life) and young people from a generation with higher expectations regarding comfort (see [45]). In the case of a 75-year old widow (with lower secondary education) living with her son, in spite of her effort to save as much energy as she can, electricity bills were higher and higher as winter progressed. Eventually became clear in the interview that her son used to turn on an electric heater in his room in the attic regardless of their frequent quarrels about it:

"Oh yes, sometimes I scold him, right? «Watch out!» «Oh, mother, this and that!» And me: «Look, you've been spending [energy]!» «Oh mother, this heater doesn't spend much, it's small and this and that...» So, that's the way it is..." (E24)

Households may also have understandings of thermal comfort that do not correspond to the conventional, universalist, notion sought by building science. Indeed, in some households the use of heating devices was avoided due to particular conditions or preferences of (one of) their members. That was the case of households where a child suffered from asthma. Since parents claimed that exposure to a heated room could trigger an attack, they were very careful in avoiding that their child entered any room where a heater was on. In other cases, interviewees claimed that they dislike electric heaters because they dry out the air in the room, as it was the case of an 81-year old woman with lower secondary education living with her husband in a rented apartment:

"I don't like being in that warmth [from the electric heater], it hurts my eyes... I've already had a cataract surgery. The eyes look like they are crying because of the warmth from the heater... It makes me itch. Do you know what I do? I have a blanket. (...) We always prefer that natural warmth from the little blanket." (E5)

However, regarding the practices of coping with cold at home, the main reason mentioned by interviewees for being unable to keep their homes with comfortable temperatures is the high cost of energy – which is mainly electricity. As only a small number of dwellings have central heating or air conditioning systems, most people use portable electric heaters. Yet, although buying this equipment can be affordable, its energy consumption easily becomes quite high when turned on regularly or for several days in a row. Thus, many households only use these devices for short periods of time (very often for less than one hour per day) and when the weather is particularly cold (as also unfolded by Gouveia et al. [25] using smart meters data). Usually only one room in the house is heated, most often the living room. Households admitted to heating their homes for longer than four hours per day almost only in rural areas, where the climate is more severe. In these cases, they have a fireplace in the kitchen, which can also be used to boil water and cook. Very often the kitchen is also used as living room. Often the fireplace is lit with firewood collected by the occupants themselves. The case of a 66-year old woman with primary education, living by herself in a social housing apartment that she claims is "freezing" and damp, illustrates why most interviewees refrain from using heating devices:

Interviewee: *"I have a radiator there, which is oil filled, but there came such a large electricity bill, Jesus! I stored it! I swear!"*

Interviewer: *"Can you tell me how much was that bill?"*

Interviewee: *"Eighty-two Euros [laughs]. It's scary. I stored it!"* (E21)

It is thus very frequent among the interviewees to give more relevance to the cost of heating the house than to the benefit of thermal comfort. When compared to other necessities, such as food, a warm environment indoors may be understood as a waste of money (or a luxury), as households can resort to inexpensive actions focused on heating their bodies instead of the environment, such as dressing more clothes and warm shoe wear and socks, putting more blankets or comforters on their beds or covering themselves with blankets and/or shawls. Often interviewees said they go to bed earlier to get warm. Some of them also use hot water bottles. Rarely did the interviewees report using electric blankets or other kinds of electric heaters, which seems to be related to the fact that heating appliances are among the home equipment that households considered having higher energy consumption. Some interviewees mentioned that to stop feeling cold they “work” (meaning mostly housework) or move around. These practices of coping with cold can only provide temporary and very limited thermal comfort; however, the fact that they are still repeated year after year, indicates that households tend to accept feeling cold at home as being part of “normal” everyday life during winter. Indeed, for many households, only in exceptional circumstances, as when a family member is ill, there are newborns at home or young children come for a visit, for example, routines are changed and one of the rooms is heated.

Also regarding the practices of coping with heat at home, most households in the sample try to achieve thermal comfort through ways that do not require energy consumption. The reason for this is once again the cost of electricity. The high cost of installing air conditioning systems has also been mentioned by some interviewees. Only very few of them had (and used) air conditioning devices (including portable ones) at home. Although many of the households had fans, their use was not generalized, being mostly limited to very hot days and for short periods – except for those households who claimed that when it is too hot, they need a fan on all night so that they can sleep. As asserted by a 74-year old man with primary education, living with his wife in a social housing apartment, the use of fans tends to be kept to a minimum:

“(…) I cannot keep it [the fan] on for long because it also uses a lot [of electricity], these are things... isn't it? It spends a lot, it's like the heater... Turn on a little bit, just to cool down when it's really hot, and then turn it off.” (E61)

Several interviewees were skeptical regarding the worth of fans, as these devices, besides spending energy, are said to only circulate “hot air”. In general households in the sample preferred natural ventilation. The most common practices of coping with heat were opening windows and doors in order to force the circulation of air from the outside, and lowering exterior roller shutters, blinds, shades or other exterior window coverings to reduce solar exposure, often with the windows open so that air could still circulate. Other common practices are showering more than once a day (using colder water), wearing less clothes, and removing all blankets from beds (and in some cases sleep over the sheets). Several interviewees said they go outside to cooler places or take advantage of their balconies and terraces as refuges from the heat.

The fact that the interviews were conducted in ten contrasting locations across the country allowed to observe that the practices of coping with cold and heat indoors by restricting the use of energy are widespread. However, two different configurations of practices stand out, pointing to the relevance of social and geographical variables. The most visible difference involves the use of fireplaces. Although fireplaces were quite common in the households interviewed in rural areas, only seldom existed in the urban households. The tradition of having a fireplace at home in rural areas is also related to the spatial and functional configuration of houses, as the fireplace is usually located in the kitchen, which

also functions as living room. This also means that family members share the same space, instead of spending more time in individual activities in separate rooms, as is common in urban areas. The possibilities of using biomass collected from the household's property (or nearby, without paying for it), and of placing pots on the fireplace to cook and heat water also contribute to this practice.

A second different configuration was observed in one of the locations. Householders interviewed in a rural civil parish in the North of the country had both income and education levels above the average of the sample. Most of them also had fireplaces at home, and in some cases additional systems such as central heating or air conditioning. Among these interviewees, knowledge and interest shown regarding wall insulation was also higher than the average. As most of these interviewees indeed used their heating systems, half of them claimed that their home has a mild indoor temperature in the winter. Such level of thermal comfort was exceptional among other interviewees in rural areas. In fact, most of rural households in the sample claimed that their homes were simultaneously cold or very cold in winter and hot or very hot in summer (that was the case of 27 out of a total of 40 households in rural areas). In general, income levels in rural areas are below the national average, and in the sample of households that would also be the case if this civil parish had not been included. The fact that interviewees in this parish were better off than expected in rural areas thus highlights how socioeconomic and geographical inequalities affect vulnerability to energy poverty. Moreover, the findings from these two configurations indicate the relevance of both income, education and knowledge on one side, and material arrangements in local contexts (such as fireplaces in rural areas) on the other side, in influencing practices of coping with cold.

6. Conclusions

In this study, the Portuguese regional energy poverty vulnerability was assessed through a composite index that combines climate, energy performance assessment of the residential dwelling stock and energy consumption levels with the estimation of the potential ability of the population to implement energy poverty alleviation measures. The energy performance of the dwelling stock was assessed through the estimation of the energy performance gap between the theoretical energy consumption, computed through a bottom-up building typology steady-state method, and the real energy consumption estimated using municipal energy consumption statistics. The population's ability to implement alleviation measures was estimated by analyzing and weighing different socioeconomic indicators that characterize the populations of the different regions. Ten civil parishes were selected in accordance with their high level of vulnerability in both the heating and cooling season, as well as their representativeness of different social, economic and climatic contexts. Sociological field research in these ten civil parishes was based on in-depth interviews with 100 households, ten in each location. The households in the sample were potentially vulnerable to energy poverty and included a diversity of situations regarding socioeconomic and demographic variables, as well as type of building and housing tenure.

Results show the extent of vulnerability to energy poverty throughout the country, as there are civil parishes from the north, center and southern region of the country in the top 50 of the highest vulnerability for heating and cooling. This is not surprising in a country with high levels of inequalities, a traditionally weak welfare system, a residential building stock with a poor energy performance, and high energy prices. However, the energy poverty vulnerability index here developed emphasizes that this vulnerability does not just affect a large extent of the population during the winter, but also during the summer. These results suggest that the specificities of different climatic regions, especially those more

exposed to warm weather, should also be taken into account when designing policies and strategies for tackling energy poverty.

Findings from the field study show that besides the extent of vulnerability to energy poverty throughout the country, many households report a high intensity of thermal discomfort at home, either in winter or summer. This is in spite of a generally mild climate, emphasizing the relevance of the socioeconomic context and the low quality of the housing stock. However, the interviews also show that there is an acceptance of thermal discomfort at home. This acceptance may be due to the fact that households living with very low incomes have low expectations regarding possible improvements in their daily lives. This is especially the case of individuals struggling to make ends meet and whose house is in a bad condition, as these situations lead to hopelessness and resignation. Nevertheless, there are also households whose reasoning about the high cost of energy points to preferring practices of coping with cold that are focused on warming their bodies instead of their home, as a way of saving money. On the other hand, individuals from younger generations, with higher levels of education, and those who have experienced thermal comfort at home sometime during their lives (often if they have been immigrants in other countries with colder climates) may have more demanding expectations. Altogether these results indicate that households tend to consider normal and acceptable to feel thermal discomfort at home, but also show signs of an emerging trend towards aspiring more thermal comfort at home. This brings into question what are the energy “needs” of households, as discussed by Bartiaux et al. [6]. In fact, as shown by Wilhite and colleagues [53], the “need” for space heating and cooling is socially constructed, being deeply rooted in its cultural significance. It is thus questionable to define universal patterns of thermal comfort, as different patterns of vulnerability should be identified taking into account social and cultural differences across space. The fact that most of the interviewees claimed that the main reason for not using heating or cooling devices was the high cost of energy indicates that a thermally comfortable home is not a priority for them –instead, for many it is considered a waste of money or a luxury. However, social and cultural transformations over time point to changing expectations regarding thermal comfort indoors, as air conditioning is increasingly available in commercial spaces, offices and transports, and in contemporary media culture living in hot or cold homes is usually not portrayed as something desirable. In order to achieve more accurate estimations of thermal comfort and vulnerability to energy poverty, it is therefore necessary to put more emphasis on households’ everyday life practices, understandings and aspirations across different spatial contexts, and on how these evolve over time, since universalistic assumptions on the energy performance of buildings and thermal regulations in some countries (like Portugal – see [38]) do not match the ways people actually deal with cold or heat at home.

The two-fold methodological approach here presented is an attempt of combining material, socioeconomic and cultural dimensions, not just by conducting both quantitative and qualitative assessments of vulnerability to energy poverty, but also by including socioeconomic variables in the index here developed. By linking the results of these two methodologies, it is possible to provide more robust insights into the designing of measures to fight energy poverty. Both methodologies point to the relevance of socioeconomic factors, especially income, and education (which is related to income). More affluent regions and households have lower levels of vulnerability to energy poverty. A cross analysis of the data here presented indicates that this is mainly due to the poor quality of buildings, as wealthier households can afford better energy performance housing and energy use. Furthermore, the inclusion in the analysis of cultural factors, which have been neglected in research on energy poverty, shows that there is ingrained resis-

tance to the use of heating or cooling devices (due to the perception that energy is too expensive), to the point that some interviewees say they prefer to warm themselves with throws and blankets. Altogether, these results suggest that measures for alleviating energy poverty should, first and foremost, focus on financing improvements in dwellings and specifically target households with low income. This strategy would allow to increase thermal comfort indoors in many old buildings that urgently need renovation. Considering social practices and understandings among the population regarding heating and cooling, and also climate and building characteristics in the country, renovation works should privilege passive thermal systems and techniques, such as insulation, natural ventilation or shading, as these are most often lacking, and low income households would probably continue to resist the use of heating or cooling appliances due to the high cost of energy.

One further observation is the fact that social acceptance of feeling cold and heat at home may contribute to hinder the social recognition of the problem of energy poverty and the need to tackle its negative consequences on the well-being and health of the population. Therefore, it is paramount to design and implement an effective public awareness strategy on the effect of indoor extreme temperatures in the health condition, and the significant magnitude of the energy poverty issue that is currently affecting the population. This should be implemented together with reinforced efforts for increased building retrofit and energy efficiency.

In the light of the term landscape of energy poverty, these findings point to the need for further research on the spatial heterogeneity of vulnerability at different scales across countries. Only through detailed analysis of particular assemblages of natural, technical, socioeconomic and cultural drivers and manifestations of energy poverty in specific regions and locations can policy-makers and planning practitioners design fully informed and realistic policies and measures to tackle energy poverty in specific landscapes. In the case of Portugal this is particularly pertinent since decision-making frameworks at the national level are influenced by European Union orientations and parameters. However, as noted by Nadaï and van der Horst [36], most assumptions and economic models underlying top-down energy policies rely on implicit universalistic views of isotropic spaces. Yet, the real world is in fact heterogeneous, and therefore policies to fight energy poverty need to consider the specificity and variability between, and within, landscapes.

Declaration of Competing Interest

None.

Acknowledgements

This research received partial funding from the Portuguese Energy Services Regulatory Authority (ERSE) through the project “Ligar – Energia para todos”, coordinated by the national Energy Agency (ADENE). The authors thank also the support given to CENSE and to ICS by the [Portuguese Foundation for Science and Technology](#) (FCT) through the strategic projects [UID/AMB/04085/2019](#) and [UID/SOC/50013/2013](#). Ana Horta also acknowledges the support given by FCT through the post-doctoral fellowship [SFRH/BPD/96878/2013](#). The authors are grateful to the anonymous reviewers for their careful reading and insightful comments.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:[10.1016/j.enbuild.2019.109423](https://doi.org/10.1016/j.enbuild.2019.109423).

Annex A

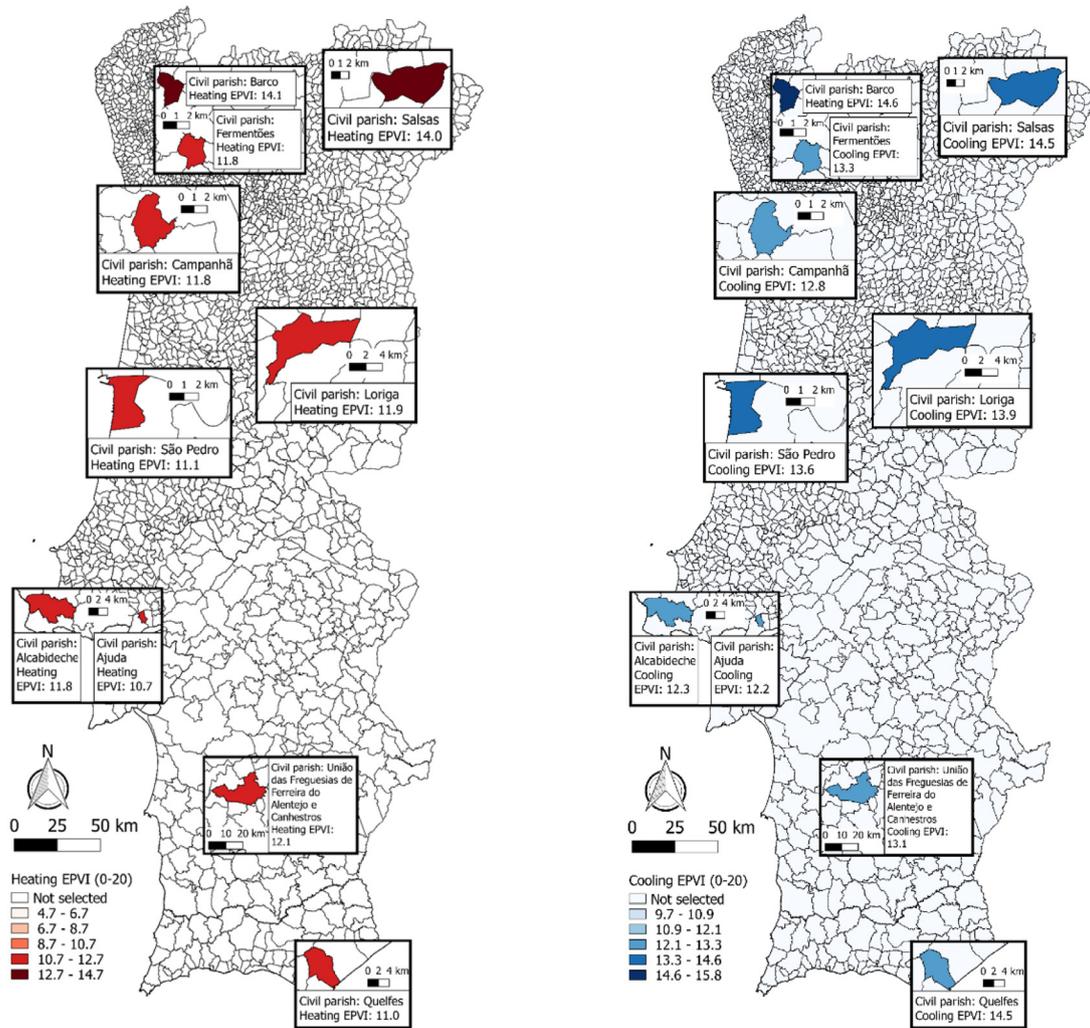


Fig. A. Geographical location of the selected civil parishes and their respective heating (left) and cooling (right) EPVI.

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