NOVA SCHOOL OF SCIENCE & TECHNOLOGY

DEPARTMENT OF ENVIRONMENTAL SCIENCES AND ENGINEERING

CAROLINA CRUZ DE CASTRO

ENERGY POVERTY AMONG HIGHER EDUCATION STUDENTS FROM MONTEVIDEO, PADUA, AND PORTUGAL: A COMPARISON BETWEEN LOCAL AND DISPLACED STUDENTS

INTEGRATED MASTER IN ENVIRONMENTAL ENGINEERING

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História reescrita

Não te forces a amar
Não te forces a lutar
Não te forces a trabalhar

Cara labuta,
Foi por amor
Dá amor à luta
Não te queiras enforcado
Pela força do patriarcado
Por tudo o que é forçado
Para ti, errado
Para muitas, por aí, a errar
Erremos todas
Mas tira daí o vaguear

Acredita que todas temos
A força da esperança
O poder do querer
O ardor do amor
O fado
Para lutar por menos erros
Para trabalhar por menos desterros
Arrebita, dedica, contradita
Suscita, excita, capacita
Ressuscita, História reescrita

(Púrpura)

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Não sei o que é que fica

Então voltamos ao mesmo assunto
Somos tão bons para o resto do mundo
Na nossa casa o espeto é de pau
A prata é a fome do lobo mau

Welcome monsieur, a casa é vossa
O mal dos outros não nos faz mossa
Quem não aguenta subir a encosta
Habitação é fratura exposta

E eu que só vinha para falar de amor
Deitar neste beat um poema em flor
Mas na porta ao lado há mais um despejo
Cai uma família, fica o azulejo
Começam as obras, que casa bonita!
Começam os guests, fome é infinita
Mais um AL, orgulho nacional
Corrida sem lei, onde vais Portugal?

Não sei o que é que fica se correrrmos mais
(...)

Desalojamento local
Para alojamento local
No mínimo, paradoxal
E agora, este local, é igual
A qualquer outra capital

Senhor Presidente não ando feliz
Eu quero ser sonhos e não quem maldiz
Calem-se os fachos que ardam bandeiras
Aqui o assunto não são as fronteiras

É sempre bem-vindo quem venha por bem
Problema é haver uma casa para cem
Salários tão baixos amarga a batuta
Que felicidade interna tão bruta

(A Garota Não)

ABSTRACT

Energy Poverty (EP) is a pressing issue that affects a significant number of people, and it is influenced by various factors, including housing conditions, household composition, energy literacy, and climate change.

Some groups are more vulnerable to EP than others, such as students, who have a high risk of falling into EP due to various factors, such as lack of knowledge of energy efficiency measures, tight budgets, or high energy expenses. Although this group is often not directly targeted by policymakers and has not been widely considered a vulnerable group, EP is a critical issue, as it intersects with their educational background, health, and general well-being.

While EP is a common problem, known to vary between regions, it is not known how the EP situation may differ between local and displaced students and how this interacts with the season of the year. Thus, this work explores the aspects of EP experienced by local and displaced students in Montevideo (Uruguay), Padua (Italy), and Lisbon/Portugal during winter and summer through a comparative analysis.

In this sense, this dissertation includes two studies based on a survey of higher education students and their responses to the questionnaires used, which covered various aspects related to EP. The first examined the perceptions of EP among university students in Montevideo, Lisbon, and Padua, considering both local and exchange students, while the second focused on local and displaced higher education students in mainland Portugal, exploring their vulnerability to EP in four of its regions.

Both studies revealed how diverse backgrounds, housing conditions and regional disparities can influence higher education students' perceptions, experiences, and vulnerability to EP. The first research associated vulnerability to EP with housing problems, particularly evident during the winter in Lisbon and Montevideo, in contrast to the more satisfactory housing conditions in Padua. According to the conclusions of the two studies, there is an urgent need to address EP with the Portuguese higher education student population. Moreover, the second research revealed the substantial challenges faced by this population, especially by displaced students and those living in the private rental sector.

Policymakers and institutions must, therefore, consider this knowledge to allocate resources effectively and implement interventions targeting this population. These efforts can improve students' living conditions, raise awareness about EP and ensure that EP does not unduly impede their educational activities.

Keywords: Energy Poverty, Higher Education Students, Lived Experience, Housing, Survey

RESUMO

A Pobreza Energética (PE) é uma questão premente que afeta um número significativo de pessoas e é influenciada por vários fatores, incluindo as condições de habitação, a composições do agregado familiar, a literacia energética e as alterações climáticas.

Alguns grupos são mais vulneráveis à PE do que outros, como os estudantes, que têm um risco elevado de cair numa situação de PE devido a vários fatores, como a falta de conhecimento de medidas de eficiência energética, rendimentos baixos ou despesas energéticas elevadas. Apesar deste grupo não ser, muitas vezes, um alvo direto dos decisores políticos, e não ser amplamente considerado como um grupo vulnerável, a PE é uma questão crítica para este grupo, uma vez que se cruza com o seu percurso educativo, saúde e bem-estar geral.

Embora a PE seja um problema comum, conhecido por poder variar entre regiões, não se sabe como a situação de PE pode diferir entre estudantes locais e deslocados e como isso interage com a estação do ano. Assim, pretendeu-se explorar os aspetos da PE vividos pelos estudantes locais e deslocados de Montevidéu (Uruguai), Pádua (Itália), e Lisboa/Portugal, durante o inverno e o verão, através de uma análise comparativa.

Neste sentido, a presente dissertação de mestrado inclui dois estudos, ambos baseados na realização de um inquérito aos estudantes de ensino superior e nas respetivas respostas aos questionários utilizados, os quais abrangeram vários aspetos relacionados com a PE. O primeiro examinou as perceções de PE dos estudantes universitários de Montevidéu, Lisboa, e Pádua, considerando os estudantes locais e de intercâmbio, enquanto o segundo centrou-se nos estudantes, locais e deslocados, do ensino superior de Portugal Continental, explorando a sua vulnerabilidade à PE em quatro das suas regiões.

Ambos os estudos revelaram como a diversidade de origens, as condições de habitação e as disparidades regionais podem influenciar as perceções, experiências e vulnerabilidade dos estudantes do ensino superior à PE. A primeira investigação associou a vulnerabilidade à PE a problemas de alojamento, nomeadamente, evidentes durante o inverno em Lisboa e em Montevidéu, em contraste com as condições de alojamento mais satisfatórias em Pádua. Segundo as conclusões dos dois estudos, há uma necessidade urgente de abordar a PE junto com a população estudantil portuguesa de ensino superior. Além disso, a segunda investigação revelou os desafios substanciais enfrentados por esta população, em especial, por parte dos estudantes deslocados e dos que vivem no setor privado de arrendamento.

Desta forma, os decisores políticos e as instituições devem ter em conta este conhecimento para atribuir recursos de forma eficaz e implementar intervenções dirigidas a esta população. Estes esforços podem melhorar as condições de vida dos estudantes, aumentar a consciencialização sobre a PE e garantir que a PE não impede indevidamente as suas atividades educativas.

Palavras chave: Pobreza Energética, Ensino Superior, Estudantes, Habitação, Inquérito

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ABBREVIATIONS

- AC – Air Conditioner
- AML - Lisbon Metropolitan Area (*Área Metropolitana de Lisboa*)
- CEPI - Composite Energy Poverty Index
- DS – Displaced Students
- ENLPCPE - Portuguese National Strategy to Combat Energy Poverty (*Estratégia Nacional de Longo Prazo para o Combate à Pobreza Energética*)
- EP – Energy Poverty
- EPAH - Energy Poverty Advisory Hub
- ES – Exchange Students
- EU – European Union
- GDP – Gross Domestic Product
- INE - Statistics Portugal (*Instituto Nacional de Estatística*)
- IPEM - Multidimensional Indicator of Energy Poverty (*Indicador Multidimensional de Pobreza Energética*)
- LIHC - Low Income High Costs
- LS – Local Students
- NUTS - Nomenclature of Territorial Units for Statistics
- PNAES - National Plan for Higher Education Accommodation (*Plano Nacional para o Alojamento no Ensino Superior*)
- PNIEC - Integrated National and Climate Plan
- PRS – Private Rental Sector
- SILC – Statistics on Income and Living Conditions
- WAEPI - Weighted Average Energy Poverty Index

1.
GENERAL INTRODUCTION

Energy Poverty (EP) is a pressing societal issue defined by the inability of individuals or households to affordably secure adequate heating, cooling, and other essential energy services in their homes (European Commission, 2022a). EP is influenced by various factors, including income, energy prices, energy efficiency, housing quality, climatic conditions, and the age group of individuals (Pye *et al*., 2015; European Commission, 2022a). In Europe, the recent surge in energy prices, driven by global events, has intensified the problem, particularly for vulnerable groups (European Commission, 2022b).

Measuring EP is challenging, as it is a private problem that varies in time and space and is culturally dependent (Bouzarovski, 2013), and complex, as it involves both objective data, like energy consumption and income, and subjective judgments of thermal comfort, which capture the lived experiences of households (European Commission, 2022c). It encompasses multiple dimensions, including the ability to maintain a comfortable indoor temperature, the presence of housing problems like leaks and dampness, energy prices, and energy expenditures (Gouveia *et al*., 2022).

Certain groups, such as people with disabilities, migrants, children, and the elderly, are recognized as more vulnerable to EP due to various factors (Pye *et al*., 2015). However, students are another potentially vulnerable group often overlooked by policymakers (Morris and Genovese, 2018). While students themselves may not always perceive their situation as energy poor (Morris and Genovese, 2018), they face risks of falling into EP due to factors like limited budgets, high energy costs, and a lack of awareness about energy efficiency (Healy, 2003).

Higher education students represent a unique demographic within the EP discussion, particularly those living in the Private Rental Sector (PRS) (*e.g.*, Kousis *et al*., 2020). The PRS, characterized by varying housing quality and stability, poses EP-related challenges (Clair *et al*., 2019). Displaced students, who heavily depend on the PRS, may be considered a particularly vulnerable group. Their living conditions are increasingly precarious due to rising property market pressures in Portugal (Portuguese Republic, 2023a). The EP situation in Portugal might be considered problematic compared to other EU countries, one of the main causes being the prevalence of old and inadequately prepared buildings with low thermal performance (Palma *et al*. 2019), which makes it relevant to study its specific situation in detail. For example, in 2022, 17.5% of the Portuguese population could not afford to keep their home adequately warm, the 4th worst in the EU (Eurostat, 2023a), and in 2020, the share of the population with a leak, damp, or rot in their dwelling was 25.2% (the 3rd worst in the EU) (Eurostat, 2023b). To reduce EP and promote decarbonization, the draft version of the Portuguese National Strategy to Combat Energy Poverty (ENLPCPE) sets four main objectives: improved

energy performance of households, access to more energy services, reduced energy costs, and increased energy literacy (Portuguese Republic, 2023b).

Additionally, in particular studies, regional differences have been important factors when analyzing the EP situation among students. For instance, Kousis *et al*. (2020) conducted a comprehensive study involving students across various countries, including Bulgaria, Cyprus, Greece, Lithuania, Romania, the UK, and Ireland. Nazarahari *et al*. (2021) conducted a comparative analysis between Japanese and non-Japanese college students. Despite some studies exploring students' vulnerability to EP (Morris and Genovese, 2018; Kousis *et al*., 2020; Fong and Kimberley Clare, 2021; Nazarahari *et al*., 2021; Mamica *et al*., 2021), there is a clear research gap in understanding how the EP situation may differ between local and displaced students and how this interacts with the season of the year.

Therefore, through a comparative analysis, the aim is to investigate the aspects of EP experienced by local and displaced students in Montevideo, Padua, and Portugal during the winter and summer. To this end, the present master's dissertation is divided into two chapters, one for each study conducted, both based on a survey of higher education students and their responses to the questionnaires, which covered various aspects of PE.

The first study[1] aims to address this research gap by examining students' EP perceptions in Montevideo (capital of Uruguay), Lisbon (capital of Portugal), and Padua (city of northern Italy), considering both local and exchange students and how their experiences vary in different seasons (winter and summer). The number of exchange students has been rising in recent years; for instance, between 2014 and 2020, the number of students participating in the Erasmus+ programme increased every year apart from 2019 to 2020 (European Commission, 2021), which makes it easy and relevant to investigate how this factor impacts students' perceptions of EP.

The second study[2] focuses on displaced and local higher education students in mainland Portugal, examining their vulnerability to EP across five regions and during different seasons (winter and summer). It investigates common challenges and impacts related to unstable PRS housing conditions and potential drivers of EP vulnerability.

Both studies contribute to the broader understanding of EP among higher education students, shedding light on how their backgrounds, housing conditions, and regional differences influence their perceptions and experiences of EP and their vulnerability to EP.

[1]Chapter 2: Students' perception of energy poverty—A comparative analysis between local and exchange university students from Montevideo, Lisbon, and Padua (published in *Frontiers in Sustainable Cities**)

[2]Chapter 3: Energy Poverty among higher education students: a study of local and displaced students in Portugal (to be submitted)

*Castro, C. C., & Gouveia, J. P. (2023). Students' perception of energy poverty—A comparative analysis between local and exchange university students from Montevideo, Lisbon, and Padua. *Frontiers in Sustainable Cities*, 5. https://doi.org/10.3389/frsc.2023.1114540

2.

STUDENT'S PERCEPTION OF ENERGY POVERTY- A COMPARATIVE ANALYSIS BETWEEN LOCAL AND EXCHANGE UNIVERSITY STUDENTS FROM MONTEVIDEO, LISBON, AND PADUA

ABSTRACT

Energy Poverty (EP) is a growing concern in EU and national policies. Limited research has been conducted on students' perception of EP and vulnerability to EP, especially on how this may be modified if the student is a local or an exchange university student and how this interacts with the season (i.e., summer, winter). Therefore, the present research aims to deepen this understanding by analyzing and comparing students' perceptions of EP and exploring their vulnerability to EP, considering their background and the city they live in, using Montevideo in Uruguay, Lisbon in Portugal, and Padua in Italy, as case studies. To achieve these aims, two populations of university students in each city were surveyed: one of Local Students (LS) and another of Exchange Students (ES). Responses from 295 students to an online survey with forty-four questions covering several aspects of EP and energy awareness, such as energy consumption habits, vulnerability drivers, energy equipment, and lived experience in maintaining comfortable internal temperatures, were collected in 2022. Differences between the perception of LS and ES in each city were analyzed, as well as differences in students' perceptions among cities. Although it is difficult to generalize, comfort levels seem to vary according to location, type of students, and season, but according to the results, there seems to be an interaction between these three factors. According to this research, most students did not identify themselves as living in EP, but several populations perceived discomfort in both winter and summer, showing their vulnerability to EP.

KEYWORDS

Energy Poverty, University Students, Perception, Lived Experience, Survey

2.1. Introduction

Energy Poverty (EP) is acknowledged as a set of conditions where "individuals or households are not able to adequately heat/cool or provide other required energy services in their homes at affordable cost" (European Commission, 2022a). According to European Commission (2022a), the context, such as climatic conditions, quality of dwelling, health condition, and age group of individuals, are factors of vulnerability to EP. The most important drivers of EP arise from a combination of low-income, high-energy prices, and low levels of energy efficiency (e.g., Pye *et al*., 2015). In 2022, there has been an increase in energy prices in Europe, caused by the war in Ukraine, which is having a negative impact on households, especially, on the energy poor (European Commission, 2022b). To mitigate this impact and to assure European independence from Russian fossil fuels before 2030, the European Commission approved the REPowerEU plan, based on diversifying gas supplies and boosting energy efficiency (European Commission, 2022b).

In data released by Eurostat (2022a), according to an EU-wide survey, in 2021, 6.9% of the EU27 population stated that they were unable to keep their home adequately warm. However, measuring EP is a challenging task, as it is a private problem that varies in time and space and is culturally dependent (Bouzarovski, 2013). Considering the analysis explored, e.g., by Gouveia *et al*. (2022) and Palma and Gouveia (2022) the data collected by the European Union Statistics on Income and Living Conditions (EU-SILC), EP should be measured using multiple indicators, portraying the multiple dimensions of the problem, such as the "Share of population not able to keep their home adequately warm", the "Share of population with leaks, damp or rot in their dwelling", "Energy Prices" or "Energy Expenditures".

It is also widely recognized that some groups are more vulnerable to EP than others, such as people with disabilities, migrants, children, and the elderly (Pye *et al*., 2015). However, some studies (e.g., Healy *et al*., 2003) report that the group of students also has a high risk of falling into EP due to several factors, such as lack of knowledge of energy efficiency measures, tight budgets, or high energy expenditures. According to Morris and Genovese (2018), this group is often not directly targeted by policy makers and has not been much considered a vulnerable group. These authors justify this consideration by the observation that students themselves do not assume that they live in EP.

In 2020, there were 18 million tertiary education (provided by universities and other tertiary educational institutions) students, and there were 1.46 million students from abroad who were undertaking tertiary level studies across the EU (Eurostat, 2022b), but limited research has been conducted on students' perception of EP and vulnerability to EP. In the United Kingdom (UK), Morris and Genovese (2018) explored how students perceive the phenomenon and how they take energy efficiency and fuel poverty into account in their (private sector) accommodation choices. Kousis *et al*. (2020) collected and analyzed data from students living in the private-rented sector from Bulgaria, Cyprus, Greece, Lithuania, Romania, the UK, and Ireland, focusing on the impact of the characteristics of students' houses on their energy bills, thermal comfort, and wellbeing. In the study of Mamica *et al*. (2021), the objective was to define the factors influencing the level of EP among Polish students, considering the changes in their attitudes and behavior resulting from the introduction of distance learning during the COVID-19 pandemic. Nazarahari *et al*. (2021) compared the attitudes of Japanese and non-Japanese college students, who lived in private or shared accommodations, towards energy usage and the impact of the high cost of energy on their use and saving practices. In all these studies, EP was recognized as a problem in this population: it was identified as an underlying

fuel poverty problem, particularly with regard to students living in privately-rented, off-campus properties (Morris and Genovese, 2018); students were exposed to fuel poverty, either due to external determinants and/or through their own decision-making (Kousis *et al*., 2020); students who experienced inappropriate temperature due to excessive costs had to move out of their homes more often (Mamica *et al*., 2021); students in Japan may be considered as vulnerable to EP in addition to the other categories of vulnerable households (Nazarahari *et al*., 2021).

Although there are a few studies that compare students' perceptions from various countries to EP, to our knowledge, in Europe and South America, there is no study investigating how the perception about EP may be modified if the student is a local or an exchange student, and how this interacts with the season of the year (winter or summer).

This is the research gap this study aims to cover. The target population herein considered is the university student community from three diverse study sites, with different geographical, social, and buildings related context: Montevideo (capital of Uruguay), Lisbon (capital of Portugal), and Padua (city of northern Italy). In order to evaluate the importance of the student's profile (local or exchange), two student populations for each city were surveyed in terms of their perception of EP: one who lived in the city (LS- Local Students) and another who entails foreign students living in that city (ES- Exchange Students). The number of ES has been increasing in recent years, for instance, between 2014 and 2020, the number of participants in the Erasmus+ program increased every year except from 2019 to 2020 (European Commission, 2021), making it easier to investigate how this factor affects the perception of students of EP.

The primary objective of the present research is to analyze the perspective of students from different origins (LS and ES) regarding their EP lived experience reading energy issues in their hometown and/or the city where they studied in the winter and summer seasons. More specifically, this study aims to answer the following research questions. What is the students' concept of EP, and how concerned are they about this problem? What did they consider most important when they were house hunting? What has been their lived experience in maintaining comfortable indoor household temperatures? Why did (or did not) they save energy, and what actions did they take? What were the conditions of the houses, and what impact did they have on students? What solutions and policy measures do they suggest to minimize the problem of EP?

We have analyzed the answers to these questions in relation to the following factors: case study city, type of student, and season of the year. Therefore, our approach is to look deeper into the group of university students, finding common threats, strategies, and impacts; while driving the discussion on EP, as EP discussions increasingly emerge across European countries.

2.2. **Methodology**

As aforementioned, we applied a case study-based approach exploring the dynamics of EP of university students in three different countries to capture grounded evidence of their vulnerability. The methodology is organized into four subsections allowing for a clear understanding of the case studies and methodological process. The first presents and describes the case study sites in terms of energy and EP indicators contextualizing the problem; the second describes the climate variables of each study site, an important factor of energy needs and consumption patterns in households; the third explains the methodology that was adopted for the survey developed, and the last focuses on the data analysis procedures.

2.2.1. Case Studies and Energy Poverty

The map of Figure 2.1 shows the study sites of the present research: Montevideo (Uruguay), Lisbon (Portugal), and Padua (Italy); two European cities and one Latin American city, unfolding diverse e.g., geography, students' population, climate, policy, economic, energy markets, buildings energy efficiency and consumption patterns. Regarding the number of university students enrolled in each city, in Montevideo, there were 175,674 students in 2018, assuming that 85.3% of national entries were in the capital (Ministerio de Educación y Cultura, 2018), in Lisbon, there were 117,083 students in 2021 (Direção-Geral de Estatísticas da Educação e Ciência, 2021), and in Padova, there were 46,945 students in 2017 (I.Stat, 2023).

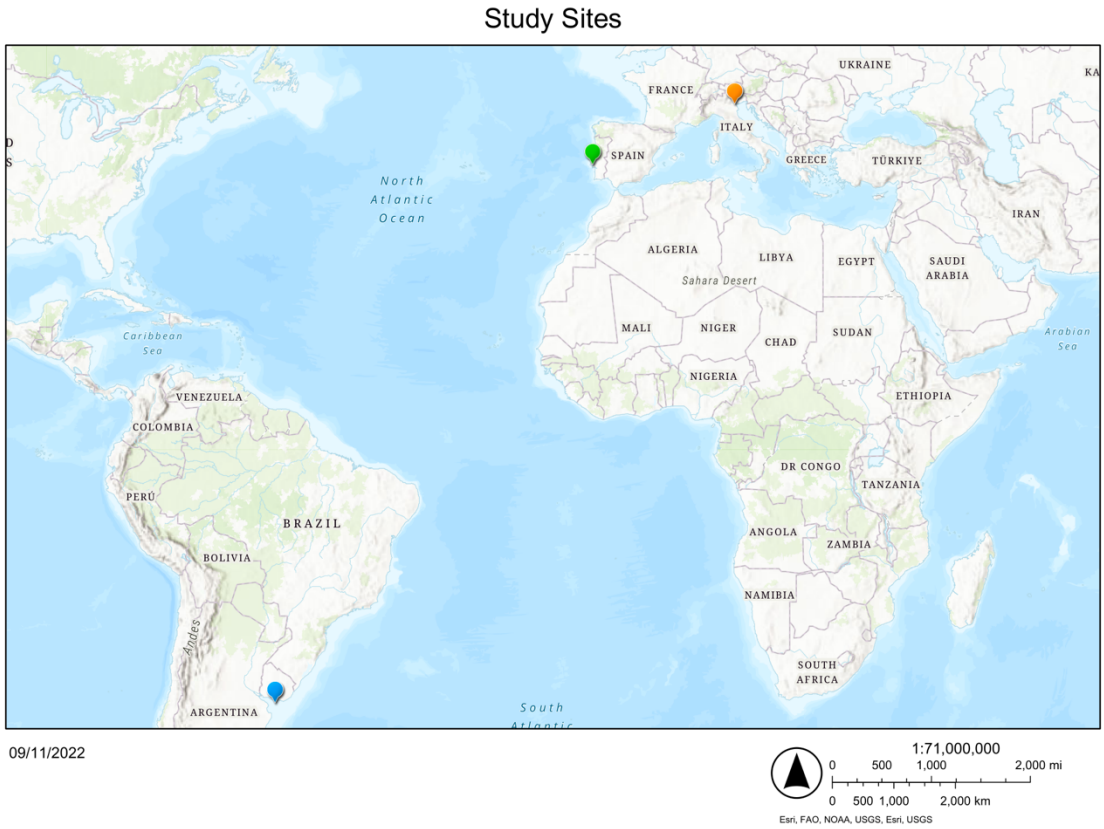

Figure 2.1- Representation of the study sites: Montevideo (capital of Uruguay) is represented in blue; Lisbon (capital of Portugal) in green; Padua (city in northern Italy) in orange.

However, these three cities also share common features. According to the World Energy Council (2021), the Energy Trilema Index (performance of a country based on three axes – energy security, energy equity, and environmental sustainability), Uruguay, Portugal, and Italy have similar rank values, respectively, 13, 14 and 15 in a total of 101 rank values. In relation to EP, in 2021, Portugal is listed as the fifth country, and Italy is the eighth country in the EU where people can least afford to keep their homes adequately heated, with around 16.4% of Portuguese people and 8.1% of Italian people (EPAH, 2022) experiencing this winter dimension of EP. On the contrary, Uruguay seems to have better EP indicators than other Latin American countries, as in Uruguayan homes, the biggest proportion of households' budgets is used for energy compared to the homes of other countries (Margulis, 2017; Guzowski *et al.*, 2021).

Pereira *et al*. (2021) provide a standardized and cross-country comparable analysis of multidimensional EP in four South American countries, including Uruguay, between 2000 and 2016. In this study, accessibility, availability, and affordability have been considered as drivers of EP and were measured by calculating the Weighted Average Energy Poverty Index (WAEPI) and the Composite Energy Poverty Index (CEPI). According to Pereira *et al*. (2021), Uruguay showed one of the best and most consistent performances, having achieved important improvements in energy accessibility and energy availability indicators. Besides that, the country has invested in the energy sector to accelerate renewable energy penetration, reducing its dependence on fossil fuels and mitigating the impact of multidimensional EP (Pereira *et al*., 2021). Fernández (2021) studied EP in Uruguay, from 2005/06 to 2016/17, using a multidimensional indicator of energy poverty (IPEM), a composite index that refers to the effective access to affordable and equitable energy services by the population (electrical energy services, energy services for food and hygiene, sanitary water heating and space heating) and to household expenditure in energy services. The main findings showed that EP was a reality for 26.4% of the households in 2016/17 and that 48% of households that experienced EP did not perceive themselves as poor (Fernández, 2021). Moreover, Banco Interamericano de Desarrollo (2023) analyzed EP in five different Latin American countries including Uruguay, considering it from the perspective of access to basic energy services: lighting, food preparation, food refrigeration, entertainment, knowledge and communication, water heating, and thermal comfort. It was observed that, in 2019, thermal comfort and knowledge and communication were those to which households had the least access in Uruguay (Banco Interamericano de Desarrollo, 2023). In 2019, while 66% of households in the country did not have access to at least one of the energy services (EP), only 2% of these households did not have access to more than half of the services they needed (severe EP), where 88% of households in severe EP were in the lowest income half of the population (Banco Interamericano de Desarrollo, 2023).

Using the EU Energy Poverty Advisory Hub (EPAH, 2022) EP indicators dashboard, we can see that Portugal had the second-highest percentage of the population living in homes with a leaking roof, damp walls, floors or foundation, or rot in window frames or floor in the EU (25.2%) with 19.8% of the population being at risk of poverty or social exclusion. Additionally, around 70% of the energy-certified residential building stock is energy-inefficient (Agência para a Energia, 2022). Besides that, between 2019 and 2021, Portugal was the country with the most significant increase in the indicator of "Arrears on utility bills" in the EU (Gouveia *et al*., 2022). Gouveia *et al*. (2019) calculated and mapped all 3092 Portuguese civil parishes to energy poverty vulnerability, for both winter and summer seasons, highlighting important hotspots of vulnerability, coupled later with interviews for capturing the lived experience of a sample of 100 households in highly vulnerable regions (see Horta *et al*., 2019). According to the draft version of the Portuguese Energy Poverty Mitigation Strategy, 1.8 to 3 million Portuguese might be suffering from energy poverty, though at different intensity levels (Portuguese Republic, 2023).

Derived from the Low Income High Costs (LIHC) approach, in the Integrated National and Climate Plan (PNIEC) (Italian Government, 2019), the Italian Government considered the LIHC-PNIEC index from Faiella and Lavecchia (2015). This index is based on expenditure data and it includes vulnerable families, with an equivalent expenditure below the median and with no heating expenditure (the ''hidden energy poor households''). According to this official measure, in 2016, there were 8.6% of energy-poor households in Italy (Faiella and Lavecchia, 2021). This value was higher (11.7%) in 2014–16, according to the new measure of

EP introduced by Faiella and Lavecchia (2021), which is independent of household preferences, being derived from the heating expenses needed to achieve a minimum level of comfort. The situation of hidden energy poverty was further explored in Italy by Betto *et al*. (2020). This information can be further complemented by assessing the EU-SILC and other EP-related indicators depicted in EPAH (2022). For example, 13.6% of households had in 2015 an absolute energy expenditure below half the national medium (i.e., abnormally low); and 25.8% of the Italian population was in 2020 at risk of poverty or social exclusion.

2.2.2. Climate characterization of the Case Study Sites

As the three study sites have different climatic contexts which can affect the thermal comfort of their inhabitants, it was considered important to take it into account to better understand EP vulnerability and energy use patterns, derived from their climate situation. Table 2.1 presents the weather description of each study site based on two variables: Average Hourly Maximum and Minimum Temperatures for winter and summer (data from Weather Spark, 2022). Considering these variables, there is a similarity between the climate situation of Montevideo and Lisbon. Indeed, Montevideo, being 9,520 kilometers away, is the further-away foreign place with temperatures most similar to Lisbon (Weather Spark, 2022). On the contrary, Padua has lower temperatures in winter (both maximum and minimum) and a slightly larger temperature range in summer than the other two cities.

Table 2.1- Weather description of each study site, based on two variables (Average Hourly Maximum Temperature and Average Hourly Minimum Temperature) for winter and summer, according to Weather Spark (2022).

Season	**Variable**	**Study Sites**		
		Montevideo	**Lisbon**	**Padua**
Winter	Average Hourly Maximum Temperature (°C)	15.75	15.75	8.25
	Average Hourly Minimum Temperature (°C)	8	9.25	0.5
Summer	Average Hourly Maximum Temperature (°C)	25.75	27	28.25
	Average Hourly Minimum Temperature (°C)	17.75	17.75	17.25

2.2.3. Survey

Based on student-based surveys and/or EP literature (e.g., Morris and Genovese, 2018; Kousis *et al*., 2020; Mamica *et al*., 2021; Nazarahari *et al*., 2021), one online survey in English and another equivalent in Spanish were created (see appendix B). These surveys were opened for responses between March and June of 2022. The online links to the surveys were disseminated across several digital platforms of the student communities (local and exchange) in the three cities, such as social media, international student networks, and by sharing from teachers. Since the two surveys were equivalent, from now on the paper, the "survey" will be considered a unique survey. The survey had forty-four questions and eleven sections. For the three cities, we received a total number of 299 responses to the survey, of which 295 were considered valid for analyzing the results (the other four were not students). The authors recognize that the sample is not representative of the number of university students per city, but

the focus was getting the perceptions, behaviors and attitudes of the university student populations surveyed, which are relevant to understand these potentially vulnerable groups and their lived experience.

The survey questions were designed to characterize each population of students and to describe their energy consumption habits, energy-related equipment, perception of EP, and their lived experience in maintaining comfortable internal temperatures. All the questions were compulsory to complete a valid survey, except for an optional open-response format question on what solutions (individual and/or collective) and policy measures the students used/suggested to minimize the problem.

2.2.4. Data analysis

Initially, the responses in English and Spanish were unified into English terms and merged into a single Excel data sheet to enable consolidated analysis and comparison of responses. Afterward, the answers of the following six populations were analyzed: Montevideo ES, Montevideo LS, Lisbon ES, Lisbon LS, Padua ES, and Padua LS. Most of the analysis of the results consisted of summarizing the information in graphs and tables of these data, apart from the data related to the house hunting choices, the students' perception of thermal comfort, and the suggestion of solutions/policies, where additional analyses were done.

The structure of the responses to the house hunting choices was related to the location factor (fixed factor, three levels - Montevideo, Lisbon, and Padua) and the factor type of student (fixed factor, two levels – ES and LS) by PERMANOVA (Anderson, 2001), considering each survey as an independent replicate. The dependent variables considered were the answers to the questions "Cost of rent", "Age of the house", "General aesthetics of the house", "Size", "Location and convenience", "Neighborhood safety", "Appearance of the area", "Light and sun exposure", "Heating/cooling equipment available", "Efficiency measures", and "Opinions of the resident(s)" (which were also used in other studies, such as in Kousis *et al*. (2020) and Morris and Genovese (2018)). Each of the responses to these variables was transformed into a value on an importance scale (1- Very important; 2- Important; 3- Moderately important; 4- Not important; 5- Not at all important). The sample size varied from 23 (Padua LS) to 103 (Lisbon LS). As factor location was significant (see Results), pair-wise tests were used to detect the pattern of differences among sites. The homogeneity of the multivariate dispersions based on the Bray-Curtis similarity was tested by the PERMDISP routine applied to the factor location and the factor type of student (Anderson, 2006). The SIMPER procedure (Clarke, 1993) was used to identify which variables (housing decisions) contributed most to the average differences among locations and between both types of students after calculating the average value for each variable and each combination of location and type of student. The variables that explained most of the differences (>70% of cumulative dissimilarity) were selected. All analyses were based on Bray-Curtis similarity of untransformed data and on unrestricted permutations of raw data, Type III sums of squares and 999 permutations (see Anderson *et al*., 2008). All analyses were performed using PRIMER 7 (Clarke and Gorley, 2015) with the PERMANOVA + add-on (Anderson *et al*., 2008).

Regarding students' perception of thermal comfort, we have also used two terms: Discomfort (if the students were uncomfortable) and Comfort (if the students were comfortable). In winter, Discomfort corresponds to "Colder than I would like", while in summer, it corresponds to "Warmer than I would like". For both seasons, being comfortable in the household corresponds to the answer "About right".

Finally, the answers (in open response format) to the question "What solutions (individual and/or collective) and policies do you use/suggest to minimize the problem?" were organized into nine different categories: “Public policies”; “Public/Private building measures”; “Public/Private reduction/efficiency”; “Renewable energy policies”; “Science investment”; “Environmental education”; “Individual reduction/efficiency”; “Individual strategies”; “Protest”. In this regard, the students who presented solutions/policies for each category and for each population were counted. Since only 30% of all students answered this question, the answers from all populations were merged, and the percentage of the solutions/policies for each category was calculated.

2.3. **Results**

The results are divided into ten subsections to allow for a better understanding of different drivers, recognizing the full depth and extent of the energy poverty problem in this sample of university students. The first four deal with the general characterization of each population: sample characterization, students’ house-hunting choices, and accommodation’s general description, satisfaction, and energy expenses. Then, the following four subsections focus on thermal comfort during winter and summer (student’s perception, accommodation specifications, and energy costs challenges), energy-saving actions, and housing conditions and impacts. Finally, the last two subsections explore students' concept of EP, their level of concern about the problem, and the solutions and policies they suggested to minimise EP.

2.3.1. Sample characterization

The samples of the present study are characterized in Table 2.2 by size and general description of respondents (gender identity, age, field of study, employment status and having social support/scholarship). The sample size ranges from 18 (ES, Montevideo) to 103 (LS, Lisbon). Most of the respondents were women, except for LS Padua (48% women, 48% men, 4% Other). Most of the students who responded were aged 18-24, with the exception of ES students from Lisbon who were over 25. Most students from Padua and LS from Lisbon were not employed, while the same was not true for Montevideo students and ES students from Lisbon. Finally, the majority of ES students had a social support/scholarship, while LS students did not.

Table 2.2- Characterization of the survey sample: sample size, and general description of respondents (current gender identity, age, field of study (2 most common), employment status (2 most common) and possession of social support/scholarship (A/E/T- Architecture/Engineering/Technology)).

	Montevideo ES	**Montevideo LS**	**Lisbon ES**	**Lisbon LS**	**Padua ES**	**Padua LS**
Sample size	18	51	39	103	61	23
Current gender identity	Woman (67%); Man (17%); Other (16%)	Woman (57%); Man (43%); Other (0%)	Woman (59%); Man (41%); Other (0%)	Woman (60%); Man (37%); Other (3%)	Woman (77%); Man (23%); Other (0%)	Woman (48%); Man (48%); Other (4%)
Age	18-24 (85%); 25+(5%)	18-24 (68%); 25+ (32%)	18-24 (39%); 25+ (61%)	18-24 (68%); 25+ (32%)	18-24 (85%); 25+ (15%)	18-24 (91%); 25+ (9%)
Field of study	A/E/T (44%); Social sciences (33%)	A/E/T (61%); Social sciences (18%)	A/E/T (39%); Social sciences (39%)	A/E/T (69%); Natural sciences/ Math (15%)	A/E/T (43%); Social sciences (25%)	A/E/T (57%); Natural sciences/ Math (30%)

Employment status	Not employed (39%); Seasonal Employment (28%)	Not employed (39%); Full-time (28%)	Not employed (41%); Part-time (28%)	Not employed (57%); Full-time (14%)	Not employed (66%); Part-time (20%)	Not employed (61%); Part-time (13%)
Possession of social support/scholarship	61%	20%	51%	17%	84%	9%

2.3.2. House hunting choices

The structure of the responses to the house-hunting choices was significantly different among locations and type of students (Table 2.3). Most of the differences between the two types of students were explained by the LS giving more importance to several housing decisions than the ES, namely "Age of the house", "Presence of Energy Efficiency Measures", "Light and sun exposure", "General Aesthetics of the house" and "Size" (Table 2.3). Pair-wise test to factor location indicated that all locations differed (Table 2.3). Students from Lisbon gave more importance to several housing decisions (Table 2.3). Indeed, only one housing decision, "Available heating and/or cooling equipment", was considered more important by Padua students than by Lisbon students. When comparing students from Montevideo and Padua, some housing decisions were considered more important by Montevideo students ("General Aesthetics of the house", "Light and Sun exposure"), while others were considered more important by Padua students ("Available heating and/or cooling equipment", "Opinions of the Housemate(s)", "Presence of Energy Efficiency Measures").

Table 2.3- a) PERMANOVA analysis of factors Location (Montevideo, Lisbon, and Padua) and Type of student (Local (LS) and Exchange (ES) students) on the answers to questions about house hunting choices. PERMDISP test to factor Location: F= 0.4473; p= 0.672. PERMDISP test to factor Type of student: F= 2.6431; p= 0.132. Bold – significant p-values (p≤0.05). b) Pair-wise tests to factor in Location. c) Simper results show the variables that explained the large majority of the differences (>70% of cumulative dissimilarity).

a) PERMANOVA				
Effect	*df*	MS	Pseudo-*F*	*p*-value
Location	2	1325.20	5.2634	**0.001**
Type of student	1	854.32	3.3931	**0.015**
Location x Type of student	2	232.69	0.9242	0.500
Res	252	251.78		
b) Pair-wise tests to factor location				
Comparison:	*P* (perm)			
Lisbon *versus* Montevideo	**0.007**			
Lisbon *versus* Padua	**0.001**			
Montevideo *versus* Padua	**0.013**			
c) Simper analysis				
Factor	Variables that explained >70% of cumulative dissimilarity			
Location:				
Lisbon *versus* Montevideo	All variables reached a higher value of importance for Lisbon than for Montevideo (variables in decreasing order of importance, explained 79%): Presence of Energy Efficiency Measures; Cost of Rent; Available heating and/or cooling equipment; Opinions of the Housemate(s); Age of the House; Light and Sun exposure			
Lisbon *versus* Padua	All variables reached a higher value of importance for Lisbon than for Padua except for "Available heating and/or cooling equipment" (variables in decreasing			

	order of importance, explained 79%): Light and Sun exposure; Age of the House; Available heating and/or cooling equipment; General Aesthetics of the house; Size; Cost of Rent.
Montevideo *versus* Padua	The variables that contributed the most (74%, in descending order) are: Available heating and/or cooling equipment (more important in Padua); Opinions of the Housemate(s) (more important in Padua); General Aesthetics of the house (more important in Montevideo); Presence of Energy Efficiency Measures (more important in Padua); Light and Sun exposure (more important in Montevideo).
Type of student: LS *versus* ES	All variables reached a higher value of importance for LS than for ES (variables in decreasing order of importance, explained 78%): Age of house, Presence of Energy Efficiency Measures, Light and sun exposure, General Aesthetics of the house, Size.

PERMDISP test to factor Location: $F = 0.4473$; $p = 0.672$. PERMDISP test to factor Type of student: $F = 2.6431$; $p = 0.132$. Bold—significant p-values ($p \leq 0.05$).

2.3.3. General description of accommodation and satisfaction with accommodation

Table 2.4 shows a general description of students' accommodation in terms of cost of rent, type of house, and satisfaction with accommodation for each population. As expected, most of the LS from all populations did not spend money with the accommodation (Table 2.4). Of all ES, those in Lisbon seem to have spent more money on accommodation (Table 2.4). Although "Privately rented house/flat DFO" was common for all the ES in all cities, the solution "Lived in a dormitory provided by the RU" was more common in Padua, but this was not the case in the other cities (Table 2.4). In addition, most students were satisfied with their accommodation, but the percentage of satisfaction was generally higher in Padua, and the lowest was for ES students in Lisbon (Table 2.4).

Table 2.4- General description of accommodation (2 most common costs and types of housing) and satisfaction with accommodation for each population (DFO- directly from the owner; F&F- living in a place that belongs to my family or friends; LA- letting agent; HA- housing agency; RU- receiving University).

	Montevideo ES	**Montevideo LS**	**Lisbon ES**	**Lisbon LS**	**Padua ES**	**Padua LS**
Cost of rent	300€ to 399€ (33%); 200€ to 299€ (28%)	Nothing (55%); 200€ to 299€ (12%); 400€ to 499€ (12%)	300€ to 399€ (28%); 400€ to 499€ (21%); Nothing (21%)	Nothing (68%); 200€ to 299€ (10%)	200€ to 299€ (36%); 300€ to 399€ (25%)	Nothing (57%); 200€ to 299€ (26%)
Type of housing	Privately rented house/flat DFO (56%); Rented room DFO (4%)	F&F (51%); Privately rented house/flat from a LA (22%)	Privately rented house/flat DFO (26%); Rented room through a HA (21%)	F&F (68%); Living in a place I own (11%)	Lived in a dormitory provided by the RU (30%); Privately rented house/flat from a LA (23%)	F&F (52%); Rented room DFO (26%)
Satisfied/ very satisfied	78%	86%	67%	82%	82%	91%

2.3.4. Energy Expenditures

In the case of the ES in Montevideo and Padua, they did not pay the household (energy-related) bills as they were included in the rent. In contrast, in Lisbon, there were more similar percentages between students who paid (49%) and did not pay (51%). In the case of the LS, most students in Montevideo (67%) paid the bills, while the other populations did not (Lisbon- 61%; Padua- 57%). In addition, 20% of respondents from all populations were unable to pay their bills due to a lack of money.

2.3.5. Thermal Comfort during winter: student's perception, accommodation specifications, and energy costs challenges

The level of thermal comfort during winter, perceived by students in Montevideo, Lisbon, and Padua, is shown in Figure 2.2. In Montevideo, 53% of the ES considered themselves uncomfortable, while 51% of the LS were comfortable (Figure 2.2). In the case of Lisbon, both ES (77%) and LS (66%) were uncomfortable, and, in contrast, both ES (48%) and LS (52%) in Padua were comfortable (Figure 2.2).

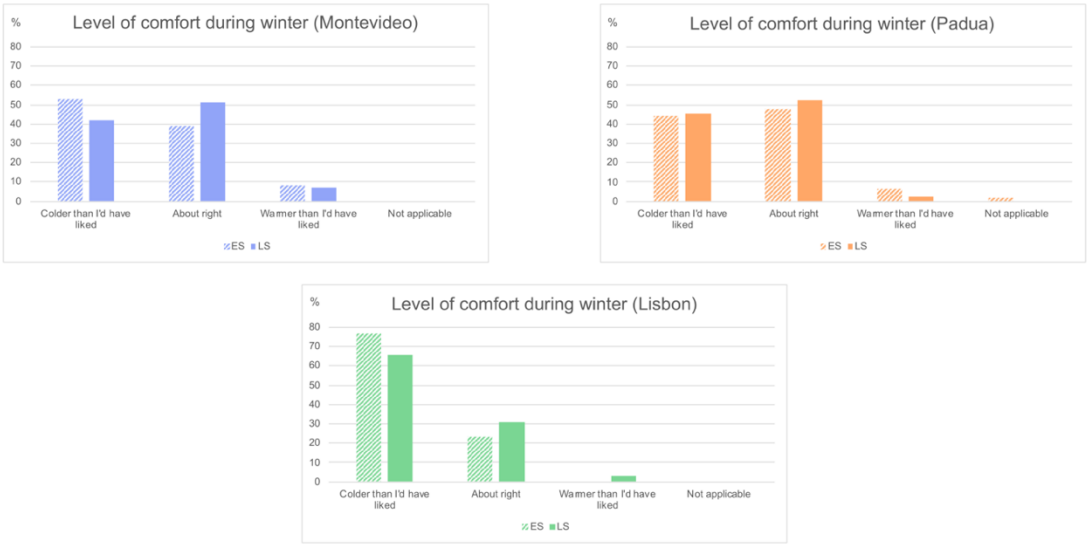

Figure 2.2- Perception of energy comfort during winter of ES and LS of Montevideo, Lisbon, and Padua.

To better understand the thermal comfort of each population during winter, it was considered the heating device(s) present in students' accommodations. It can be analyzed a pattern for each study site (both ES and LS), where the most common device was "air conditioner" for Montevideo, "electric heater" for Lisbon, and central heating system ("CH building (adjustable in each room)") for Padua (from Figure B.0.1 to Figure B.0.6). Moreover, it should be noted that "fireplace" corresponded to 20% of the LS of Montevideo and Lisbon answers, which was present in a small percentage of the other populations.

To relate energy cost challenges to thermal comfort during winter, respondents were asked whether or not they reduced energy use because they were concerned about costs. Figure 2.3 shows that around 61% of LS in Lisbon and Padua made this reduction (primarily by putting the heating off or down, respectively), and also about 47% of Montevideo LS and Lisbon ES.

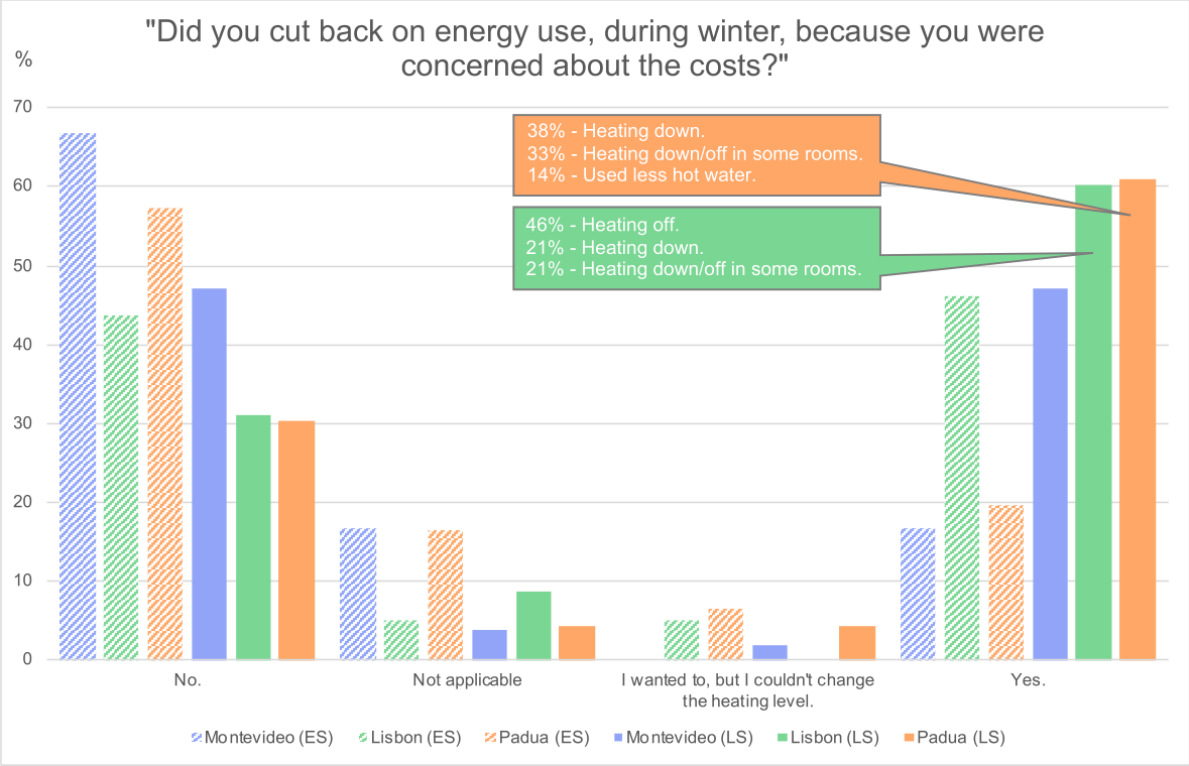

Figure 2.3- Energy costs challenges for each population during winter.

2.3.6. Thermal Comfort during summer: student's perception, accommodation specifications and energy costs challenges

In Lisbon, 51% of the ES considered themselves comfortable, while 54% of the LS were uncomfortable (Figure 2.4). In the case of Montevideo, both ES (50%) and LS (53%) were comfortable, and, on the contrary, in Padua, both ES (28%) and LS (52%) were uncomfortable (Figure 2.4). However, the Padua ES, when responding to the survey, had not yet experienced summer, so most of their responses were not applicable and, thus, probably not representative of the population.

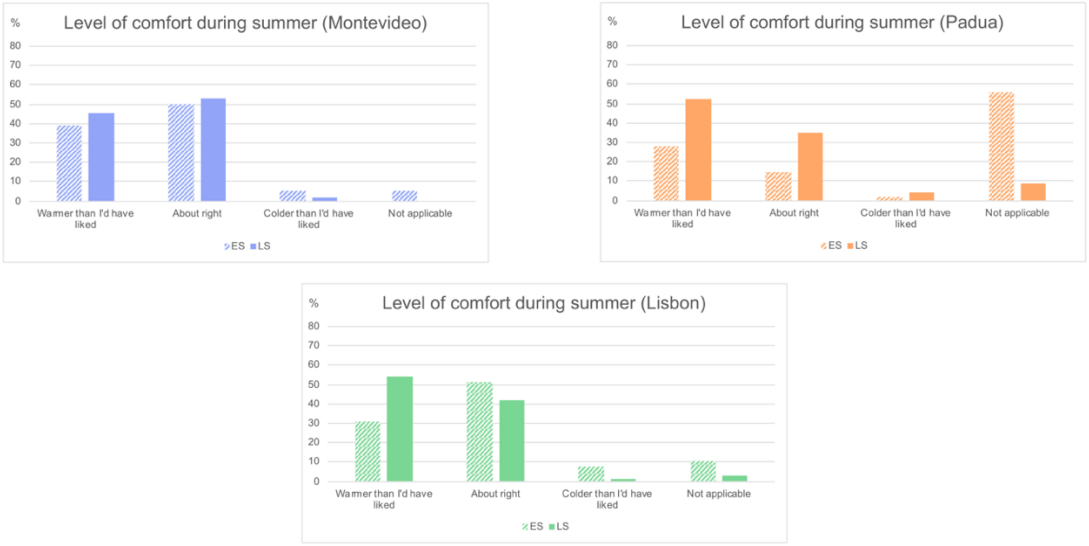

Figure 2.4- Perception of energy comfort during summer of ES and LS of Montevideo, Lisbon, and Padua.

Cooling devices are present in students' accommodations during summer (Figure B.0.7 to Figure B.0.10). In general, the most common response was "air conditioner" for Padua LS and Montevideo ES, "electric fan" for Montevideo LS, and in the case of the other three populations (Padua ES; Lisbon ES and LS), students had no cooling device at all in their accommodation (in most cases, students did not need it, or the devices did not exist).

Moreover, during summer, 57% of Padua LS reduced energy use because they were concerned about costs (primarily by switching off the fan/air conditioning), and the other populations didn't make this reduction (Figure 2.5).

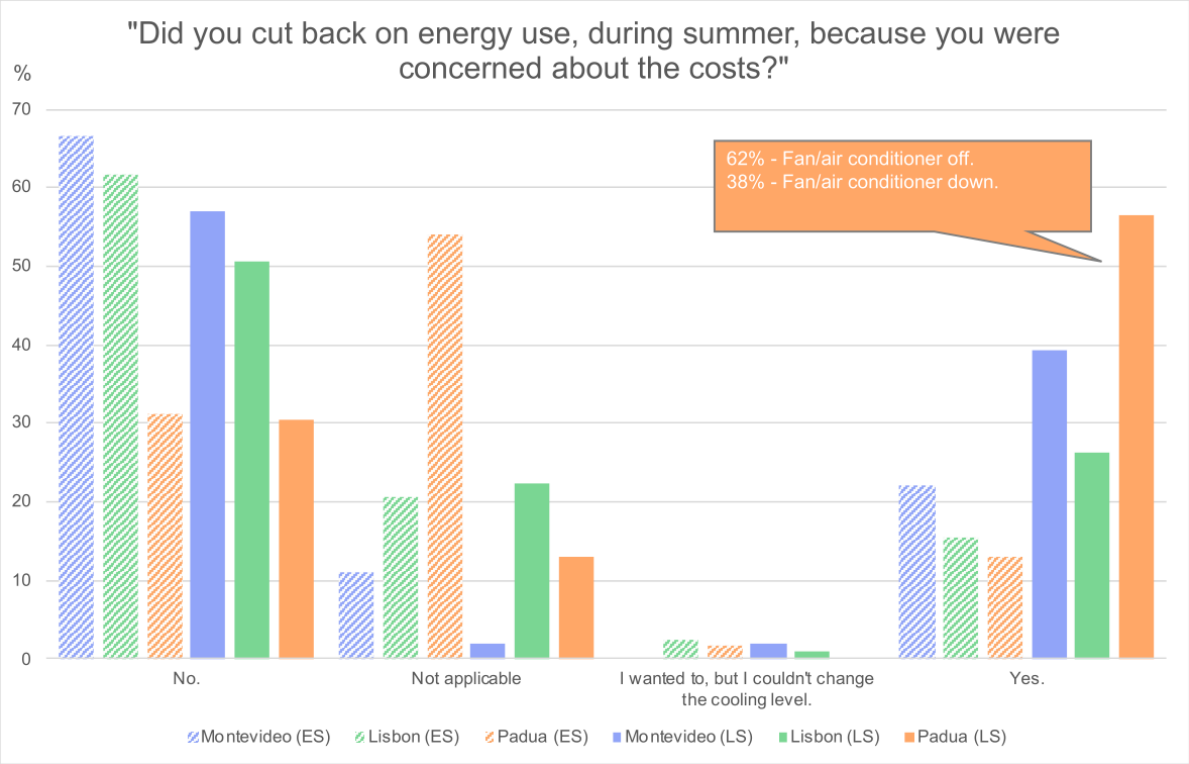

Figure 2.5- Energy costs challenges for each population during summer.

2.3.7. Energy saving

When asked, "What stopped you from using more energy?", "Its relationship with greenhouse gas emissions and climate change" was the statement with the highest percentage of responses from all populations, apart from the LS of Montevideo, in which case "I couldn't afford higher consumption" was the most common response. In the case of the four populations from Montevideo and Padua, the second most common response was "I spent most of the day outside", and in the case of the two populations from Lisbon, it was "I couldn't afford higher consumption". To consume less energy, more than 88% of all respondents from all the populations took action, and the most common action across all populations was, in fact, an adaptive strategy - "Wore more or less clothes". The second most common action was: "Consciously took actions to reduce consumption" (Lisbon ES and LS; Montevideo LS); "Spent more time outside" (Montevideo and Padua ES); "Endured less consumption (would have preferred to use more)" (Padua LS).

2.3.8. Housing conditions and impacts

Figure 2.6 illustrates the presence of different problems in the student's current or previous accommodation. Most students in Padua (ES and LS) did not report problems (Figure 2.6). On the other hand, around 50% of the populations in Montevideo and Lisbon stated that damp or mold was present on the walls or ceilings of their accommodation (Figure 2.6). Among the students of these two study sites, ES and LS in Montevideo reported more problems than those in Lisbon (both ES and LS), and ES in each city reported more problems than the corresponding LS populations (Figure 2.6).

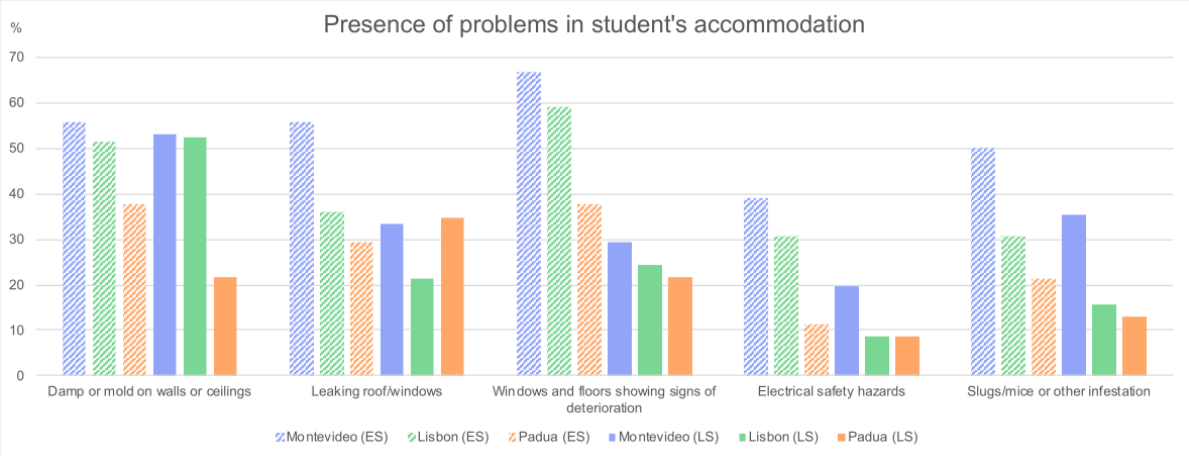

Figure 2.6- Presence of problems in student accommodation in each population.

In the case of LS, the housing conditions in Montevideo were worse than in Lisbon, but most students in Montevideo considered that these conditions were not poor (61%) (Figure B.0.14). From Figure B.0.13 to Figure B.0.18, it is shown, for each population, whether the students' poor housing conditions affect them, and if so, in what way(s). In general, the majority of ES from all populations (Montevideo- 61%; Padua- 68%) and most students from Lisbon (ES- 76%; LS- 58%) stated that these conditions affected them. Furthermore, for all students who reported that these conditions affected them, the most frequent way they were affected was "It made me feel uncomfortable".

2.3.9. EP concept and perception

In the first section of the survey, most students from all populations selected the EP concept, which is currently presented by the European Commission (2022a). In the last section of the survey, when confronted with this concept, except for the Lisbon ES population, more than 85% of all students answered "No" to the question "Did you consider yourself to be in Energy Poverty?". In the case of Lisbon ES, the percentage of "No" was slightly lower (67%).

Regarding the level of awareness of this problem, in the case of both populations from Lisbon, there was a majority of "Concerned" or "Really concerned" students about EP (ES- 69%; LS- 63%). In relation to the other populations, most students were either indifferent or not concerned about this problem. In addition to their level of concern, the students gave their opinion on how they predicted the problem would evolve with climate change. Except for Montevideo ES, most (≥65%) predicted that EP would get worse or much worse with climate change. In the case of Montevideo ES, 44% considered the relationship indifferent, and 17% predicted that it would not get worse with climate change.

2.3.10. Solutions and policies

Finally, thirty percent of the respondents answered, in open response format, to the question "What solutions (individual and/or collective) and policies do you use/suggest to minimize the problem?", and the answers are shown in Figure 2.7. The category that had the highest percentage (35%) of the suggestions of solutions/policies from the students is public policies (Figure 2.7), such as: "tax cuts on electricity"; "subsidies to improve household energy efficiency levels"; "price regulation of items according to their energy efficiency"; "penalties for non-efficient energy use"; "rewarding people for their efforts to save energy"; "mandatory energy saving measures when building or renovating houses"; "government action to reduce inequality"; "carry out a CO_2 tax, so that wealthier people and companies pay more for emissions, and return to each person the same amount of money earned from the tax as climate money"; "support the rehabilitation of existing buildings"; "subsidies to finance 100% renovation of energy-poor and rented housing".

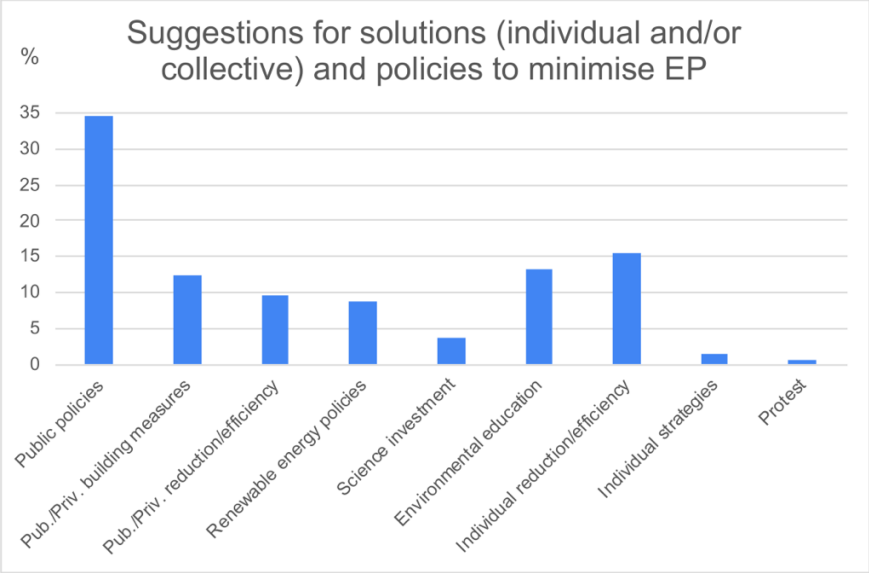

Figure 2.7- Answers from 30% of all populations to the question "What solutions (individual and/or collective) and policies do you use/suggest to minimize the problem?".

Regarding public or private building measures (13%), respondents suggested solutions related to the installation of more energy-efficient and energy-saving devices and insulation in the structure of windows, doors and floors or through temperature-maintaining elements such as carpets. In addition, the solution of improving the energy efficiency levels of homes was categorized into public or private reduction/efficiency measures. Nine percent of the suggestions were related to renewable energy policies, such as diversifying energy inputs, investing in renewable energy, implementing smart grids in cities, and promoting renewable energy communities.

From the students' perspective, investment in science (4%) should be conducted to identify people who are energy-poor more broadly, to create viable business models to address EP mitigation, or in a way that deepens knowledge about renewable energy integration in households. On the topic of environmental education (13%), students mentioned education about energy use and energy efficiency measures at the household level, "informing students that this is a real problem that can affect them in the short and long term" and how they can minimize it by providing the necessary tools to do so.

On an individual level, protesting had one percent of the suggestions, and some examples of other individual strategies (1%) that were referred were reducing energy consumption, implementing energy efficiency measures at home (giving importance to sun exposure, type of windows, natural ventilation, insulation, etc.), wearing more clothes, and living in communities or shared houses.

2.4. Discussion

One of the major insights from this research is that most surveyed students from all populations did not consider themselves to be in EP, aligning with the reported by Morris and Genovese (2018) in the context of university student populations in the UK.

Regarding the level of awareness of EP, both ES and LS of Lisbon were the only populations with a majority of "Concerned" or "Really concerned" students about the problem, aligned with recent results of a city-level survey on EP (Lisboa e-nova, 2022). In addition, the students from Lisbon described more Discomfort than those from the other study sites (Table 2.5), and Lisbon was the only city with the majority of both ES and LS, noting that their poor housing conditions affected them. To make a summary of the types of thermal comfort of each population, the following Table 2.5 systematizes the information given in Figures 2.2, 2.4.

Table 2.5- Summary of the types of comfort during winter and summer for each population, where C- Comfort and D- Discomfort.

	Montevideo ES	**Montevideo LS**	**Lisbon ES**	**Lisbon LS**	**Padua ES**	**Padua LS**
Winter	D	C	D	D	C	C
Summer	C	C	C	D	D*	D

* Most Padua ES had not yet experienced summer; thus, their responses were not representative of the population.

The level of comfort can be influenced by the lived experience of maintaining comfortable internal temperatures and by factors such as climate, level of awareness about EP, presence of equipment, house conditions, and income. Although it is difficult to generalize, different thermal comfort levels standards vary according to location, type of students and season, with the results unfolding interaction between these three factors.

In relation to the level of comfort perceptions according to the type of student (ES or LS) in each season, the results show a situation for each location: in Padua, this factor does not seem to have been relevant (both ES and LS perceived the same level of comfort in each season); in Lisbon, it seems to have affected the summer-related responses (in summer, most ES felt comfortable, while LS felt uncomfortable); in the case of Montevideo, it appears to have affected the winter responses (in winter, most ES felt uncomfortable, while LS felt comfortable) (Table 2.5).

Based on the climatic description we made of the three locations using recent temperature data, we verified that the climate variables in Montevideo and Lisbon are very similar and that in Padua is more extreme, namely in winter. However, it is precisely in Padua, during winter, that most students (ES and LS) feel comfortable, probably as a result of better housing conditions and a wider availability of centralized heating systems. In the other two cities, in winter, most ES and LS in Lisbon felt uncomfortable, while in Montevideo only the majority of ES felt uncomfortable. In summer, the situation is different in Montevideo and Lisbon, as most ES and LS in Montevideo felt comfortable, while in Lisbon only the majority of ES felt comfortable.

Considering the climatic variation among the three cities and if we assume that the ES population of the various locations was more similar to each other than the corresponding LS, as they share a common characteristic which is having left their comfort zone (their country), we can consider that the EP situation of university students was worse during winter in Montevideo and Lisbon than in Padua. In relation to summer, the EP situation seems to have been generally more benign, as both ES from Montevideo and Lisbon reported being comfortable. Regarding Padua, as the survey was carried out until May, we did not consider the answers of ES as representative of the summer situation for this type of students. In general, we consider that the summer vulnerability case should not be as important as the winter case, since it is equivalent to the major vacations in all three countries, where students are usually away from home for longer periods.

If we use EP indicators such as the EU-SILC indicators discussed in Gouveia *et al*. (2022), "Share of population with leaks, damp or rot in their dwelling", we can consider once again that Montevideo and Lisbon were more problematic locations than Padua, since, for instance, most students (ES and LS) reported problems of "Damp or mold on walls or ceilings" in their accommodations. In relation to this indicator, in 2020, 25.2% of the Portuguese dwellings had these problems (Eurostat, 2022c), while the Lisbon survey conducted by Lisboa e-nova (2022) to the general population; depicts 31% of households with humidity issues, 29% reporting window leakages and 34% reporting insulation problems on walls and roofs. Therefore, this percentage is even higher in our study, according to the ES and LS from Lisbon (51% and 52%, respectively). In Kousis *et al*. (2020), regarding students from seven different European countries, most Greek, English and Irish students reported these "Damp or mold on walls or ceilings" in their private-rented accommodation.

The EP situation seems to be more problematic in Montevideo and Lisbon than in Padua during winter, a pattern that can be explained by the fact that most of ES in Montevideo and Lisbon had poor housing conditions, which affected them (may explain their Discomfort in winter) and that in Padua most students did not report the presence of problems in their accommodation (may explain their Comfort during winter). Besides that, compared to the other cities, in Padua, more students were living in a dormitory of a residence, and there was a generally higher percentage of satisfaction with the accommodation.

However, the more problematic EP situation that seems to exist in Montevideo and Lisbon, does not seem to have been perceived by the LS in the same way. In fact, while most LS in Montevideo felt comfortable in winter and summer, most LS in Lisbon did not feel comfortable in both seasons. This discomfort from Lisbon LS may be explained by the fact that, contrary to Montevideo LS, most of the LS reduced energy use because they were concerned about the energy bills (in winter) and did not have cooling devices (in summer). Contrary to what would be expected, students from Lisbon were more selective when house hunting (possibly, because they are more aware of the problem) and the house conditions of Montevideo had more issues than the ones of Lisbon (besides, most of Montevideo LS had considered their housing conditions not poor). These differences may be due to economic and/or cultural aspects of the two countries. According to Fernández (2021), 48% of households that experienced EP in Uruguay did not perceive themselves as poor, even if they did not have access to basic energy services or have it at an unaffordable cost. This fact may be indicative of adaptive preferences and/or cultural elements that lead households to not feel that certain energy services are necessary; but it is also an indication of a reduced level of expectations in the satisfaction of needs by this population (Fernández, 2021). In Horta *et al*. (2019), interviews of Portuguese households showed that they tended to consider it normal and acceptable to experience thermal discomfort at home (like the Uruguayan households), but currently, there may

be a tendency for the Portuguese to no longer consider it normal and acceptable, starting with students' perception of EP.

The solutions and policies proposed, in general, by 30% of all the students, could be used by the citizens and political agents of the studied cities, particularly to decrease the EP of Montevideo and Lisbon during winter. Giving a few examples, providing "subsidies to finance 100% renovation of energy-poor and rented housing", and improving the energy efficiency of buildings; which is already being done by the Italian and Portuguese Governments with the Superbonus 110% (Italian Government, 2022), in Italy, and the "Efficiency Voucher" and "More Sustainable Buildings" funding schemes in Portugal (Fundo Ambiental, 2022). Besides, further suggestions consider doing research to "identify people who are energy-poor more broadly", "informing students that this is a real problem that can affect them in the short and long term" and how they can minimize it. Besides being important to give university students access to information and tools to minimize EP, it is important to allow their voices to be heard by involving them in designing solutions.

Some of the proposed solutions and policies are already encompassed in the draft version of the Portuguese National Strategy to Combat Energy Poverty (ENLPCPE). To reduce EP and promote decarbonization, the ENLPCPE sets four main objectives: improved energy performance of households, access to more energy services, reduced energy costs, and increased energy literacy (Portuguese Republic, 2023). The amount of energy required for space heating and the health effects associated with a cold house are more significant than for cooling, which should make winter-related EP the priority for the country (Gouveia *et al*., 2019). Palma *et al*. (2022) showed that increasing equipment efficiency to regulation levels and implementing a "deep change" in the heating equipment stock is effective in reducing winter EP in Portugal.

Although university students are often not directly targeted by policymakers (Morris and Genovese, 2018), the status of this group may be addressed by default through other policies without acknowledging the specifics of this group's vulnerability to EP. As an example, university students may live in housing where quality in relation to energy performance is covered by building standards, housing policies, and building specifications determined by the university.

2.5. **Conclusion**

In order to analyze and compare students' perceptions of EP and to explore their vulnerability to EP, two types of populations of university students (one of Local Students, LS, and another of Exchange Students, ES) were surveyed. The survey covered several aspects of EP and energy awareness, and the answers to its forty-four questions were analyzed according to the case study city, the type of student, and the season of the year.

The group of university students was analyzed in depth, finding common threats, strategies and impacts; and also, differences in the EP lived experience of students from different backgrounds in their hometown and/or the city where they studied, in the winter and summer seasons.

The present research shows that addressing EP is complex and that there is probably an interaction between the factors of location, type of students, and season. Although most students did not identify themselves as living in EP, several populations perceived discomfort in both winter and summer, showing their vulnerability to EP. What makes the EP situation worse for university students seems to have been related to the presence of problems in ac-

commodation, particularly in winter, in Lisbon and Montevideo, compared to better accommodation, namely in residences in Padua. Moreover, LS and ES may have different perceptions, as ES from countries with colder climates may have higher expectations of thermal comfort than LS, who, in turn, may find it easier to accept the situation of living in EP due to economic and/or cultural aspects, finding alternative adaptive strategies to cope with the cold.

Framing the potential differences between three cities, two students' profiles (local vs exchange), and on the topic of thermal comfort, its variation in relation to the season (winter or summer), this research fills a gap in the current literature and knowledge field regarding how EP is felt and understood by a potentially significant vulnerable group as university students.

Regarding the limitations of the present study, on the one hand, the case of EP in Uruguay is less comparable with Portugal and Italy than the cases of these EU countries among themselves, which have similar data collection on EP indicators and overarching policies. On the other hand, it was not possible to analyze the perception of the ES from Padua in summer, so it would be important to understand if we can assume the discomfort of LS for this population as well. Thus, it is proposed that, in future studies, the methodology be oriented to cover all relevant periods for the dissemination of the survey, making future analysis of the results possible. Furthermore, the fact that students' house hunting choices depend on the general market availability for accommodation options in each of the locations and that was not analyzed in depth in the present study, we suggest it could be done in future studies to better explore students' vulnerability. Consequently, it is suggested that future research should explore behavioral patterns such as adaptive strategies and students' adaptation measures to mitigate their vulnerability to EP. Finally, it would be relevant to use comparable metrics across multiple studies to better understand energy consumption patterns. As next steps, it is considered important to extend the analysis to the scale of each country under study, comparing the situation between cities in these countries and between the type of student (local or displaced), capturing the actual reality of EP among university students living in these countries.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author Contributions

CC: conceptualization, overall methodology, analysis of results, and writing—original draft preparation. JPG: overall methodology, analysis of results, review and editing of the manuscript. All authors have read and agreed to the published version of the manuscript.

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Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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3.

ENERGY POVERTY AMONG HIGHER EDUCATION STUDENTS: A STUDY OF LOCAL AND DISPLACED STUDENTS IN PORTUGAL

ABSTRACT

Portugal faces substantial Energy Poverty (EP) challenges compared to its EU counterparts, mainly stemming from aged buildings with poor thermal performance. This situation is especially critical for higher education students, who exhibit increased vulnerability to EP due to unstable housing conditions within the Private Rental Sector (PRS). Among these students, displaced individuals are notably vulnerable and heavily reliant on the PRS. Thus, this study delves into the thermal comfort and potential EP vulnerability of higher education students, both displaced (DS) and local (LS), across four Portuguese regions (Norte, Centro, AML, and Alentejo). Surveying 848 students via a 32-question online survey between September 2022 and April 2023 reveals that discomfort prevails in both summer and winter for most populations. DS experienced greater discomfort than LS, potentially attributable to their reliance on the PRS, which often entails precarious housing. Although regional disparities in thermal comfort were not significant, the causes of discomfort varied significantly between regions. Notably, DS from Alentejo emerged as the most potentially vulnerable population to EP within the study cohort. This study underscores the imperative for policymakers, higher education institutions, and researchers to redirect their focus towards enhancing student housing, particularly within the PRS and older buildings, while addressing the EP vulnerability of DS.

KEYWORDS

Energy Poverty, Higher Education Students, Vulnerability, Lived Experience, Survey

3.1. **Introduction**

Energy poverty (EP) is defined as a situation wherein an individual cannot secure materially and socially necessitated energy services in their home, encompassing aspects of security of supply, affordability, and access (Bouzarovski *et al*., 2021). While the causes of EP are complex and multifaceted, three primary factors are commonly identified: low income levels, poor household energy efficiency and building performance, and high energy prices (European Commission, 2022). Vulnerability to EP varies among households and individuals and can be influenced by sociodemographic factors, household composition, health, energy literacy, cultural factors, and climate change (European Commission, 2022).

Identifying and measuring EP at the local level can be challenging, as EP is a private issue that fluctuates over time and across regions, often dependent on cultural factors (Bouzarovski, 2013). Two main types of information contribute to this assessment: measurable EP, relying on objective data such as energy consumption, income, and building efficiency, and perceived EP, which relies on subjective judgments like thermal comfort, assessed through qualitative methods like observations and interviews, capturing the lived experiences of households (European Commission, 2022).

EP can be measured using multiple indicators of both types. The EU (European Union) Energy Poverty Advisory Hub (EPAH) depicts multiple indicators organized by various topics (e.g. climate, buildings, energy consumption, socio-economic) to grasp the EP problem and related drivers and consequences and how they can aid Member-States and other agency levels in their national strategies and policies (Gouveia *et al*., 2022, Gouveia *et al*., 2023). EPOV used 28 indicators to analyze EP, divided into two categories: primary if they were understood to directly depict EP, and secondary if they were meant to help characterize the circumstances that lead to a situation of vulnerability (Gouveia *et al*., 2022). EPAH updated the original 28 EPOV indicators into 21 indicators, such as: "Inability to keep home adequately warm", "Arrears on utility bills" (primary indicators); and "Pop. Liv. dwellings comfortably warm in winter time", "Pop. Liv. dwelling comfortably cool during summer time", "At risk of poverty or social exclusion", "Pop. Liv. dwelling with presence of leak, damp and rot" (secondary indicators) (Gouveia *et al*., 2022).

EP in Portugal might be considered problematic compared to other EU countries. In fact, according to Eurostat (2023a) and Eurostat (2023b), in 2022, 17.5% of the Portuguese population couldn't afford to keep their home adequately warm (the 4th worst in the EU), and 4.7% was not able to pay for utility bills (heating, electricity, gas, water, etc.) on time due to financial difficulties. Moreover, in 2020, the share of the population with a leak, damp, or rot in their dwelling was 25.2% (the 3rd worst in the EU) (Eurostat, 2023c), and 20.1% (2022) was "At risk of poverty or social exclusion" (Eurostat, 2023d). Although the concern about EP is mainly centred on winter, a large percentage of the Portuguese population also finds it difficult to maintain a comfortable temperature in their homes in summer, given that, in 2012, 35.7% of the population lived in a dwelling not comfortably cool during summer time (the 2nd worst in the EU) (Eurostat, 2012).

One of the leading causes of the EP situation in Portugal is the prevalence of old and inadequately prepared buildings with low thermal performance, which increases vulnerability to EP (Palma *et al*. 2019) since 65% of energy-performance certified residential buildings in the country fall within energy class C or lower (Agência para a Energia, 2023), and that 50.2% of the classic buildings existing in 2021 had been built before 1980 (INE, 2023a).

Housing conditions are particularly relevant for one of the populations considered vulnerable to EP, the higher education student population (*e.g*., Morris and Genovese, 2018).

Studies focused on this demographic group have highlighted their increased vulnerability, primarily stemming from precarious housing conditions in the Private Rental Sector (PRS) (Morris and Genovese, 2018; Kousis *et al.*, 2020; Fong and Kimberley Clare, 2021). Higher education students represent a significant portion of the demand within the PRS in various regions. They form a specialized market niche characterized by housing supply tailored to their distinct requirements (Rugg *et al.*, 2002). However, residing in the PRS can contribute to EP, as vulnerability to EP often relates to rental conditions and terms, such as housing quality and tenancy stability (Clair *et al.*, 2019).

Within the higher education student population, displaced students may be considered a particularly vulnerable group since they are very dependent on the PRS. In Portugal, the living conditions of this group, particularly for those facing financial constraints, have become increasingly critical due to rising property market pressures (Portuguese Republic, 2023a). The 2021/2022 academic year witnessed 119,818 displaced students, constituting 35.5% of the total student population in public higher education in Portugal (Portuguese Republic, 2023a).

While some studies have explored the vulnerability of higher education students in terms of EP, they have not explicitly focused on displaced students. Previous research has investigated the impact of PRS housing characteristics on students' energy expenses, thermal comfort, and overall well-being (Kousis *et al.*, 2020). Additionally, some studies have examined factors influencing students' EP levels, such as the type of accommodation (Subdivided Units, which have a floor area of between 9 and 18m^2, which equates to around 10m^2 per person) (Fong and Kimberley Clare, 2021), private or shared accommodation (Nazarahari *et al.*, 2021); the shifts in attitudes and behaviors due to the COVID-19 pandemic (Mamica *et al.*, 2021); or the student type (local or exchange) (Castro and Gouveia, 2023).

In certain studies, regional differences have been important factors when analysing the EP situation among students. For instance, Kousis *et al.* (2020) conducted a comprehensive study involving students across various countries, including Bulgaria, Cyprus, Greece, Lithuania, Romania, the UK, and Ireland; Nazarahari *et al.* (2021) conducted a comparative analysis between Japanese and non-Japanese college students; and Castro and Gouveia (2023) examined variations in students' EP perception and vulnerability based on diverse geographical, social, and building-related contexts in Montevideo, Lisbon, and Padua.

The present study aims to investigate the perception and vulnerability to EP of higher education students of two profiles (displaced or local) residing in mainland Portugal, comparing the situation among its five NUTS II regions and considering two seasons (winter or summer). We aim to identify common challenges and impacts while discussing students' vulnerability to unstable housing conditions in the PRS and their potential EP situation. In addition, we explore potential drivers of EP vulnerability, particularly heating and cooling equipment ownership, challenges related to energy bill payments, and the condition of the students' housing.

3.2. **Methodology**

As previously mentioned, we employed a comprehensive approach to examine the dynamics of EP among higher education students living in mainland Portugal to assess their potential vulnerability to this issue. The methodology comprises five distinct subsections designed to facilitate a clear understanding of the regions under study and the procedural framework. The first subsection provides the methodology for crafting the survey, while the second indicates the selected case study regions. Additionally, to provide a context that encompasses essential facets of household energy needs and consumption patterns, the third and fourth

subsections offer an insight into each region's climate and socio-economic characteristics, respectively. Lastly, the fifth subsection is dedicated to elucidating the procedures employed in data analysis.

3.2.1. Survey

An online survey with thirty-two questions was created with two versions (in English and Portuguese, considered a single survey), based on Castro and Gouveia (2023) forty-four questions survey, with only a few writing changes. This survey was opened for responses between September 2022 and April 2023, focusing on the Portuguese high-education student community. An open online dissemination was made. Several contact points were identified in public and private institutions of Portuguese polytechnic and university education were identified and established to support dissemination and increase the number of responses.

Out of 894 initially collected surveys for mainland Portugal, 46 were incomplete. The Algarve region had less than 5% of the total responses, so this region was excluded from the analysis. Considering that a valid response to the survey was one in which the respondent answered most of the questions, we were left with 848 valid surveys from the four remaining regions, which had sufficient response rates.

The survey questions were designed to characterize each population of students and to describe their energy consumption habits, energy-related equipment, perception of EP, and their lived experience in maintaining comfortable internal temperatures. Two types of populations of high education students (one of Displaced Students, DS, and another of Local Students, LS) were considered in four Portuguese regions: North region (Norte), Centre region (Centro), Lisbon Metropolitan Area (AML), and Alentejo.

3.2.2. The four Portuguese regions

To unify the responses across different populations, we merged the responses for each NUTS II region (Norte, Centro, AML and Alentejo), corresponding to the region where each respondent's higher education institution is located. Figure 3.1 shows all the higher education institutions of the respondents according to the corresponding region.

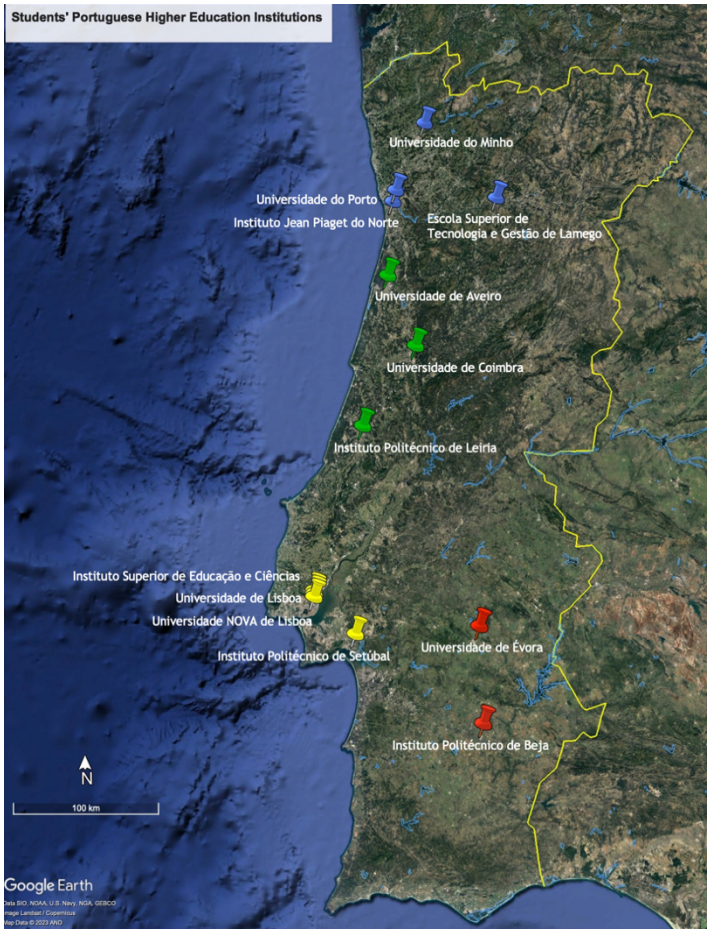

Figure 3.1- Representation of Portuguese higher education institutions of the respondents (in blue are those from the Norte region, in green are those from the Centro region, in yellow are those from the AML region, and in red are those from the Alentejo region), adapted from Google Earth.

3.2.3. Climate characterization of the Portuguese regions

Recognizing the climatic nuances inherent to each Portuguese region becomes pivotal as it can affect the perceived thermal comfort experienced by its inhabitants. This crucial aspect was considered to facilitate a more profound comprehension of the susceptibility to EP and the intricate energy consumption behaviours exhibited within the populations under examination.

Table 3.1 presents the weather description of each Portuguese region based on two variables: Average Hourly Maximum and Minimum Temperatures for winter and summer (data from Weather Spark, 2023). This climatic characterization of each Portuguese region was based on the climatic characterization of the cities where the higher education institutions of more than 5% of respondents in each region are located (for Norte: Porto and Braga; for Centro: Aveiro, Coimbra and Leiria; for the AML: Lisbon; for Alentejo: Évora) (see Table 3.3 in Results). The regions are generally climatically similar in winter and summer, apart from summer in the Alentejo, which has more extreme high temperature values and a greater temperature range (Table 3.1).

Table 3.1- Weather description of each Portuguese region (Norte, Centro, AML and Alentejo) based on two variables (Average Hourly Maximum Temperature and Average Hourly Minimum Temperature) for winter and summer, according to Weather Spark (2023).

Season	Variable	Portuguese Regions			
		Norte	Centro	AML	Alentejo
Winter	Average hourly maximum temperature (ºC)	15 (Porto=Braga)	16 (Coimbra) 15 (Aveiro=Leiria)	17 (Lisbon)	16 (Évora)
	Average hourly minimum temperature (ºC)	6 (Porto=Braga)	5 (Aveiro=Leiria=Coimbra)	8 (Lisbon)	5 (Évora)
Summer	Average hourly maximum temperature (ºC)	27 (Braga) 24 (Porto)	28 (Coimbra) 27 (Leiria) 25 (Aveiro)	29 (Lisbon)	33 (Évora)
	Average hourly minimum temperature (ºC)	13 (Porto=Braga)	13 (Aveiro=Leiria=Coimbra) 12 (Coimbra)	15 (Lisbon)	13 (Évora)

3.2.4. Socio-economic characterization of the Portuguese regions

The socio-economic profiles of the four Portuguese regions were constructed by considering seven key indicators: poverty, labour market, disposable income, economic growth, human capital, electrical energy consumption and Air Conditioning (AC) ownership (Table 3.2). These comprehensive indicators collectively offer a holistic perspective on the socio-economic landscape of each region, enabling a nuanced analysis of their unique characteristics and vulnerabilities related to energy poverty.

The choice of these indicators is linked to objective data such as energy consumption and income (measurable EP) (European Commission, 2022) and some of the complementary indicators of EPAH: "Pop. Liv. dwelling equipped with air conditioning", "At risk of poverty or social exclusion" (Gouveia *et al*., 2022).

Of all four regions, AML has the lowest poverty risk rate despite having the highest unemployment rate (Table 3.2). In addition, AML is the region with the highest disposable income, GDP, and higher education attainment rate (Table 3.2). Despite this, it is the Alentejo region that has the highest electricity consumption per inhabitant and the highest AC ownership (Table 3.2). The highlight of the Norte region is that it has the highest poverty risk rate, while the Centro has the lowest unemployment rate and the lowest ownership of AC (Table 3.2).

Table 3.2- Socio-economic description of each Portuguese region (Norte, Centro, AML and Alentejo) based on seven indicators.

Indicator	Source	Portuguese Regions			
		Norte	Centro	AML	Alentejo
Poverty Risk Rate (% of total population) in 2021, based on the national threshold	INE (2023b)	20.0	15.6	10.4	14.9
Unemployment Rate (%) in the 1st Quarter of 2023	INE (2023c)	7.6	5.6	8.0	7.2
Gross Household Disposable Income per capita (€)	INE (2023d)	10 595	11 279	14 518	11 533

Gross Domestic Product (GDP) per capita	INE (2023e)	19 450	19 983	30 109	21 670
Higher education attainment rate of the resident population aged 25-64 (%)	INE (2023f)	28.7	29.7	40.9	25.2
Electrical energy consumption per inhabitant (kWh/inhab.) in 2021	INE (2023g)	4 097.4	5 726.9	4 037.8	7 086.7
Private households with AC (%) in 2015	PORDATA (2019)	13.2	10.2	18.7	30.3

3.2.5. Data analysis

Initially, the 838 valid responses in Portuguese or English were unified into English terms and merged into a single data sheet to enable consolidated analysis and comparison of responses. Afterwards, the answers of the following eight populations were analysed: Norte DS, Norte LS, Centro DS, Centro LS, AML DS, AML LS, Alentejo DS, and Alentejo LS.

All questions were answered by all the 838 students, except 12 respondents (9 DS and 3 LS from AML) who did not respond to the following questions: "Is this a full-time residence or do you spend time in another residence at the weekends?"; "I find the thermal comfort conditions most comfortable in..."; "Year in which the building you inhabit was built"; "My building has draughts, cracks, humidity or mould"; and "How do you heat/cool your residence?".

Nine distinct subsections of the results were created to enhance comprehension regarding various influencing factors. These sections serve to fully grasp the profound scope of EP among highly educated Portuguese students. The initial two subsections provide a comprehensive portrait of each population, achieved by characterizing the sample and giving a general description of the accommodations. Subsequently, the following two subsections delve into the student's perception of thermal comfort during winter and summer and the used heating and cooling equipment. The next three subsections are dedicated to exploring energy expenditures, the challenges posed by energy costs, and the extent of adopting energy-saving measures. Ultimately, the final two subsections examine building conditions and the impacts of thermal discomfort and poor building conditions.

Broadly, the responses were structured based on the percentage of students within each population and graphs and tables were employed to illustrate this variation across all subsections. For some questions (see Table D.0.1), the original survey categories were restructured into fewer categories to streamline the analysis. The revised categories and the corresponding revised title of the question are detailed in Table D.0.1.

Specific subsections and the respective questions, identified in Table 3.3, underwent a multivariate analysis in which each question was treated as a response variable. The subsections were organized according to the indicators to which they related. While subsection 3.3. relates to subjective thermal comfort (perceived EP), subsection 3.8. refers to building efficiency (measurable EP) (European Commission, 2022). Subsection 3.6. is related to the EPAH's indicator, "Arrears on utility bills", which is understood to directly depict EP vulnerability (Gouveia *et al*., 2022). The contextual factors of dwelling types and available heating/cooling equipment (European Commission, 2022) are represented in subsections 3.8. and 3.4. respectively, which are also related to the EPAH's secondary indicators that aim to characterize the circumstances that lead to a situation of vulnerability to EP: "Pop. Liv. dwelling with presence of leak, damp and rot"; "Pop. Liv. dwelling equipped with heating"; and "Pop. Liv. dwelling equipped with air conditioning" (Gouveia *et al*., 2022). Finally, subsection 3.8. aims to represent the impacts of thermal discomfort and poor building conditions from the other subsections.

Table 3.3- Identification of the subsections where a multivariate analysis was carried out and the respective questions treated as response variables. Information on categories of the variables not shown in this table is given in Table D.0.1.

Subsection	**Questions/Response variables**
3.3. Students' perception of thermal comfort during winter and during summer	Level of thermal comfort during winter
	Level of thermal comfort during summer
3.4. Heating and cooling equipment	Heating and cooling equipment (10 variables with two categories each corresponding to the existence or absence of a particular device)
3.6. Energy costs challenges	Level of difficulty in paying their energy bills
	Level of cuts in energy use to reduce energy bills
	"Did you cut or reduce energy consumption for heating your residence during the winter due to energy costs?"
	"Did you cut or reduce energy consumption for cooling your residence during the summer due to energy costs?"
3.8. Building conditions	Year of construction of the building they live in
	Presence of problems in students' accommodation (draughts, cracks, humidity, or mould)
	Did the poor building conditions of your house affect you?
3.9. Impacts of thermal discomfort and poor building conditions	Level of impact of thermal discomfort on students' capacity to concentrate and/or educational attainment
	Level of impact of thermal discomfort on students' health (e.g., frequent colds in winter, respiratory problems)
	Level of limitation on ability to purchase other goods and services when paying energy bills

Five multivariate analyses were carried out corresponding to the five subsections shown in Table 3.4. Each analysis included a PERMANOVA (Anderson, 2001) with two fixed and orthogonal factors: type of student (two levels— DS and LS) and region (four levels— Norte, Centro, AML, and Alentejo). The categories of each variable are listed in Table D.0.1 (new categories), are the original categories of the survey (Appendix A) or are specified in Table 3.3. For the "Level of difficulty in paying their energy bills," a response of 0 was assigned to students who did not answer the question and, therefore were not responsible for paying these energy bills. Regarding the question about the "Year of construction of the building they live in," the response "Don't know" was incorporated into the analysis using the value “3”, that corresponded to the average of the answers.

Each survey was an independent replicate. The sample size varied from 19 (Norte DS and Centro LS) to 391 (AML LS) (see Table 3.4), except for subsection “3.4. Heating and cooling equipment” where the sample size was slightly lower in Norte LS (n=50), AML LS (n=386), AML DS (n=216). As factor type of student was significant for the subsections 3.3. and 3.4. (see Results), pair-wise tests were used to detect the pattern of differences among regions regarding the subsections 3.4., 3.6., 3.8., and 3.9. The homogeneity of the multivariate dispersions based on the Bray-Curtis similarity was tested by the PERMDISP routine applied to the factor location and the factor type of student (Anderson, 2006). The SIMPER procedure (Clarke, 1993) was used to identify which variables contributed most to the average differences among regions and between both types of students after calculating the average value for each variable and each combination of region and type of student. The variables that explained most differences (>70% of cumulative dissimilarity) were selected. All analyses were based on Bray-Curtis similarity of untransformed data and on unrestricted permutations of

raw data, Type III sums of squares and 999 permutations (see Anderson *et al*., 2008). All analyses were performed using PRIMER 7 (Clarke and Gorley, 2015) with the PERMANOVA + add-on (Anderson *et al*., 2008).

3.3. **Results**

The results are presented in nine sections. The first two sections provide an overview of each population and describe their accommodations. The next two sections focus on how students perceive thermal comfort in winter and summer and the heating and cooling equipment they use. Following that, three sections explore energy expenses, the challenges related to energy costs, and the use of energy-saving measures. Lastly, two sections examine building conditions and the impacts of thermal discomfort and poor building conditions.

3.3.1. Sample characterization

A comprehensive characterization of each population subset within the present study, detailing their size and general respondent attributes, is presented in Table 3.4. These attributes encompass sex, age, nationality, presence of chronic/long-term illnesses, employment status, possession of social support/scholarships, education, field of study, higher education institution, and type of higher education institution.

The sample sizes ranged from 19 individuals in Norte DS and Centro LS to 391 individuals in AML LS, and the majority of the respondents were females aged 18-24, categorized as either 18-20 or 21-24. The vast majority of the respondents were Portuguese (more than 89% of all populations, except for AML DS, where 27% were of other nationalities). More than 70% did not report chronic/long-term illnesses (Table 3.4).

Most respondents (more than 53% of all populations) were engaged as full-time students, with respondents from the Norte (both DS and LS) and Centro DS having social support or scholarships, while the same is not valid for students in the AML and Alentejo regions (Table 3.4).

In terms of geographic distribution, the higher education institutions of more than 5% of respondents in each region were located in Porto and Braga for Norte; Aveiro, Coimbra, and Leiria for Centro; Lisbon for AML; and Évora for Alentejo (Table 3.4).

Table 3.4- Characterization of the survey sample: sample size, sex, age (2 most common), nationality, having a chronic/long-term illness, employment status (the majority), possession of social support/scholarship, education (2 most common), field of study (2 most common), higher education institution, and type of higher education institution (A/E/T, Architecture/Engineering/Technology).

Population	Norte (DS)	Norte (LS)	Centro (DS)	Centro (LS)	AML (DS)	AML (LS)	Alentejo (DS)	Alentejo (LS)
Sample size	19	51	44	19	226	391	54	34
Sex	Female (74%); Male (26%)	Female (57%); Male (43%)	Female (68%); Male (32%)	Female (68%); Male (26%); Non binary (5%)	Female (58%); Male (41%); Non binary (%)	Female (60%); Male (40%)	Female (78%); Male (22%)	Female (59%); Male (38%); Non binary (3%)
Age	21-24 (53%); 18–20 (26%)	21-24 (39%); 18–20 (20%)	18–20 (45%); 21-24 (36%)	18–20 (32%)	21-24 (38%); 18–20 (35%)	18–20 (41%); 21-24 (33%)	21-24 (39%); 18–20 (35%)	21-24 (24%); 18–20 (21%)
Nationality	Portuguese (89%); Other (11%)	Portuguese (100%)	Portuguese (93%); Other (7%)	Portuguese (95%); Other (5%)	Portuguese (73%); Other (27%)	Portuguese (94%); Other (6%)	Portuguese (94%); Other (6%)	Portuguese (94%); Other (6%)
Have a chronic/long-term illness	0%	25%	30%	21%	15%	21%	26%	29%
Employment status	Full time student (74%)	Full time student (55%)	Full time student (89%)	Full time student (68%)	Full time student (76%)	Full time student (70%)	Full time student (81%)	Full time student (53%)
Possession of social support/scholarship	68%	53%	66%	47%	38%	24%	48%	32%
Education	12th year (37%); Master´s degree (37%)	Bachelor´s degree (43%)	Bachelor´s degree (43%); 12th year (36%)	12th year (42%); Master´s degree (37%)	12th year (40%); Bachelor´s degree (32%)	12th year (46%); Bachelor´s degree (32%)	12th year (44%); Bachelor´s degree (35%)	12th year (38%); Master´s degree (32%)
Field of study	Social Sciences (47%); Mathematics/Exact sciences (26%)	A/E/T (39%); Life sciences/Medicine (24%); Social Sciences (24%)	Life sciences/Medicine (68%)	Life sciences/Medicine (74%)	A/E/T (45%); Social Sciences (23%)	A/E/T (51%); Life sciences/Medicine (22%)	Life sciences/Medicine (41%); A/E/T (22%); Social Sciences (22%)	Social Sciences (47%)
Higher Education Institution	Universidade do Minho (74%); Universidade do Porto (21%); Escola Superior de Tecnologia e Gestão de Lamego (5%)	Universidade do Minho (69%); Universidade do Porto (16%); Universidade Aberta (12%); Instituto Jean Piaget do Norte (4%)	Universidade do Aveiro (43%); Instituto Politécnico de Leiria (41%); Universidade de Coimbra (16%)	Universidade do Aveiro (53%); Instituto Politécnico de Leiria (21%); Universidade Aberta (21%); Universidade de Coimbra (5%)	Universidade NOVA de Lisboa (75%); Universidade de Lisboa (23%); Instituto Politécnico de Setúbal (2%)	Universidade NOVA de Lisboa (70%); Universidade de Lisboa (20%); Universidade Aberta (4%); Instituto Superior de Educação e Ciências (3%); Instituto Politécnico de Setúbal (2%)	Universidade de Évora (98%); Instituto Politécnico de Beja (2%)	Universidade de Évora (97%); Universidade Aberta (3%)
Type of Higher Education Institution	Public (100%)	Public (96%); Private (4%)	Public (100%)	Public (100%)	Public (95%); Private (5%)	Public (96%); Private (4%)	Public (100%)	Public (100%)

3.3.2. General description of accommodation

Regarding LS, Figure 3.2 shows that most of the LS from Norte and AML were relatives of the owner of the building. Centro LS were distributed mainly between the categories "Owner of building" and "Relative of building owner" (37% in both categories). Alentejo LS were distributed primarily between the categories "Owner of building", "Relative of building owner", and "Long-term renter" (26%, 35%, and 26%, respectively). With regard to DS, most students from all populations were distributed in the "Long term renter" and "Short term renter" categories (63% from Norte, 73% from Centro, 70% from AML, and 80% from Alentejo, adding the percentages of these two categories together) (Figure 3.2).

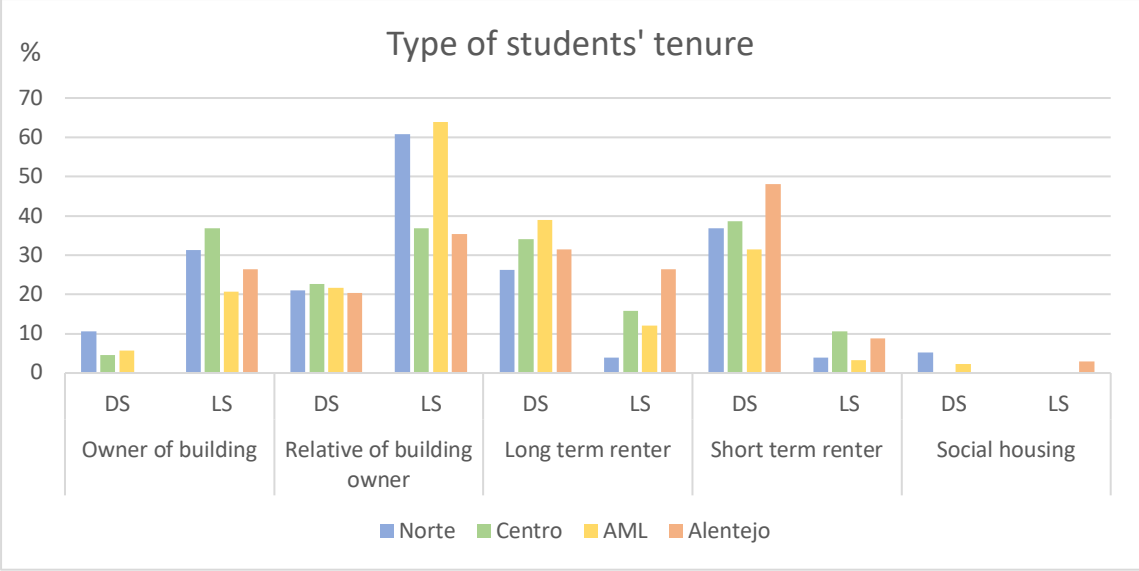

Figure 3.2- Type of student's tenure of each population.

As might be expected from the results in Figure 3.2, Figure 3.3 shows that, as far as LS are concerned, the majority of LS from all regions lived in a residence that they owned or that was owned by family or friends (between 56% of Alentejo LS and 86% of Norte LS). Regarding the DS, most students from all populations fell into the "House/apartment rented directly from owner" or "Room rented directly from owner" categories (53% in Norte, 59% in Centro, 60% in AML, and 78% in Alentejo, adding the percentages of these two categories together), which is in line with the two most frequent types of tenure in these four populations (Figures 3.2 and 3.3).

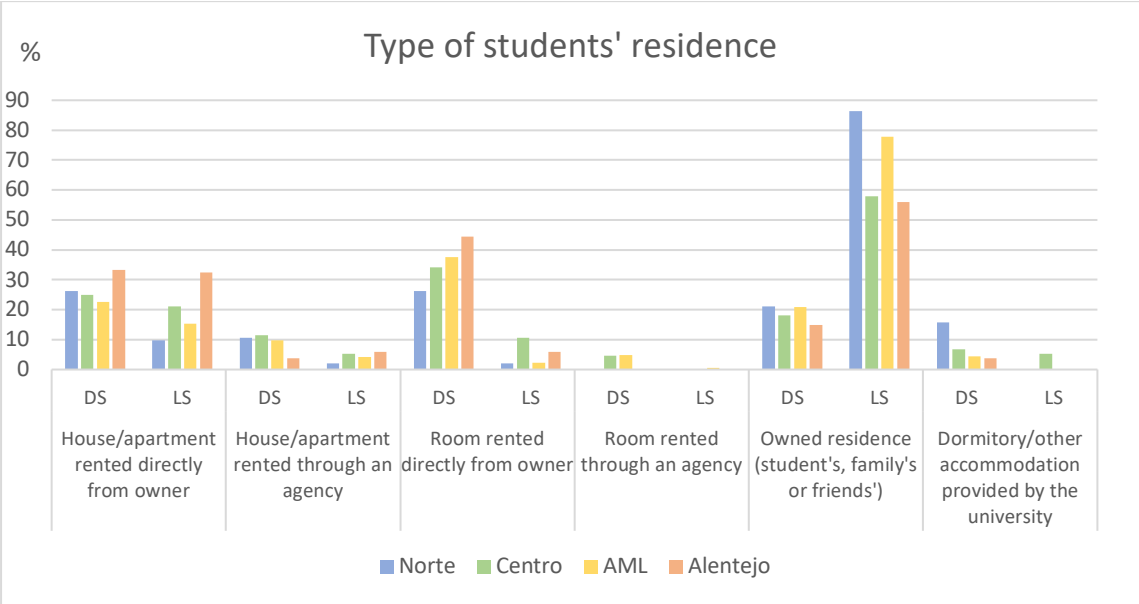

Figure 3.3- Type of student's residence of each population.

With regard to the question "Is this a full-time residence or do you spend time in another residence at the weekends?", the vast majority of the LS in all regions answered "it's a full-time residence" (between 68% of Centro LS and 96% of Norte LS) (Figure 3.4). In the case of Norte DS, the answer with the highest values was also "it's a full-time residence", while in the case of Centro DS, the answer with the highest values was "sometimes I spend time in another

residence on weekends". Between these two response categories, the DS from AML and Alentejo were similarly distributed (between 41% and 46%) (Figure 3.4).

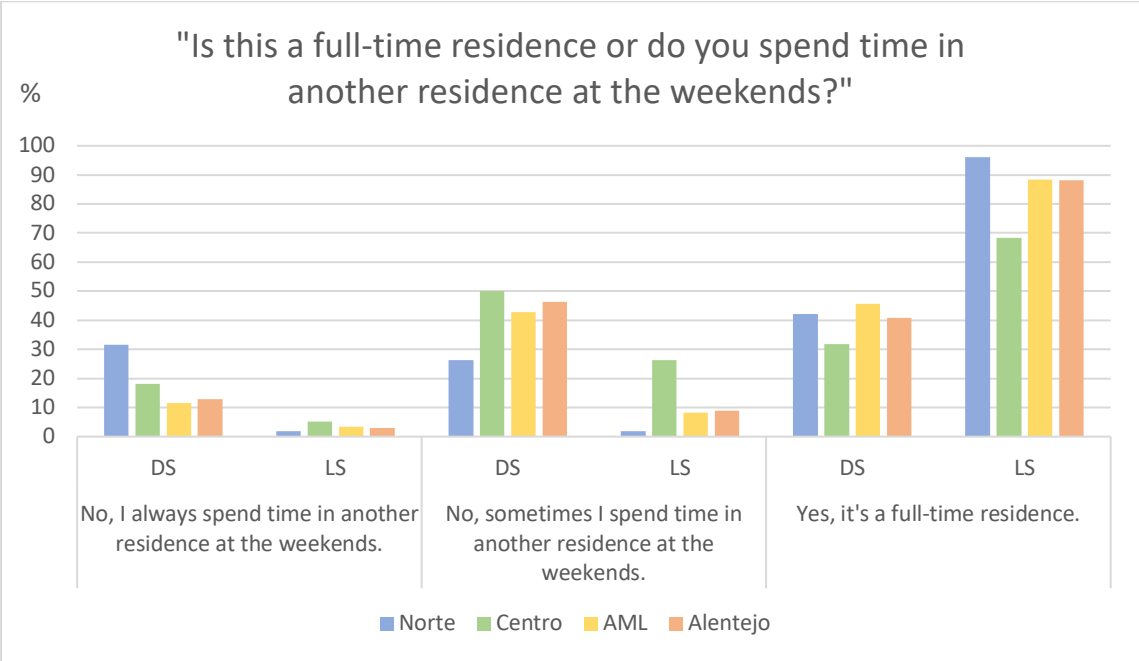

Figure 3.4- Answers from all populations to the question "Is this a full-time residence or do you spend time in another residence at the weekends?".

In terms of the residence where students felt the most comfortable thermal comfort conditions, Figure 3.5 illustrates that across all regions, the DS responses primarily leaned towards the option "Another residence where I frequently spend time in Portugal (at the weekend with family or similar)", with percentages ranging from 40% in AML to 57% in Alentejo. In the case of Norte DS, this percentage was 42%, a figure closely aligned with the 37% attributed to the response "The residence I rent to facilitate my studies" (Figure 3.5). On the other hand, LS in all regions predominantly selected the " doesn't apply" option (Figure 3.5), potentially due to the absence of an alternative residence in their circumstances.

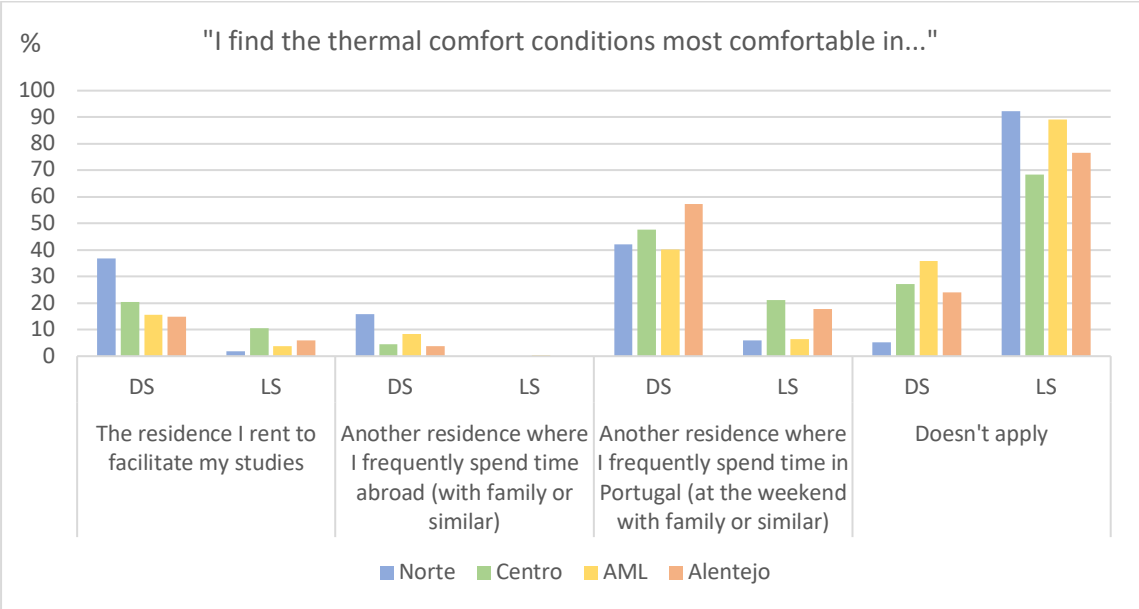

Figure 3.5-Residences where each population felt the most comfortable thermal comfort conditions.

3.3.3. Student's perception of thermal comfort during winter and during summer

The perception of thermal comfort during winter and summer among DS and LS across the Norte, Centro, AML, and Alentejo regions is depicted in Figure 3.6 and Figure 3.7.

In general terms, most students fell into the "Comfort" or "High Discomfort" categories, with "Mild Discomfort " generally being less prevalent. More specifically, student responses exhibit variability based on both the region and student type (DS or LS) (Figures 3.6 and 3.7). According to the results of the PERMANOVA analysis (shown in Table D.0.2), there were significant differences between DS and LS, while there were no significant differences among regions, and the interaction between the two factors was not significant. The SIMPER analysis to variation between DS and LS showed that both winter discomfort and summer discomfort were higher in the DS group than in the LS group.

Regarding winter, the discomfort in the Alentejo stands out, both for DS (59%) and LS (38%), and the low percentage of DS in the Norte who say they are comfortable (16%). In summer, the highlight is the discomfort perceived by DS in the Norte (63%) and the low level of comfort felt for the same population (16%).

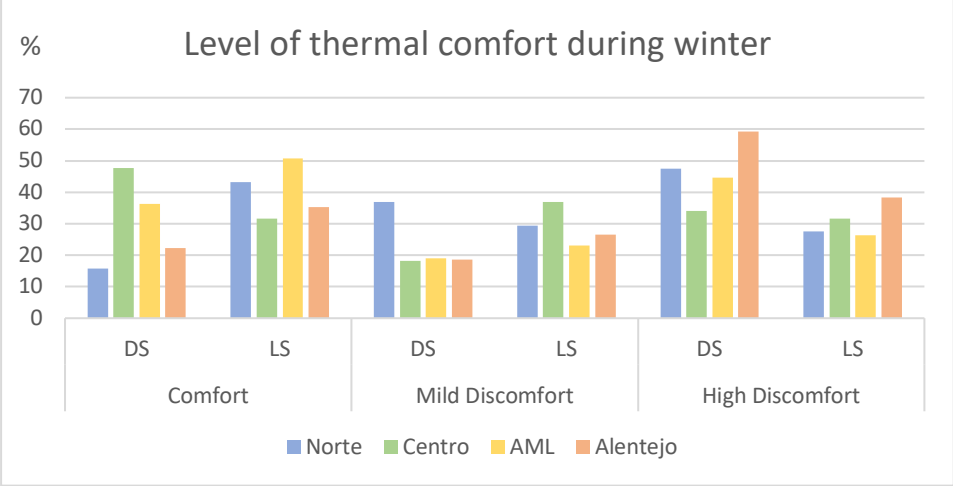

Figure 3.6- Perception of thermal comfort during winter of each population (from comfort to high discomfort).

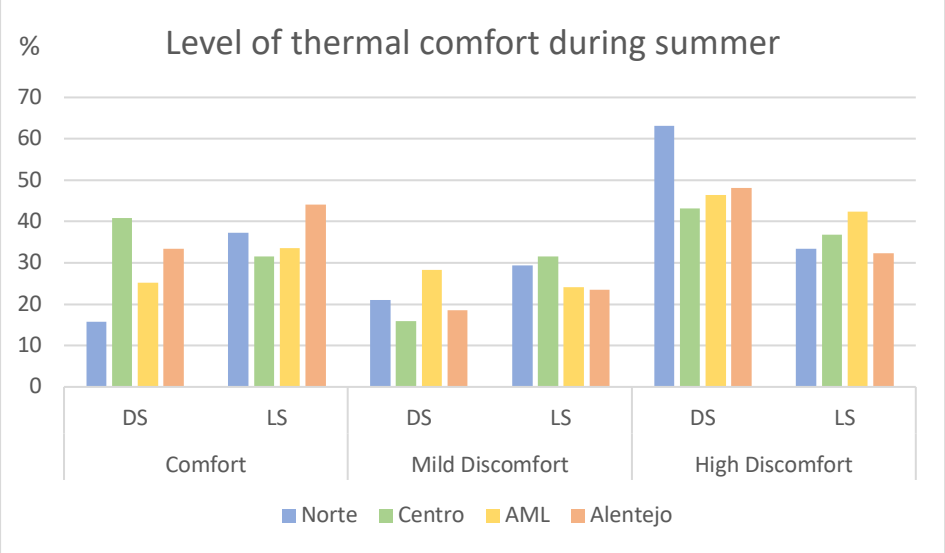

Figure 3.7- Perception of thermal comfort during summer of each population (from comfort to high discomfort).

3.3.4. Heating and cooling equipment

All population groups indicated that they possessed a diverse array of heating and cooling equipment in their residences, with up to ten different types of equipment, although some students indicated that they did not have any kind of equipment (Figure 3.8).

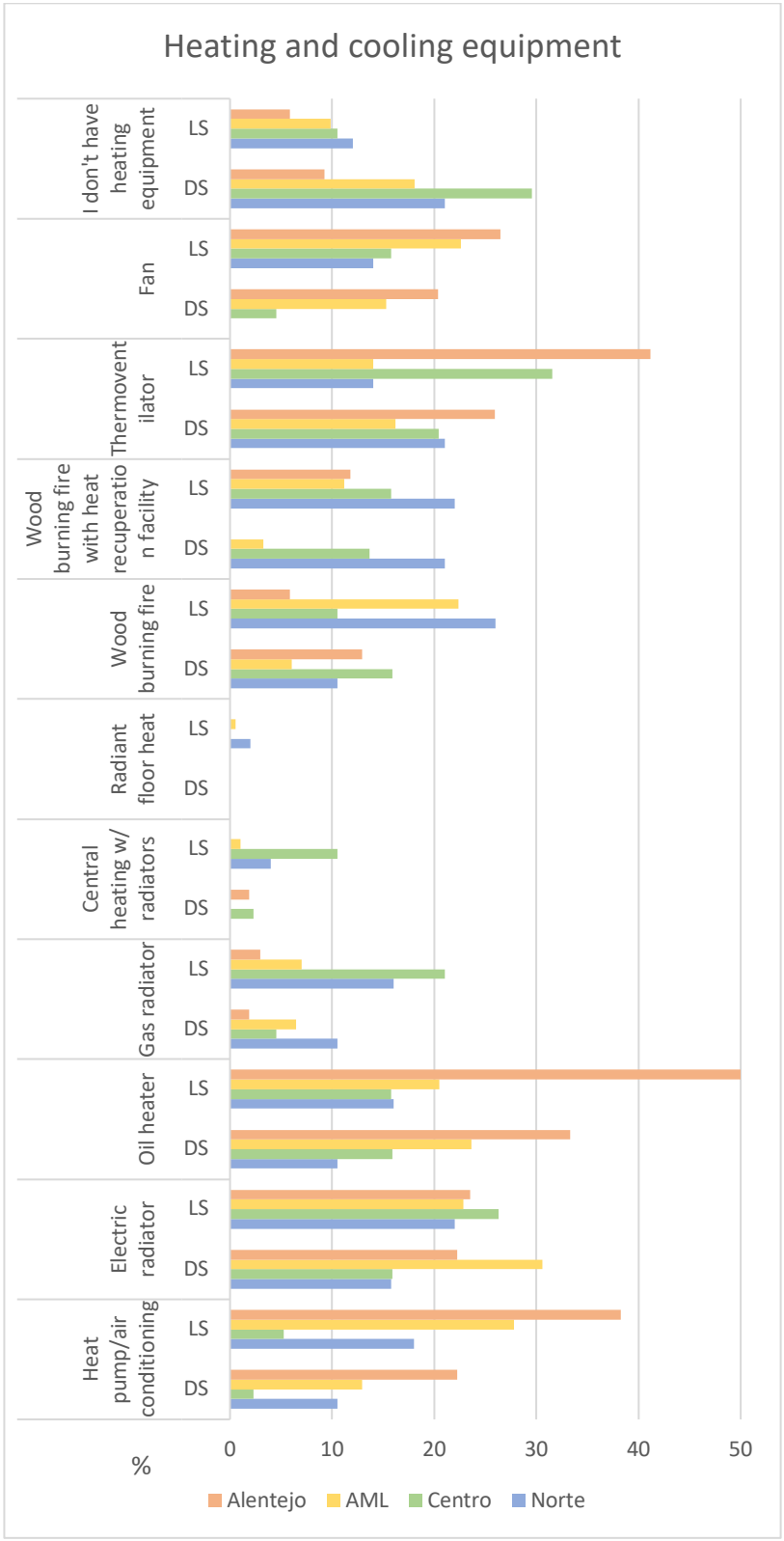

Figure 3.8- Heating and cooling equipment in each population.

As a result of the PERMANOVA analysis, there are significant differences between the types of students (DS versus LS) and among regions (Table D.0.2). Pair-wise tests applied to differences among regions revealed the following pattern: the Norte region is statistically equivalent to the Centro region, forming the Norte-Centro (NC) group, which is significantly different from AML and Alentejo. Furthermore, AML is significantly different from Alentejo.

SIMPER analysis applied to the dissimilarity between the types of students showed that the following devices explained 67% of this dissimilarity: electric radiator, oil heater and thermoventilator were more used by DS, while LS used more heat pump/air conditioning. Results from SIMPER analysis among NC, AML and Alentejo are shown in Table 3.5. In general, NC students reported less use of heating and cooling equipment and specific use of wood burning fire compared to the other regions. The main explanation for the differences between the Alentejo and AML regions is the greater use of oil heater, thermoventilator and heat pump/air conditioning in Alentejo and electric radiator and fan in AML.

Table 3.5- Significantly higher values of equipment ownership in each pair of regions, according to the Simper analysis. NC=Norte and Centro regions.

Devices/ Regions	**NC vs AML**	**NC vs Alentejo**	**AML vs Alentejo**
Heat pump/air conditioning	AML	Alentejo	Alentejo
Electric radiator	AML	Alentejo	AML
Oil heater	AML	Alentejo	Alentejo
Thermoventilator	NC	Alentejo	Alentejo
Fan	-	-	AML
Wood burning fire	NC	NC	-
No heating equipment	NC	NC	-

3.3.5. Energy expenditures

Regarding LS, in all regions except AML, the majority paid their energy-related household bills, with Centro standing out with 79% and Alentejo with 71% (Figure 3.9). Similarly, among DS in all regions, the majority paid these household bills and noteworthy figures include 79% in Norte and 76% in Alentejo (Figure 3.9). In the case of AML, both LS and DS exhibited a relatively even distribution between the two response options, ranging from 48% to 52% (Figure 3.9).

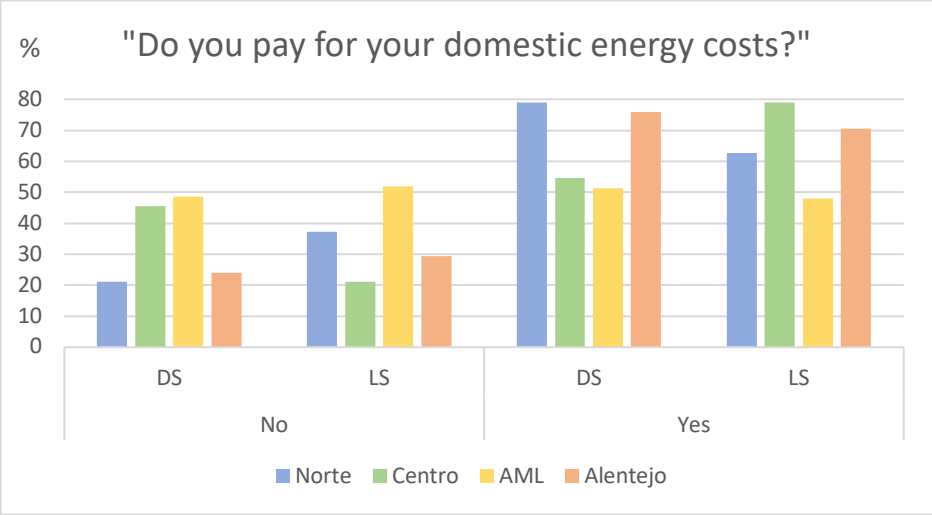

Figure 3.9- Answers from all populations to the question "Do you pay for your domestic energy costs?".

3.3.6. Energy costs challenges

Most students from all populations who answered that they paid their energy-related household bills had a low level of difficulty in paying them (Figure 3.10).

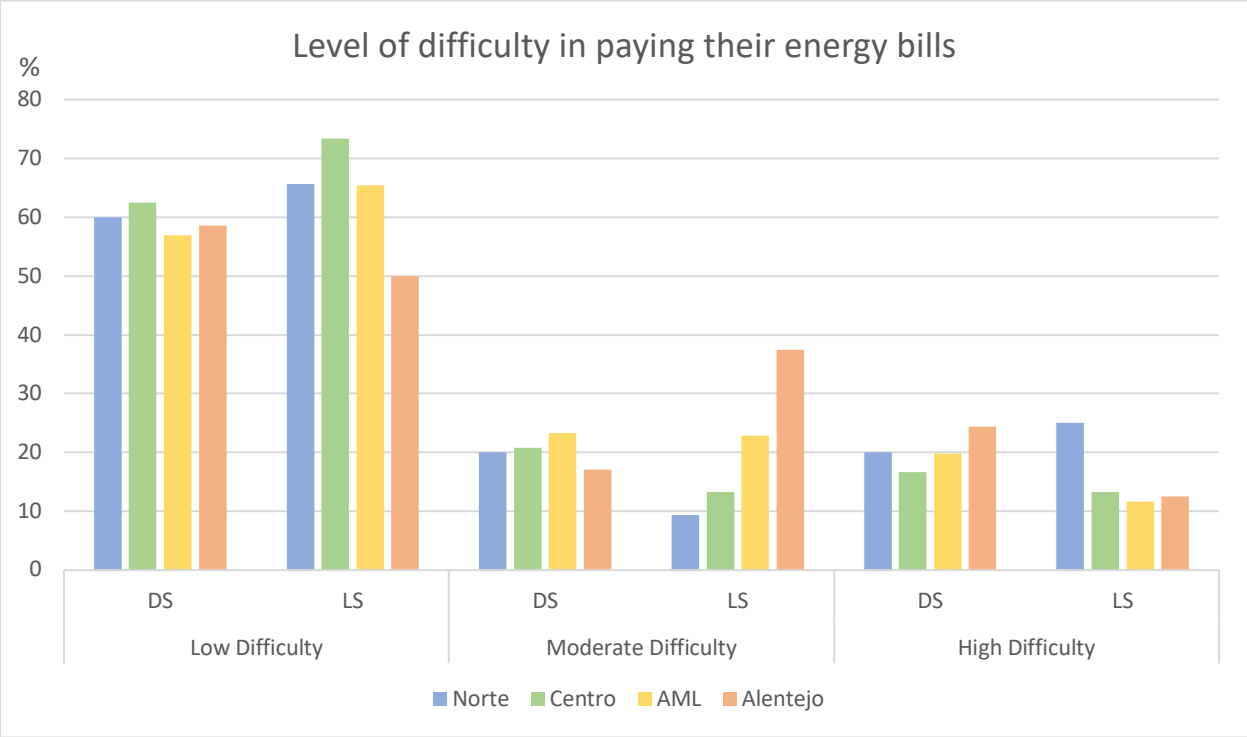

Figure 3.10- Level of difficulty of each population in paying their energy bills (from low to high difficulty).

The results that follow relate to the entire sample of students and not just those who paid their energy bills. The majority of students from all populations (except for DS from AML with 47%) highly refrained from using heating and/or cooling equipment as a way of reducing the energy bills (Figure 3.11).

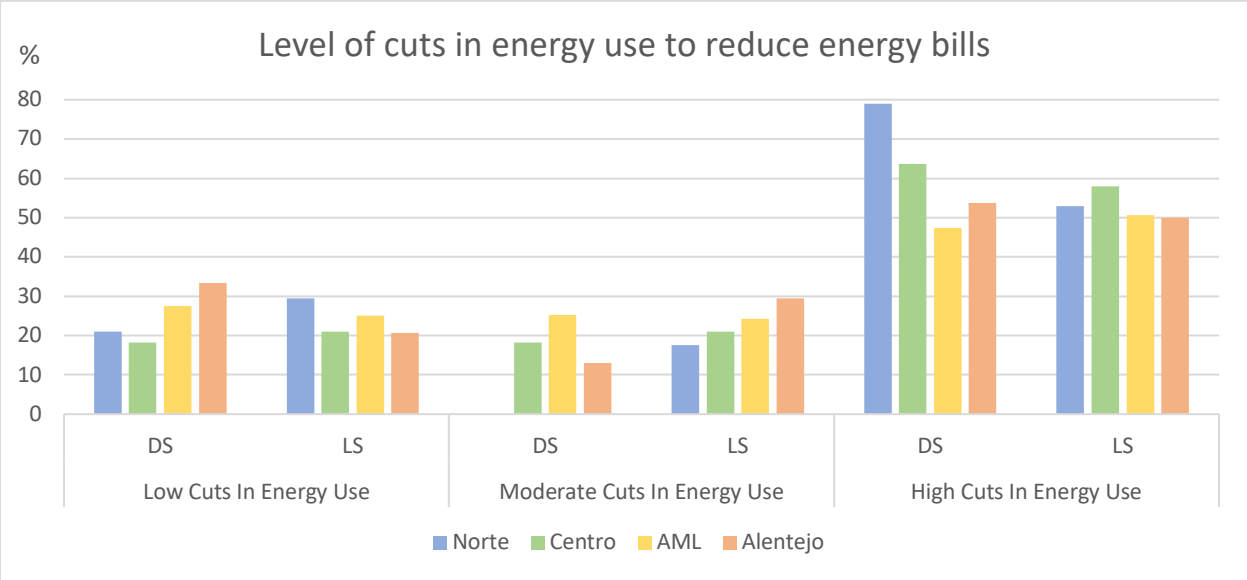

Figure 3.11- Level of cuts in energy use by each population to reduce their energy bills (from low to high cuts in energy use).

These notable reductions can be primarily attributed to the fact that the majority of all populations have reduced their energy consumption for home heating during the winter due to cost considerations (Figure 3.12).

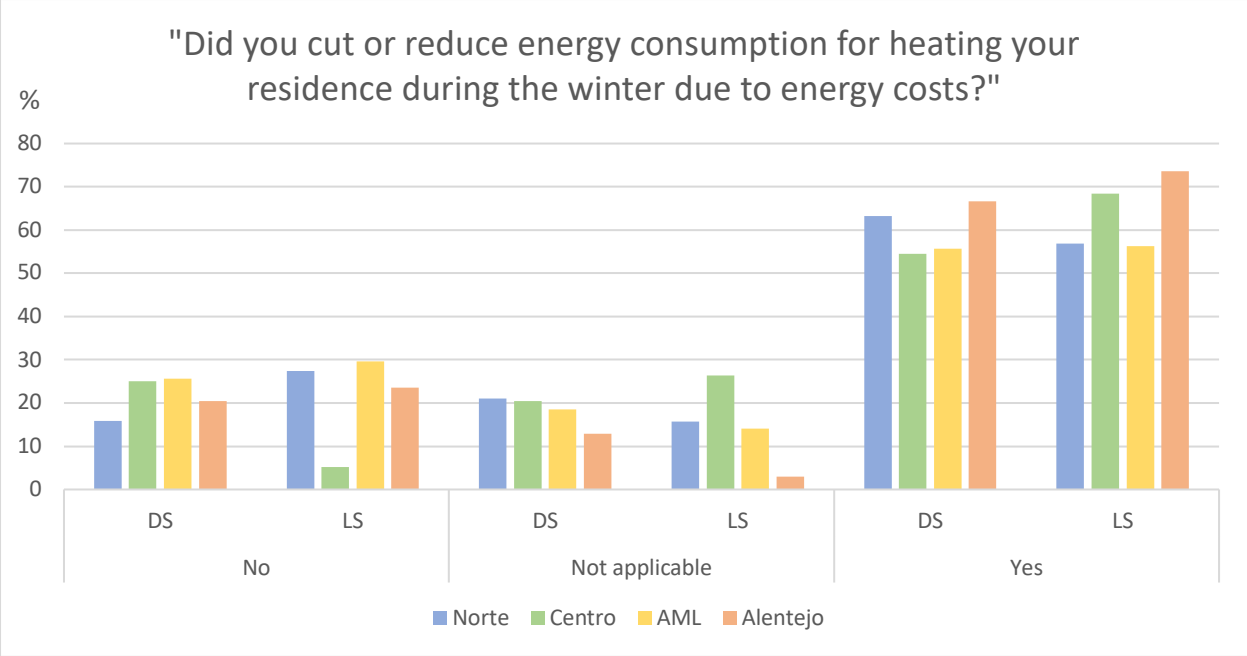

Figure 3.12- Answers from all populations to the question "Did you cut or reduce energy consumption for heating your residence during the winter due to energy costs?".

Regarding the question of whether individuals had curtailed their energy usage to cool their homes during the summer due to cost considerations, the prevailing response in the Norte and Centro regions was "not applicable" for the majority, ranging between 53% and 61% (Figure 3.13).

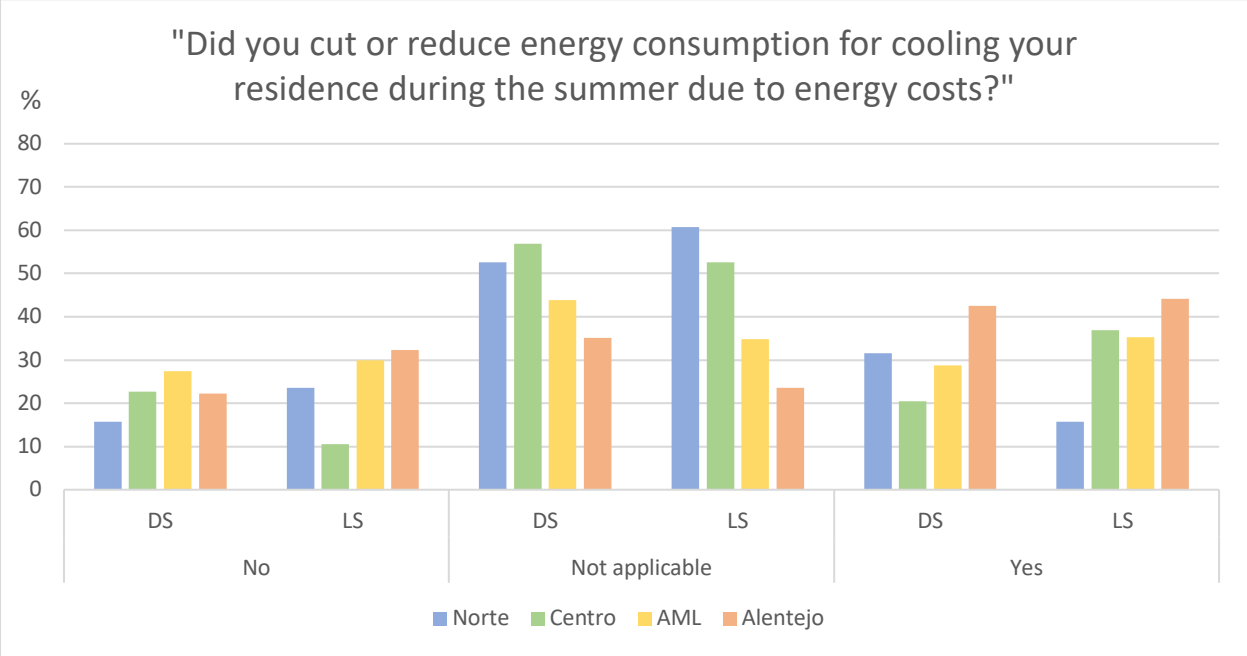

Figure 3.13- Answers from all populations to the question "Did you cut or reduce energy consumption for cooling your residence during the summer due to energy costs?".

Following the PERMANOVA analysis, differences were observed among the regions, there were no significant differences between DS and LS, and the interaction between the two factors was not significant (Table D.0.2). Pair-wise tests applied to differences among regions revealed that the Norte region is statistically equivalent to the Alentejo region, forming the Norte-Alentejo group, which is significantly different from AML. Moreover, there were no defined pattern for Centro.

In relation to the SIMPER analysis, Norte-Alentejo exhibits higher values than AML for the "level of difficulty in paying their energy bills", the "level of cuts in energy use to reduce energy bills", the answer to "Did you cut or reduce energy consumption for heating your residence during the winter due to energy costs?".

In summary, it can be inferred that AML is more favourable (students face fewer difficulties), than Alentejo and Norte regions, where students experience higher levels of difficulty in paying their energy bills and higher levels of cuts in energy consumption.

3.3.7. Energy saving

The vast majority (more than 60%) of students across all populations exhibited a high level of adoption of measures to endure heat or cold conditions instead of using heating or cooling equipment (Figure 3.14).

The Centro region stands out with the highest values, recording 84% of DS and 95% of LS adhering to this practice. Among DS, values are relatively consistent across regions, with 84% in the Norte and Centro regions, 76% in AML, and 83% in Alentejo (Figure 3.14).

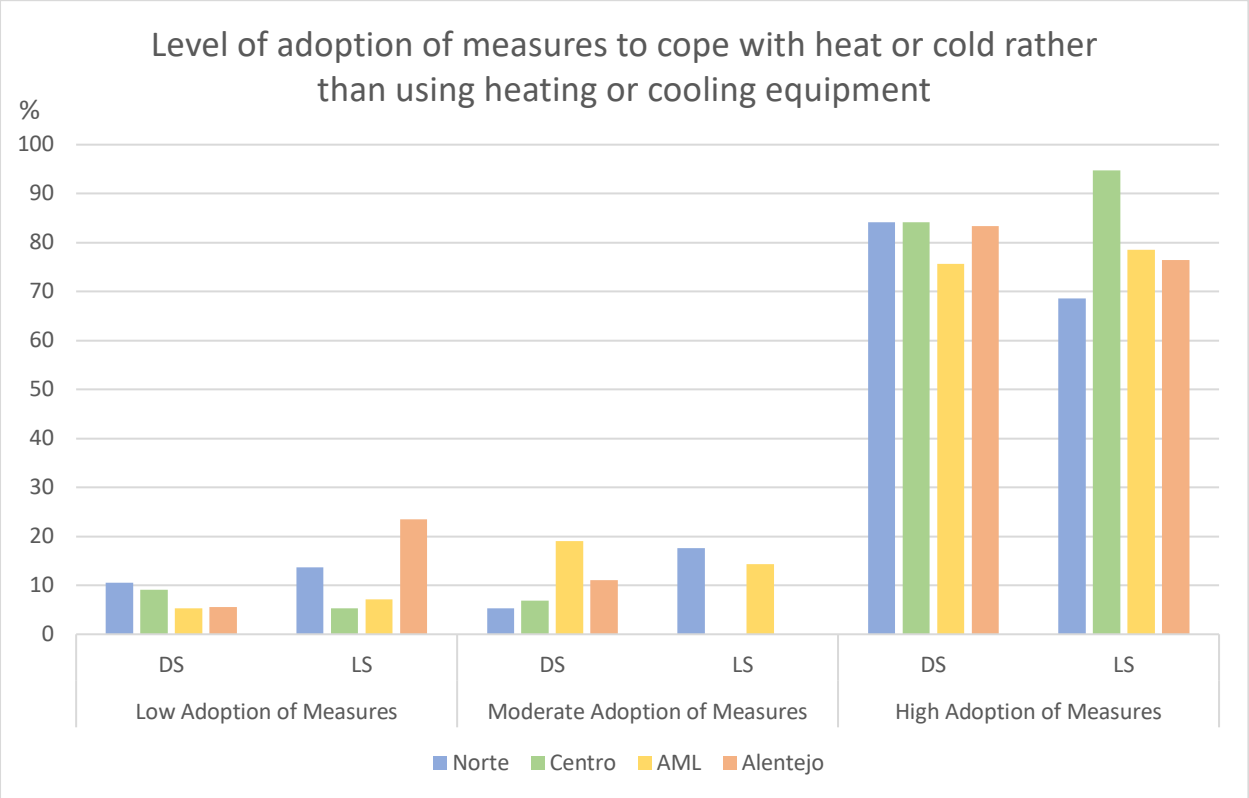

Figure 3.14- Level of adoption of measures by each population to cope with heat or cold rather than using heating or cooling equipment.

3.3.8. Building conditions

Regarding the construction year of the students' residing buildings, Figure 3.15 shows the distribution of the populations in five categories: ”Pre 1920”, “1920-1990”, “1991-2006”, “Post 2006”, and “Don't know”.

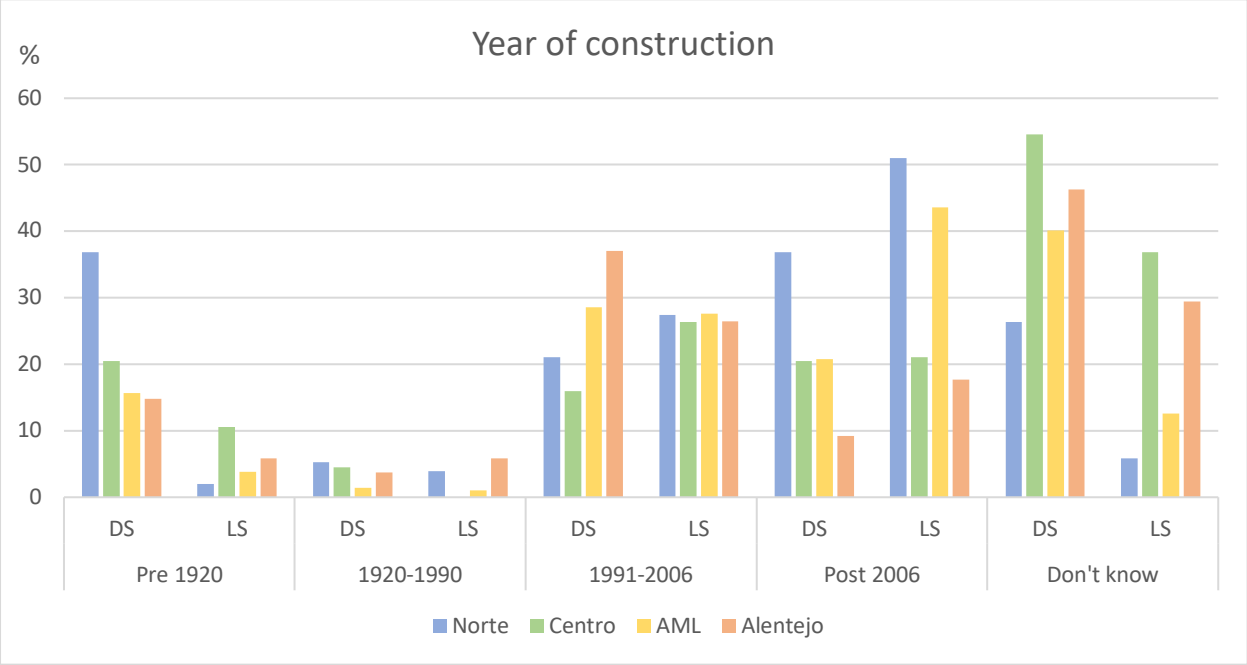

Figure 3.15- Year of construction of the building where students from each population lived.

The majority of all the populations (except the Norte DS) stated that there were problems in the building where they lived, such as draughts, cracks, humidity or mould (Figure 3.16).

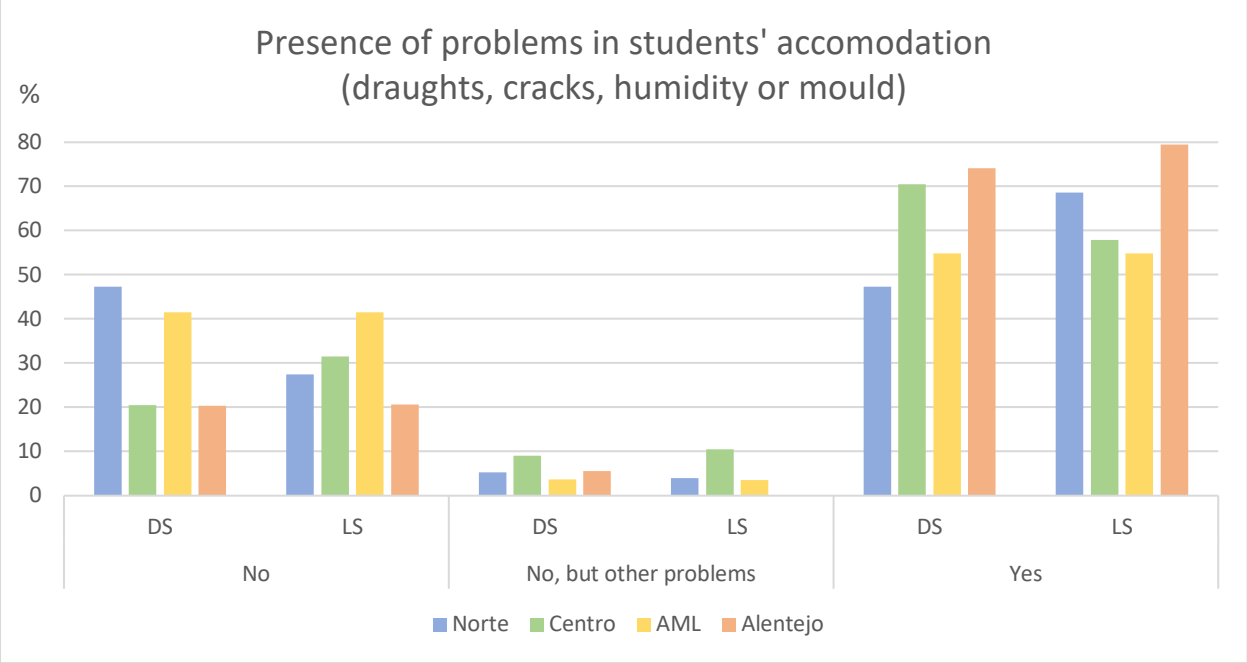

Figure 3.16- Presence of problems (draughts, cracks, damp or mould) in the accommodations of each population.

Moreover, the vast majority of students from all populations felt that the poor building conditions of their home affected them (Figure 3.17).

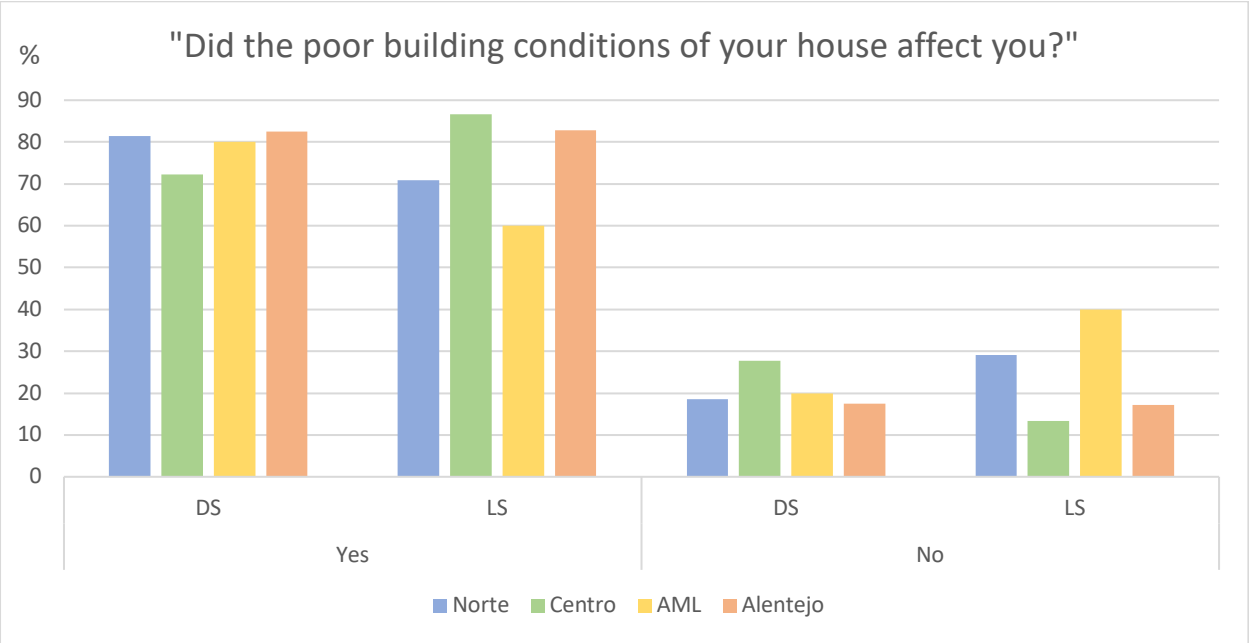

Figure 3.17- Answers from all populations to the question "Did the poor building conditions of your house affect you?".

As a result of the PERMANOVA analysis, in relation to the housing conditions, differences were observed among the regions and between the types of students (LS and DS), and the interaction between the two factors was not significant (Table D.0.2). Pair-wise tests applied to differences among regions revealed that the AML is statistically different from the Alentejo region, and there was no defined pattern for Centro and Norte.

SIMPER analysis applied to the dissimilarity between the types of students showed that DS exhibits higher values than LS for the "year of construction of the building they live in" (older buildings for DS) and for the "presence of problems in students' accommodation (draughts, cracks, humidity, or mould)".

In relation to the SIMPER analysis among AML and Alentejo, Alentejo exhibits higher values than AML for the "year of construction of the building they live in" (older buildings for Alentejo) and for the "presence of problems in students' accommodation (draughts, cracks, humidity, or mould)".

In conclusion, it can be inferred that the Alentejo and DS share the common characteristics of older buildings and a higher incidence of housing problems, and these distinctions are statistically significant.

3.3.9. Impacts of thermal discomfort and poor building conditions

Across all populations, the levels of impact resulting from thermal discomfort on education and health predominantly exhibit higher values within the low impact range (Figures 3.18 and 3.19).

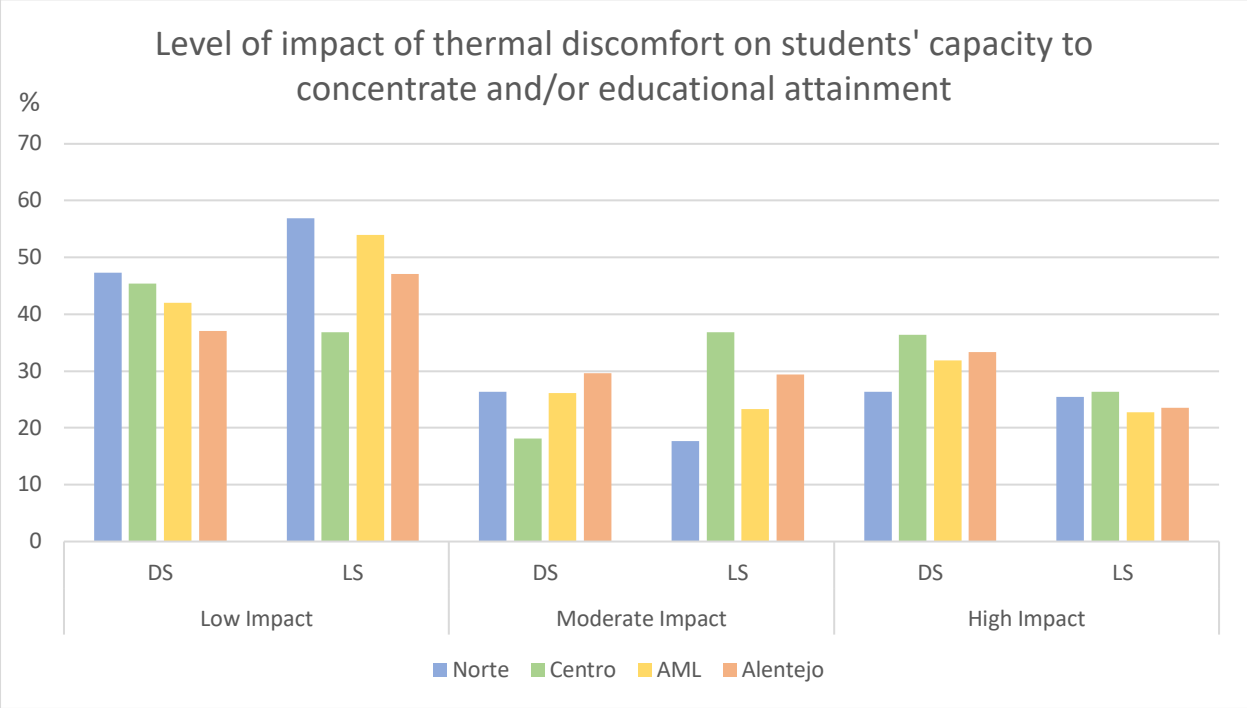

Figure 3.18- Perception of the level of impact of thermal discomfort on the capacity to concentrate and/or educational attainment of each population (from low to high impact).

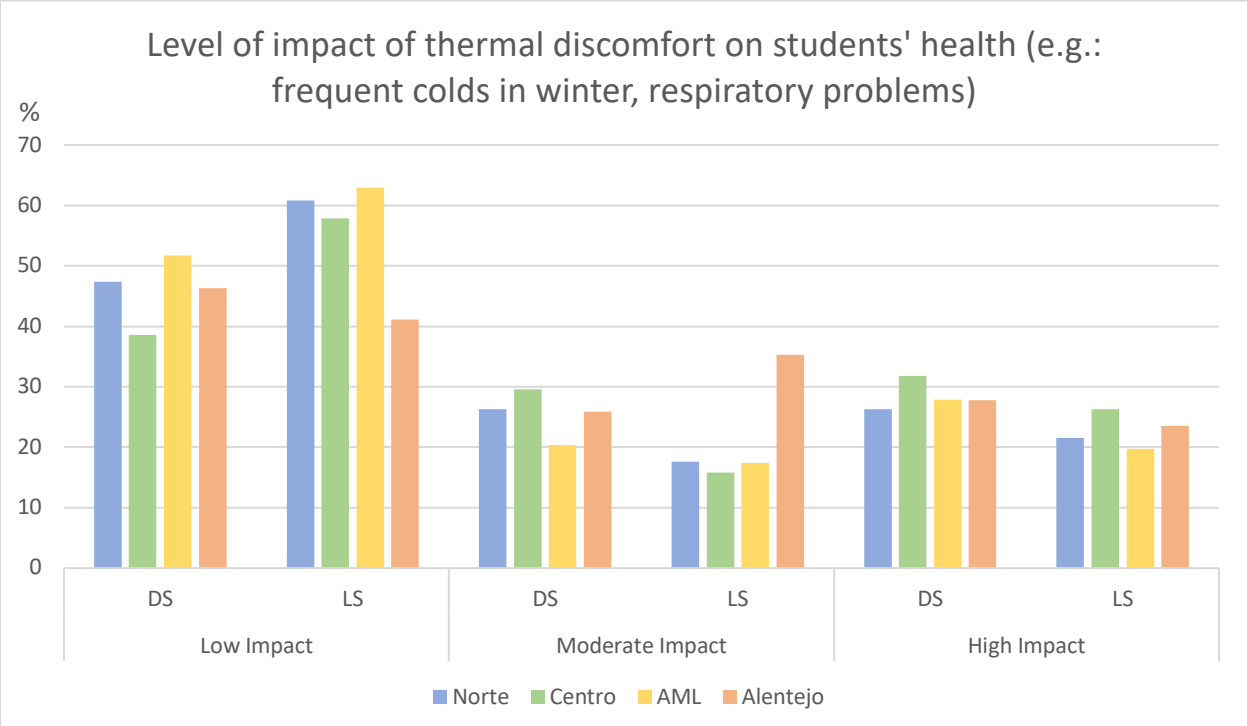

Figure 3.19- Perception of the level of impact of thermal discomfort on the health (e.g.: frequent colds in winter, respiratory problems) of each population (from low to high impact).

According to Figure 3.20, the majority of students from all populations, when paying energy-related household bills, had a low level of limitation on their ability to purchase other goods and services, including items like medicines or internet access.

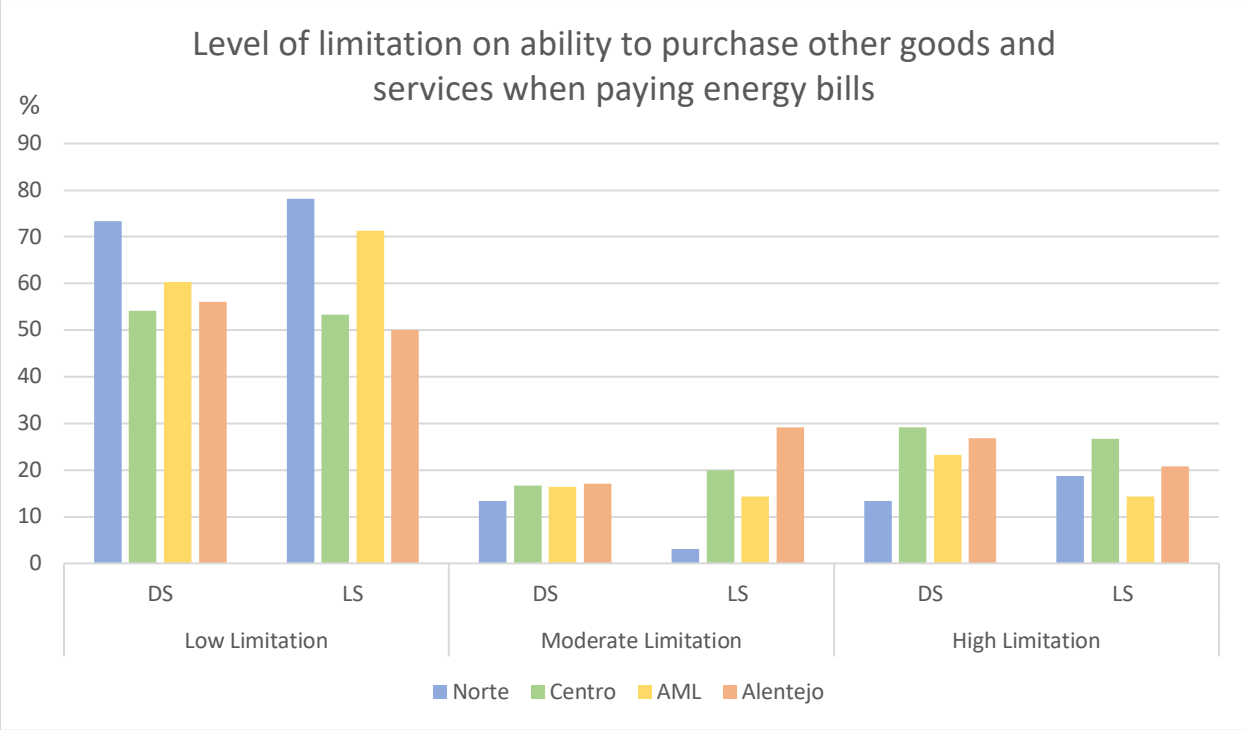

Figure 3.20- Perception of the level of limitation of each population in terms of their ability to purchase other goods and services when they pay their energy bills (from low to high limitation).

According to the PERMANOVA analysis, differences were observed among the regions, but there were no significant differences between DS and LS, and the interaction between the two factors was not significant (Table D.0.2). Pair-wise tests applied to differences among regions revealed that the Centro region is statistically equivalent to the Alentejo region, forming the Centro-Alentejo group, which is significantly different from AML. Moreover, there were no defined pattern for Norte.

Regarding the Simper analysis, Centro-Alentejo exhibits higher values than AML for the "level of limitation on ability to purchase other goods and services when paying energy bills" and the "level of impact of thermal discomfort on students' capacity to concentrate and/or educational attainment".

In summary, it can be inferred that AML is more favourable (students face fewer impacts), than Alentejo and Centro regions, where students experience higher limitations and impacts.

Finally, among students who perceived the poor building conditions of their homes as impactful, the primary effect across all populations was feeling uncomfortable, and the secondary effect, ranking second highest, was a reduction in their capacity to concentrate on their work or studies (Figure 3.21).

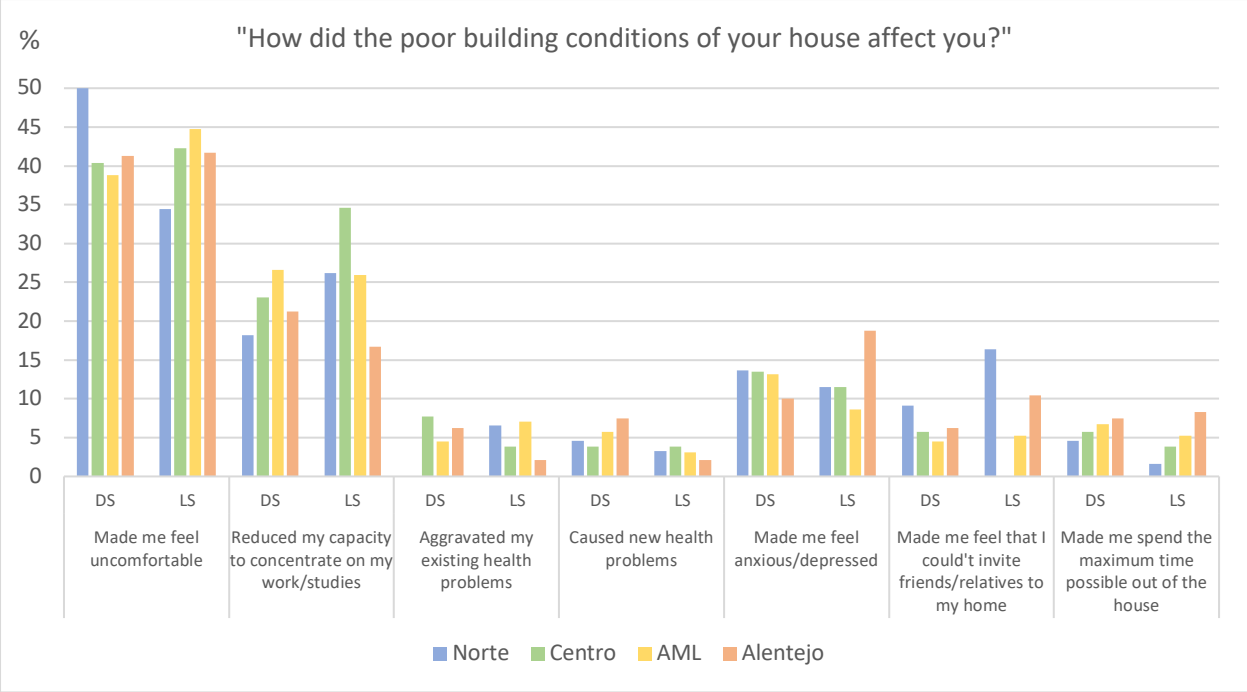

Figure 3.21- Ways in which the poor building conditions of each population's residences affected them.

3.4. Discussion

Most displaced students (DS) or local students (LS) from the four mainland Portuguese regions studied (Norte, Centro, AML, and Alentejo) felt uncomfortable (mild or high discomfort) in summer and winter, except for LS in AML in winter, where the majority felt comfortable. No differences in the perceived thermal comfort were found among regions, but differences in this perception were observed between DS and LS. Both winter discomfort and summer discomfort were higher in the DS group than in the LS group. In particular, the highest values for the percentage of DS with discomfort in winter were observed in Alentejo region, while the highest values for discomfort in summer were recorded for DS in the Norte region.

The analysis of the causes of this variation in perceived thermal comfort was organized into three sets of possible causes: heating and cooling equipment ownership, challenges with energy bill payments, and the building conditions in which they lived. However, only two sets showed differences between DS and LS: building conditions and ownership of heating and cooling equipment. DS tend to live in older buildings with more problems (draughts, cracks, damp, or mould), whereas LS have better building conditions. These differences might be explained by the rental status of DS compared to the homeownership status of most LS, which is in accordance with the highlighted students' EP vulnerability stemming from precarious housing conditions in the Private Rental Sector (PRS) (Morris and Genovese, 2018; Kousis *et al.*, 2020; Fong and Kimberley Clare, 2021), as vulnerability to EP often relates to rental conditions and terms, such as housing quality and tenancy stability (Clair *et al.*, 2019). LS also tend to have more heat pumps/air conditioners, which contribute to their greater thermal comfort, while DS tend to own less efficient devices like electric radiators, oil heaters, and thermoventilators, which may explain their increased thermal discomfort compared to LS.

Although no differences were found in the perception of thermal comfort between regions, analyzing the potential causes of discomfort revealed significant differences between regions. In other words, the similar discomfort perceived in the different regions seems to

have had various reasons. Equipment ownership differed significantly among regions, with students in the Alentejo region having more heat pumps/air conditioners than those in AML, potentially due to Alentejo's higher extreme temperature values and older buildings. Regarding building conditions, the Alentejo had significantly older buildings and a higher incidence of housing problems than the AML. In fact, in terms of Portuguese NUTS III (sub-regions), there is an uneven distribution of the ageing index of buildings, with three sub-regions in the Alentejo having the oldest housing stock (Alto Alentejo, Baixo Alentejo and Alentejo Central) (INE, 2023a).

Similarly, Alentejo recorded significantly worse figures for the last set of causes analyzed, challenges with energy bill payments, when compared to the other regions. Students in the Alentejo and Norte regions experienced greater difficulties in paying their energy bills and made greater cuts in energy consumption than those in AML. Some additional factors that may contribute to these difficulties in the Norte region are its high at-risk-of-poverty rate (INE, 2023b) and the presence of social support or scholarships for many respondents from this region. These same factors and the greater difficulties with paying energy bills in the Norte region may explain the high values of percentage of DS feeling thermal discomfort in winter and summer in this region.

Despite the generalized thermal discomfort and potential vulnerability to EP of all populations, when students were asked about the impact resulting from thermal discomfort on their education and health, as well as their limitations in purchasing goods and services when paying energy-related household bills, the most frequent response category was "low impact" or "low limitation". This fact may be explained by a lack of knowledge and/or awareness on this issue or by the tendency to consider it normal and acceptable to feel thermal discomfort at home (Horta *et al*., 2019). However, there were regional differences in these responses. Students in the Alentejo and Centro regions felt greater limitations and impacts from the EP, compared to AML. A factor that may contribute to these limitations in the Centro region is the presence of social support or scholarships for many respondents from this region.

As a result, AML seems to be the most favorable region of all, with students having newer buildings and a lower incidence of housing problems, facing fewer challenges with energy bill payments and, as would be expected, fewer impacts from EP. This result may explain the comfort in winter for LS from AML, but not the discomfort in winter for DS and in summer for both LS and DS in this region. In fact, Castro and Gouveia (2023) showed the vulnerability of university students in Lisbon to EP, which was exacerbated by housing problems, particularly during the winter.

In summary, both the Alentejo region and DS populations were confronted with older buildings and a higher prevalence of housing problems, suggesting they represent potentially more vulnerable populations to EP. Thus, the DS from Alentejo seem to be the most potentially vulnerable to EP among the studied populations, as well as being one of the two populations that perceived the greatest discomfort in winter.

Given that students are neglected by policymakers and that students often do not identify themselves as a vulnerable group to EP (Morris and Genovese, 2018; Castro and Gouveia, 2023), and since they may not be aware of the consequences of experiencing thermal discomfort at home, there is a critical need to shift research and policy focus to raise awareness of the poor quality of student housing. Therefore, policymakers should adapt and formulate policies based on the findings of this study, with particular attention to students in Alentejo and DS at a national level. This should be addressed within the framework of the Portuguese National Strategy for Combating Energy Poverty (ENLPCPE) (Portuguese Republic, 2023b) and the National Plan for Higher Education Accommodation (PNAES) (Portuguese Republic, 2023a).

Firstly, the ENLPCPE should aim to enhance the energy performance of accommodation for these student populations, broaden access to energy services, reduce energy costs, and improve energy literacy. Secondly, as DS face increasingly challenging living conditions due to escalating property market pressures in Portugal (Portuguese Republic, 2023a), addressing this issue necessitates more than just the construction of new student residences or building adaptations, since the PNAES aims to increase the bed capacity from 15,073 to 26,772 until 2026 in a universe of 119,818 DS in public higher education (Portuguese Republic, 2023a). Thirdly, collaborative efforts between ENLPCPE and PNAES are essential, as this issue intersects both domains and requires urgent attention and action from both sides. For instance, actions should be taken directly within the PRS, potentially including incentives for private landlords who rent to DS and for projects that enhance energy efficiency within the PRS. Additionally, minimum efficiency standards should be mandated when renting to higher education students, as proposed by Morris and Genovese (2018).

Moreover, higher education institutions could play a crucial role in addressing this challenge by engaging with energy providers, landlords, local authorities, and student unions. These engagements could facilitate access to affordable energy suppliers, address inefficiencies in student housing, and raise awareness about EP through student unions' collective influence.

Addressing the urgent need for building renovation in Portugal, especially within the PRS and older buildings, should be a priority. Palma *et al*. (2022) suggest a particular focus on renovating older house archetypes, primarily to reduce space heating needs. To achieve this, there is a requirement for more attention to be given to improving overall energy efficiency in buildings, and traditional top-down approaches to building renovation policies have often fallen short in delivering desired outcomes (Palma *et al*., 2022). Palma *et al*. (2022) propose a more effective bottom-up approach, utilizing archetype-based methods to estimate energy needs reduction and a retrofit measures database to calculate investment costs. Their findings emphasize the significance of prioritizing roof renovations when designing support schemes and the combination of internal and external wall insulation as a promising strategy to reduce energy needs during the heating season (Palma *et al*., 2022).

Finally, higher education institutions should be empowered to certify suitable accommodations, ensuring they meet the required energy efficiency standards and minimize the risks of EP among higher education student populations. To make meaningful progress in this field, collaborative efforts involving student groups, higher education institutions, landlords, as well as local and national governments are essential. These stakeholders must work together to enhance the quality of accommodations for higher education students and reduce their vulnerability to EP.

3.5. **Conclusion**

The state of Energy Poverty (EP) in Portugal presents high challenges when compared to other EU nations, primarily attributed to the prevalence of ageing buildings with poor thermal performance which elevates the risk of EP. These housing conditions are especially pertinent for the higher education students' population, who is increasingly vulnerable to EP, mainly due to unstable housing situations within the Private Rental Sector (PRS). Within this population, displaced students stand out as an exceptionally vulnerable group, heavily reliant on the PRS. Notably, in Portugal, the living conditions of displaced students, particularly those with financial limitations, have become increasingly precarious due to the surging pressures within the property market.

Therefore, the present study analysed and compared the thermal comfort and potential vulnerability to EP between displaced and local higher education Portuguese students. In this way, we conducted a survey involving two distinct student populations: Displaced Students (DS) and Local Students (LS). This comprehensive survey encompassed various facets of EP, and the 848 responses to its thirty-two questions were analysed based on the type of student, the region, and the season of the year.

This study sheds light on the thermal discomfort and potential vulnerability to EP among higher education students (DS or LS) across four mainland Portuguese regions (Norte, Centro, AML, and Alentejo). It revealed that most populations commonly experienced discomfort in both summer and winter, with variations observed between the two student groups (it was higher for the DS than for the LS). While regional differences in thermal comfort were not significant, the causes of discomfort varied significantly between regions.

The analysis identified three key factors contributing to perceived thermal discomfort: building conditions, heating and cooling equipment ownership, and energy bill payment challenges. DS tended to reside in older buildings with more structural problems, whereas LS had better building conditions. LS also possessed more energy-efficient equipment, contributing to their enhanced thermal comfort. These differences might be explained by the rental status of DS compared to the homeownership status of most LS, since the vulnerability of DS to EP may be due to the precarious housing conditions in the PRS.

These findings highlighted potentially vulnerable populations, particularly DS from the Alentejo region, who faced older building conditions and more building conditions issues. Despite widespread discomfort and potential vulnerability to EP, students, in general, reported a low impact on their education and health, as well as their purchasing goods and services limitations when paying energy-related household bills. This could be attributed to a lack of awareness of the consequences of such discomfort or a normalization of it.

Recognizing the negligence of students by policymakers and their lack of self-identification as a vulnerable group to EP, this study underscores the urgency of refocusing research and policy attention on the substandard quality of student housing. Policymakers should use this research to tailor policies, with particular consideration for Alentejo students and DS at the national level. This realignment should occur within the framework of the Portuguese National Strategy for Combating Energy Poverty (ENLPCPE) and the National Plan for Higher Education Accommodation (PNAES). Collaboration between ENLPCPE and PNAES is essential, particularly within the PRS, with potential incentives for landlords and the enforcement of minimum efficiency standards for student rentals. To address Portugal's urgent need for building renovations, with a specific focus on the PRS and older buildings, an approach similar to the one proposed by Palma *et al*. (2022) should be adopted, prioritizing older house archetypes, and utilizing a bottom-up methodology.

Lastly, higher education institutions should be empowered to certify suitable accommodations meeting energy efficiency standards, minimizing EP risks among students. Collaboration among student groups, higher education institutions, landlords, and local and national governments is essential to enhance accommodation quality and reduce student vulnerability to EP. Such collaboration could facilitate access to affordable energy, address housing inefficiencies, and raise EP awareness. This collective effort is considered to be pivotal for achieving meaningful progress in this critical area and should be at the centre of necessary future research into collaborative processes in this field.

With regard to the study's limitations, we acknowledge that a more comprehensive analysis would necessitate a more representative sample encompassing all seven Portuguese regions, to avoid an emphasis on the AML in the overall sample. Consequently, we propose

that higher education institutions in all regions of Portugal integrate EP-related questions into their regular student surveys, similar to those included in this study. Such questions should consider the housing situation of students, whether they reside in public institutional housing, private residences, or the PRS, as these distinctions can significantly affect their vulnerability to EP. From the results of these regular surveys, each institution could adapt its actions according to the vulnerability of each student population to EP, involving all relevant stakeholders, including the students themselves.

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Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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4. General Conclusion

Energy poverty (EP) is a critical issue affecting many people, making it difficult for them to maintain comfortable temperatures and to access, pay for, and secure essential energy services in their homes. This multifaceted problem is influenced by factors such as income levels, housing conditions, energy prices, household composition, weather conditions, and climate change.

It is also broadly recognized that some groups are more vulnerable to EP than others, such as people with disabilities, migrants, the elderly, children, and students. Students have a high risk of falling into EP due to various factors, such as a lack of knowledge of energy efficiency measures, tight budgets, or high energy expenditure. This group is often not directly targeted by policymakers and has not been widely considered a vulnerable group, but EP is particularly relevant to them as it intersects with their educational experience, health, and general well-being.

Although there are some studies comparing the perceptions of students from different countries in terms of EP in Europe and South America, there was no study investigating how the perception of EP might be modified if the student was local or an exchange student and how this would interact with the season (winter or summer).

In this context and recognizing this research gap, the first study examined the unique aspects of EP experienced by local students (LS) and exchange students (ES) in Montevideo, Lisbon, and Padua in winter and summer. It delved into the disparities in EP vulnerability between these student populations, shedding light on how distinct factors contribute to their EP experiences. This international perspective showed the varying challenges students face across different cultural, economic, and infrastructural contexts.

Regarding the results of this research, while most students did not explicitly identify themselves as living in EP, a substantial portion reported discomfort during both winter and summer, indicating their vulnerability to EP. The students who perceived the most discomfort were those from Lisbon, and Lisbon was the only city in which most ES and LS reported that poor housing conditions affected them. The vulnerability to EP for the respondents appeared to be linked to accommodation issues, particularly evident during winter in Lisbon and Montevideo, in contrast to more satisfactory housing conditions, notably in Padua. In addition, LS and ES might have distinct perceptions of EP, with ES from colder climates potentially having higher expectations of thermal comfort than LS. The latter group, possibly influenced by economic and cultural factors, might be more adaptable to living in EP, employing alternative strategies to cope with cold conditions.

However, this study had some limitations since the EP situation in Uruguay is less comparable to that in Portugal and Italy due to differences in data collection and policy contexts.

Another limitation is that it was not possible to analyze the Padua ES during the summer (their responses were not representative of the population), since most of them had not yet experienced summer. Concerning future studies, it was suggested that it is essential to examine behavioral patterns, adaptive strategies, and adaptation measures among students to mitigate vulnerability to EP. Finally, expanding the analysis to the national level in each country of this study (Uruguay, Portugal, and Italy), comparing the situation between cities in these countries and between the type of student (local or displaced) was seen as the next step, to provide information on the real-life experiences of EP among university students in these countries.

EP is a significant challenge in Portugal, driven by aging buildings with poor thermal performance. This problem is particularly pronounced among higher education students, especially those in the private rental sector displaced students, in particular, are vulnerable due to financial constraints and rising property market pressures.

In this way, the second study compared thermal comfort and EP vulnerability between DS and LS in Portugal across four mainland Portuguese regions (Norte, Centro, AML, and Alentejo) and different seasons (summer and winter). As would be expected from the discomfort results of the first study, results revealed widespread discomfort in both summer and winter. This discomfort was especially felt by DS, attributed to the fact that DS lived in older, more problematic buildings while LS had better conditions and energy-efficient equipment. These differences might be explained by the rental status of DS compared to the homeownership status of most LS since the vulnerability of DS to EP may be due to the precarious housing conditions in the Private Rental Sector (PRS). Thus, this study highlighted the substantial challenges higher education students face, particularly those living in the PRS and DS.

Despite these results, it was recognized that a more complete analysis for Portugal would require a more representative sample from all seven Portuguese regions, to avoid an overemphasis on AML within the overall sample. In both studies, it was recognized that the sample could have been larger, but this study depended on the number of valid responses obtained. However, the objective was to capture the perceptions, behaviors, and attitudes of the surveyed student populations, which are essential for gaining insights into these potentially vulnerable groups and their lived experiences.

Comparing the two studies, the category of LS in the first study encompassed both DS and LS categories. To explore variations in vulnerability, the focus was directed towards distinguishing between these groups in the subsequent Portuguese case study. However, a part of the DS in the second study included ES, which makes it not appropriate to compare the responses of the Lisbon and AML populations between the two studies. Due to the specificities of each population, three different populations could have been considered in the second study: LS, DS, and ES, which was one of the limitations for comparing both studies.

Furthermore, although both questionnaires covered various aspects of EP and energy awareness, the first had forty-four questions, while the second, based on the first, was simpler, with thirty-two questions, not covering the aspects of “House hunting choices”, “EP concept and perception”, and “Solutions and policies”. In addition, in the first study, only one subsection was subjected to multivariate analysis ("Housing hunting choices"), while in the case of the second study, this was done for five subsections ("Students' perception of thermal comfort during winter and summer", "Heating and cooling equipment", "Energy cost challenges", "Building conditions", "Impacts of thermal discomfort and poor building conditions"). Thus, the second study analyzed the causes of variation in perceived thermal comfort as a function of variations in three sets of possible causes: challenges with energy bill payments, heating and cooling equipment ownership, and the building conditions in which they lived. Only

these last two sets showed differences between DS and LS, while the similar discomfort perceived in the different regions seemed to have had other causes.

Since EP vulnerability can vary significantly even within the same country, the second study emphasized that it is imperative to tailor interventions based on regional and institutional differences. It also highlighted the need for immediate policy changes, building renovations, and collaborative efforts among stakeholders to mitigate this problem.

To effectively combat EP, it was suggested that higher education institutions in Portugal should incorporate questions related to EP in their regular student surveys, such as those included in these studies. These questions should capture the unique aspects of EP experienced by different student populations: DS, ES, and LS. Moreover, institutions should consider the housing situation of DS, whether they reside in public institutional housing, private residences, or the PRS, as this distinction can significantly impact their vulnerability to EP. Based on the findings of these regular surveys, each institution could act according to the vulnerability of each population to EP, involving the necessary stakeholders, including the students themselves.

In conclusion, the results of the first and second studies underline the urgency of tackling EP among higher education students, as it is a widespread problem with various impacts that most are unaware of. EP not only affects students' wellbeing but also has implications for their academic success and overall quality of life. Therefore, by recognizing the nuances of vulnerability to EP, policymakers, and institutions can better allocate resources and implement specific measures to improve students' living conditions, raise awareness of the issue, and ensure that their educational paths are not unduly hindered by EP.

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A.
Annex A - Survey - Chapter 2

A.1. Survey | Students' perception about Energy Poverty (Portugal, Uruguay, and Italy)

*Mandatory

1. **For you, what does it mean to live in Energy Poverty?** *

Select only one option.

- I'm not aware of this concept.
- To live without money to pay for the energy costs of my home.
- To live without being able to adequately heat/cool or provide other required energy services in my home at affordable cost (lighting, use of appliances, etc).
- Other: _____

A.2. But first… Let me know a little more about you.

2. **Where are you from?** *

Select only one option.

- Italy
- Portugal
- Uruguay
- Prefer not to state
- Other: _____

3. **Are you a displaced student?** *

Select only one option.

- Yes
- No
- Other: _____

4. **What do you study?** *

Select only one option.

- Architecture/Engineering/Technology
- Arts/Humanities
- Life sciences/Medicine

- Mathematics/Natural sciences
- Social sciences

5. **What is your level of study?** *

Select only one option.

- 1st Year Undergraduate
- 2nd Year Undergraduate
- Final Year Undergraduate
- Masters
- Ph.D.
- Other: _____

6. **Is your university public or private?** *

Select only one option.

- Public
- Private

7. **What is your employment status?** *

Select only one option.

- Part-time during term-time
- Holiday/Seasonal Employment
- Un-paid internship/Voluntary
- Not currently in employment
- Other: _____

8. **Have you ever studied abroad (in Lisboa, Montevideo or Padova)?** *

Select only one option.

- Yes, I'm currently studying abroad (in Lisboa, Montevideo or Padova).
  Continue to question 9
- Yes, I have already studied abroad (in Lisboa, Montevideo or Padova).
  Continue to question 9
- Yes, but not in Lisboa, Montevideo or Padova.
  Continue to question 13
- No, and I'm currently studying in my home country.
  Continue to question 13

A.3. About your studying abroad situation

9. **Where are you studying/ have you studied abroad?** *

Select only one option.

- Lisboa
- Montevideo
- Padova

10. **Do/did you benefit from any social support or scholarship?** *

Select only one option.

- Yes, a social support from my home university.
- Yes, a scholarship for the duration of my exchange.
- Yes, both the social support and the scholarship.
- No.
- Other: _____

11. **Which of these best describes your accommodation, while studying abroad?** *
Select only one option.

- Privately rented house/flat rented from a letting agent
- Privately rented house/flat rented directly from the owner
- Rented room through a housing agency
- Rented room directly from the owner
- Sublet a room
- Living/lived in a dormitory or other accommodation provided by the receiving University
- Living/lived in a place I own
- Living/lived in a place that belongs to my family or friends
- Other: _____

12. **How much rent do/did you pay?** *
Select only one option.

- Nothing
- 0€ to 99€
- 100€ to 199€
- 200€ to 299€
- 300€ to 399€
- 400€ to 499€
- 500€ to 599€
- 600€ to 699€
- 700€ or more

Continue to section 5

A.4. About your studying situation

13. Where do you study? *
Select only one option.

- Lisboa
- Montevideo
- Padova

14. Do you benefit from any social support or scholarship? *
Select only one option.

- Yes, a social support.

- Yes, a scholarship.
- No
- Other: _____

15. Which of these best describes your current accommodation? *
Select only one option.

- Privately rented house/flat rented from a letting agent
- Privately rented house/flat rented directly from the owner
- Rented room through a housing agency
- Rented room directly from the owner
- Subletted a room
- Living in a dormitory or other accommodation provided by my University
- Living in a place I own
- Living in a place that belongs to my family or friends
- Other: _____

16. How much rent do you pay? *
Select only one option.

- Nothing
- 0€ to 99€
- 100€ to 199€
- 200€ to 299€
- 300€ to 399€
- 400€ to 499€
- 500€ to 599€
- 600€ to 699€
- 700€ or more

17. How long have you lived in this accommodation? *
Select only one option.

- For less than 3 months.
- Between 3 and 6 months.
- Between 6 and 9 months.
- Between 9 and 12 months.
- Between 1 and 2 years.
- Between 2 and 3 years.
- For more than 3 years

18. Is it a full-time residence or do you go to another house during the weekends? *
Select only one option.

- Yes, it's a full-time residence.
- No, sometimes I go to another house during the weekends.
- No, I always go to another house during the weekends.

19. During the COVID-19 pandemic (and online classes), did you leave this accommodation permanently or temporarily? *

Select only one option.

- I left permanently.
- I left temporarily.
- I never left.

A.5. Criteria when house hunting

20. How important, if at all, were the following criteria when you were house hunting? *

Select only one option per line.

	Not applicable	*Not all important*	*Not important*	*Moderately important*	*Important*	*Very important*
Cost of Rent						
Age of the House						
General Aesthetics of the House						
Size						
Location and Convenience						
Neighbourhood Safety						
Appearance of the Area						
Light and Sun exposure						
Available heating and/or cooling equipment						
Presence of Energy Efficiency Measures (e.g. double glazing windows)						
Opinions of the Housemate(s)						

A.6. Energy comfort

21. What heating device(s) do/did you use? *

Select all that apply.

- Air conditioner
- Electric heater
- Central heating for the whole building (adjustable in each room)
- Fireplace
- District heating
- Central heating with radiators
- Gas-Fired Space Heaters

- Radiant floor heat
- None, I can't/couldn't afford it
- None, I don't/didn't need it
- None, I don't/didn't think about it
- None, don't/didn't exist
- Other: _____

22. How would you describe the overall level of comfort in your accommodation during the winter? *

Select only one option.

- Much colder than I would have liked
- A bit colder than I would have liked
- About right
- A bit warmer than I would have liked
- A lot warmer than I would have liked
- Both too warm and too cold
- Not applicable
- Other: _____

23. Did/Have you cut back on energy use in your accommodation, during the winter, because you were concerned about the costs? *

Select all that apply.

- No.
- Yes, turned the heating off, even though I would have preferred to have it on.
- Yes, turned the heating down, even though I would have preferred it to be warmer.
- Yes, turned the heating down or off in some rooms but not others, even though I would have preferred not to.
- Yes, had to cut back on my fireplace expenses.
- Yes, used less hot water than I would have preferred.
- I wanted to, but I couldn't change the heating level.
- Not applicable
- Other: _____

24. What cooling device(s) do/did you use? *

Select all that apply.

- Air conditioner
- Electric fan
- Central cooling for the whole building (adjustable in each room)
- Central cooling station
- None, I can't/couldn't afford it
- None, I don't/didn't need it
- None, I don't/didn't think about it

- None, don't/didn't exist
- Other: _____

25. How would you describe the overall level of comfort in your accommodation during the summer? *

Select only one option.

- A lot warmer than I would have liked
- A bit warmer than I would have liked
- About right
- A bit colder than I would have liked
- Much colder than I would have liked
- Both too warm and too cold
- Not applicable

26. Did/Have you cut back on energy use in your accommodation, during the summer, because you were concerned about the costs? *

Select all that apply.

- No.
- Yes, turned the fan/air conditioner off, even though I would have preferred to have it on.
- Yes, turned the fan/air conditioner down, even though I would have preferred it to be cooler.
- Yes, turned the fan/air conditioner down or off in some rooms but not others, even though I would have preferred not to.
- I wanted to, but I couldn't change the cooling level.
- Not applicable
- Other: _____

27. Do/did you pay for the household (energy related) bills? *

Select only one option.

- Yes, for all of them.
- Yes, for some of them.
- No, they are/were included in rent payments.
  Continue to question 32.
- No, I don't/didn't pay for this at all.
  Continue to question 32.

28. Have you been/were you delayed/unable to pay any of these bills due to lack of money? *

Select all that apply.

- Yes: rent or mortgage payments.
- Yes: gas, electricity or other energy bills.
- No.
- Other: _____

A.7. Energy bills

29. How do/did you pay for the following household bills? *

Select only one option per line.

	Included in rent payments	*Paid directly to the supplier by myself/my housemates*	*Paid separately to landlord*	*Paid separately to another service*	*Not applicable, we don't/didn't pay for this at all*	*I don't know*
Electricity						
Gas						
Fireplace expenses						

30. Do/did you check the details of your energy bills? *

Select only one option.

	1	**2**	**3**	**4**	**5**	
Never						**Always**

31. Do/did you find it difficult to pay for energy? *

Select only one option.

- Yes, it is/was expensive.
- No, it is/was cheap.
- No, but I can/could afford it.

A.8. Energy saving

32. What stops/stopped you from using more energy? *

Select all that apply.

- I can/could not afford higher consumption.
- The lack of equipment existing.
- I can/could not afford to buy efficient equipment.
- I have/had pressure from the owner and/or my housemates to use less energy.
- Its relationship with greenhouse emissions and climate change.
- I spend/spent most of the day outside.
- Nothing, I do/did not mind spending more energy.

33. What action(s) do/did you take to use less energy? *

Select all that apply.

- Spend/spent more time outside (library, restaurant, café, supermarket, etc.)
- Consciously take/took actions to reduce consumption (buy/bought more efficient appliances, etc.)
- Wear/wore more or less clothes
- Endure less consumption, even though I prefer/would prefer to use more Insulate/insulated my house
- None
- Other: _____

A.9. Housing conditions and satisfaction with accommodation

34. Are/were the following present in your current, or previous homes/rooms you have lived whilst you have been a student? With what level of impact? *

Select all that apply.

	Yes, in current accommodation (long term negative impact).	*Yes, in current accommodation (short term negative impact).*	*Yes, in previous accommodation (long term negative impact).*	*Yes, in previous accommodation (short term negative impact).*	*Yes, in both current and previous accommodation (long term negative impacts).*	*Yes, in both current and previous accommodation (short term negative impacts).*	*No.*
Damp or mold on walls or ceilings							
Leaking roof/windows							
Windows and floors showing signs of deterioration							
Electrical safety hazards							
Slugs/mice or other infestation							

35. Overall, how satisfied are/were you with your accommodation? *

Select only one option.

	1	**2**	**3**	**4**	**5**	
Very Dissatisfied						**Very Satisfied**

36. Do/did the poor housing conditions of your accommodation affect you in any of the following ways? *

Select all that apply.

- It makes/made me feel uncomfortable.
- It has been decreasing/decreased my ability to concentrate on my studies.
- It has made/made an existing health problem(s) worse.
- It has brought/brought on a new health problem(s).
- It makes/made me feel miserable.
- It makes/made me feel anxious or depressed.
- I don't/didn't feel able to invite friends or family to the house.
- I have spent/spent as much time as possible away from the house.
- My house conditions are/were not poor.
- Other: _____

A.10. Energy Poverty - what is your perception?

Energy Poverty is a set of conditions where "individuals or households are not able to adequately heat/cool or provide other required energy services in their homes at affordable cost", due to a combination of low income, poor housing energy performance and energy costs.

In 2020, 8% of the European Union's population stated that they were unable to keep their home adequately warm, with around 18% of Portuguese people and 11% of Italian people experiencing one of the many forms of Energy Poverty (Eurostat, 2021).

37. Do/did you consider yourself to be in Energy Poverty? *

Select only one option.

- Yes
- No

38. How concerned are you about this problem? *

Select only one option.

	1	2	3	4	5	
Not concerned at all						**Really concerned**

39. To what extent has your perception of this problem changed with the COVID-19 pandemic? *

Select only one option.

- It has intensified.
- My perception came during the pandemic.
- It has reduced.
- My perception has not changed.

40. How do you foresee this problem evolving with climate change? *

Select only one option.

	1	2	3	4	5	
It will get much worse						**It will get much better**

41. What solutions (individual and/or collective) and policies do you use/suggest to minimize the problem?

A.11. To finish a few more questions about you

42. What sex were you assigned at birth? *

Select only one option.

- Female
- Male
- Intersex
- Prefer not to state
- Other: _____

43. What is your current gender identity? *

Select only one option.

- Woman
- Man
- Non-binary
- Genderqueer
- Prefer not to state
- Other: _____

44. How old are you? *

Select only one option.

- Under 18
- 18-20
- 21-24
- 25-29
- 30+
- Prefer not to state

B. Annex B - Supplementary Figures - Chapter 2

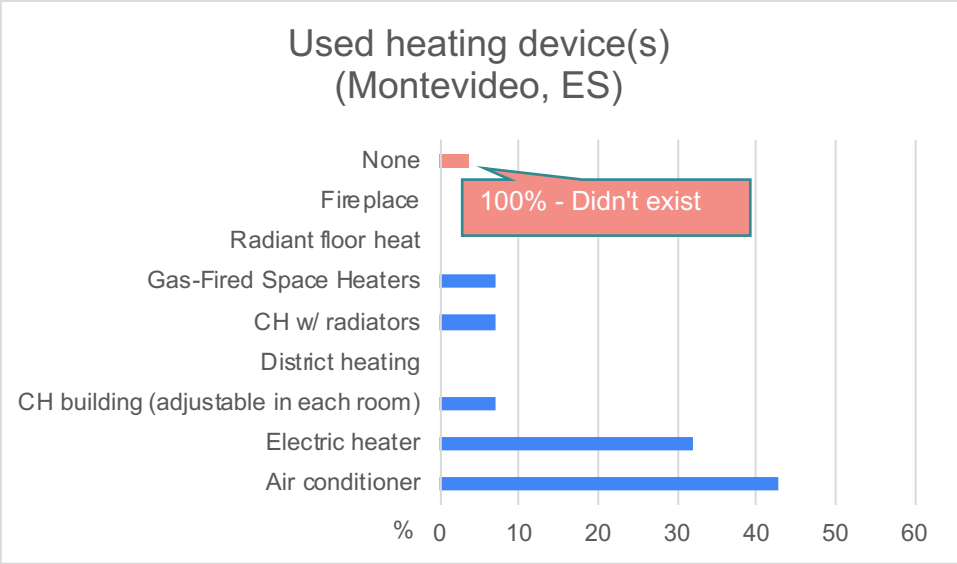

Figure B.0.1- Accommodation specifications related to the device(s) used for heating (ES of Montevideo).

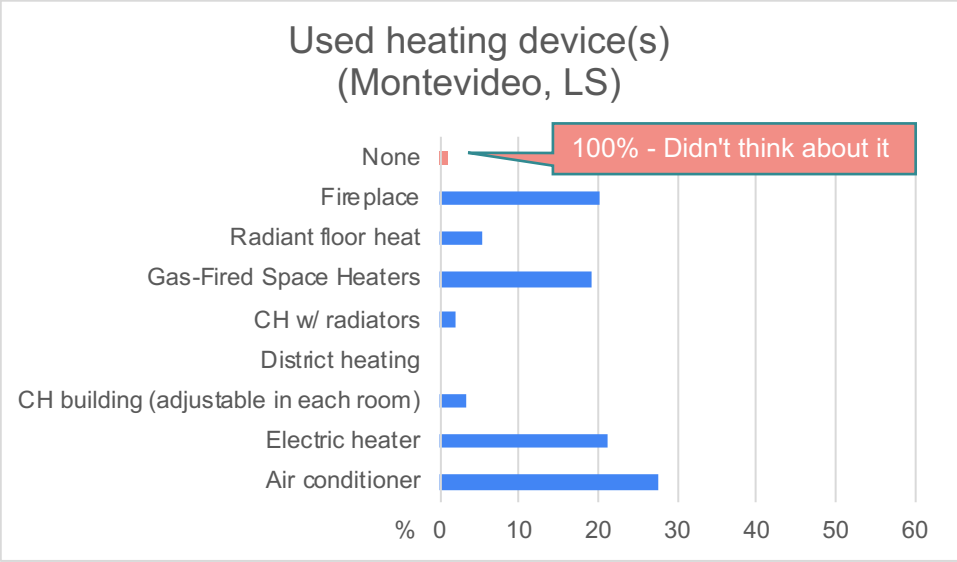

Figure B.0.2- Accommodation specifications related to the device(s) used for heating (LS of Montevideo).

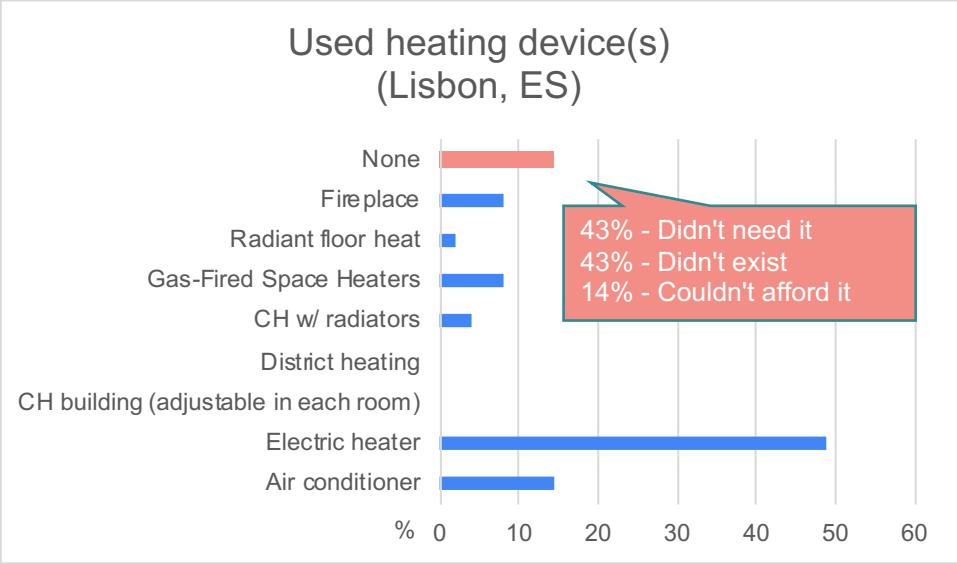

Figure B.0.3- Accommodation specifications related to the device(s) used for heating (ES of Lisbon).

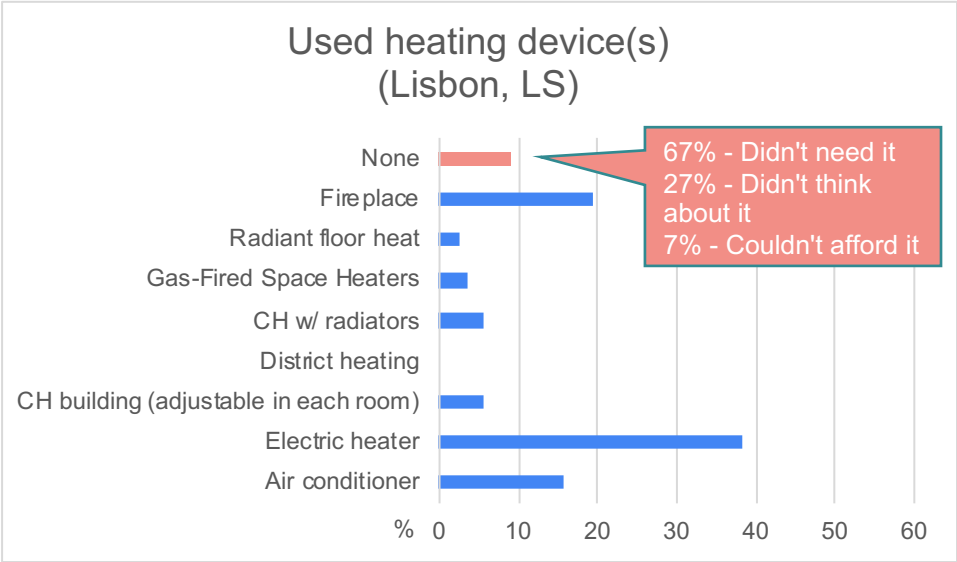

Figure B.0.4- Accommodation specifications related to the device(s) used for heating (LS of Lisbon).

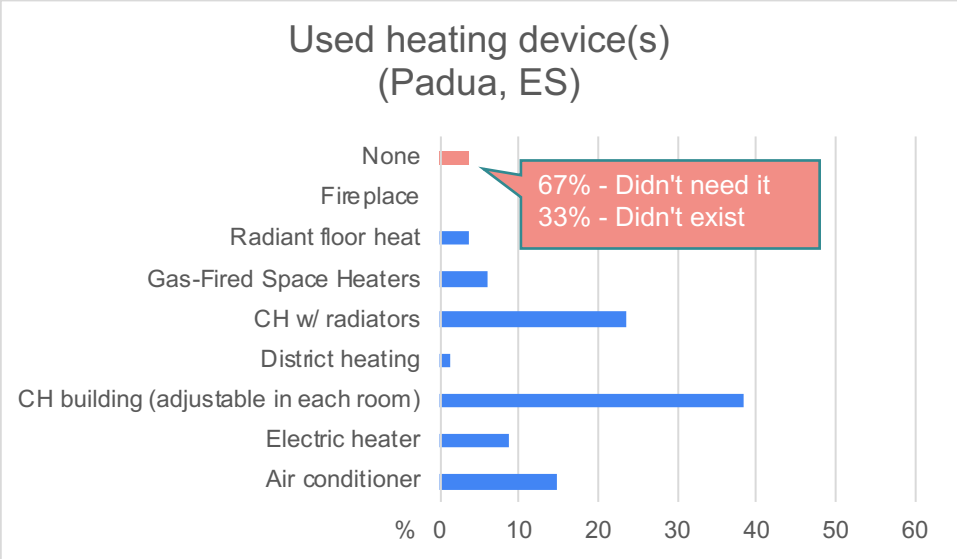

Figure B.0.5- Accommodation specifications related to the device(s) used for heating (ES of Padua).

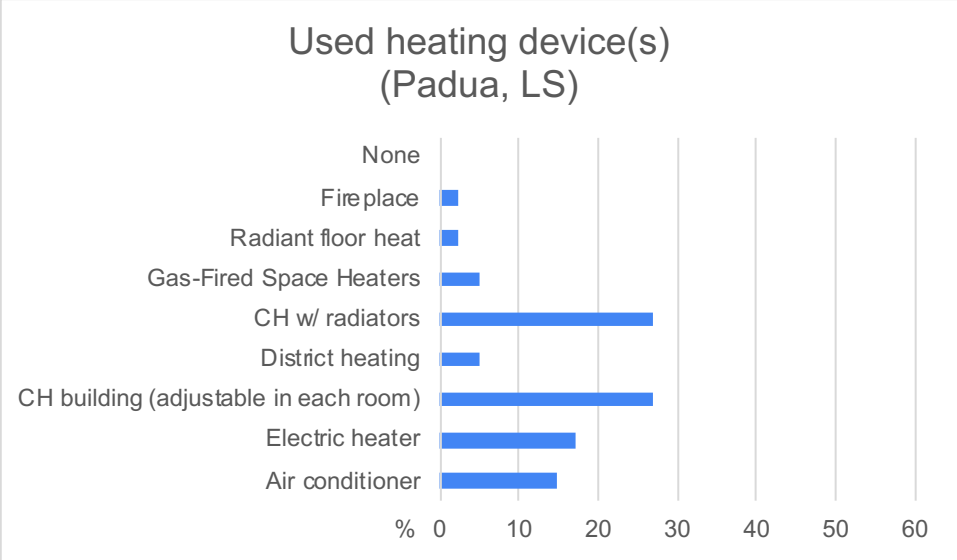

Figure B.0.6- Accommodation specifications related to the device(s) used for heating (LS of Padua).

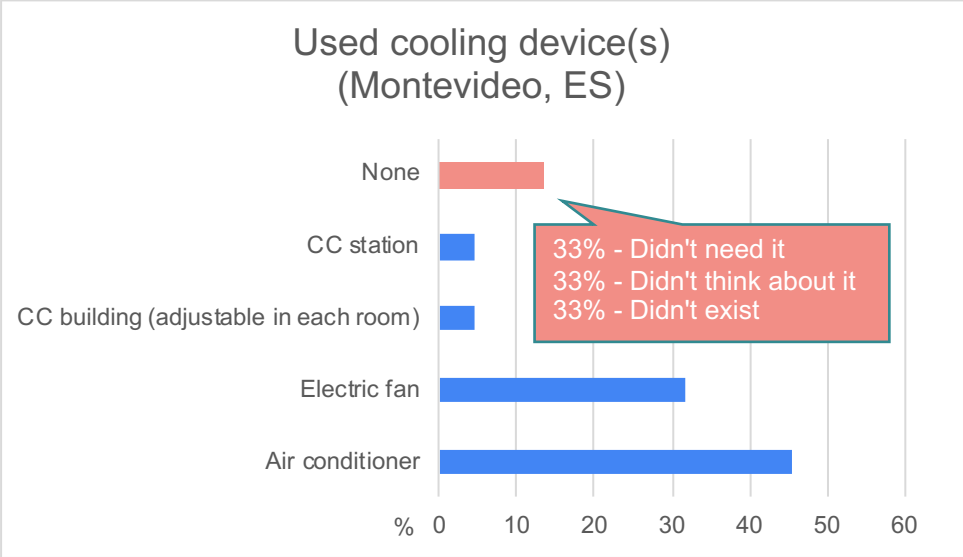

Figure B.0.7- Accommodation specifications related to the device(s) used for cooling (ES of Montevideo).

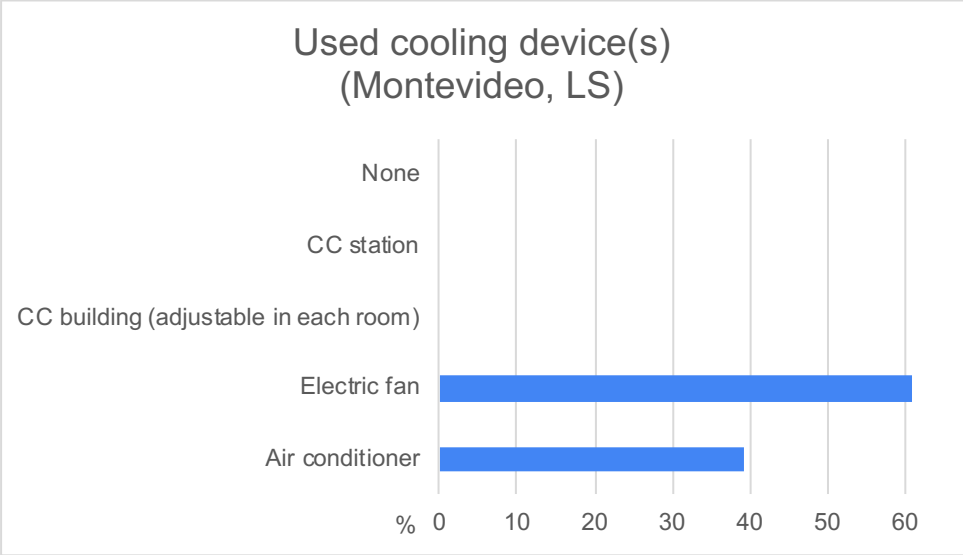

Figure B.0.8- Accommodation specifications related to the device(s) used for cooling (LS of Montevideo).

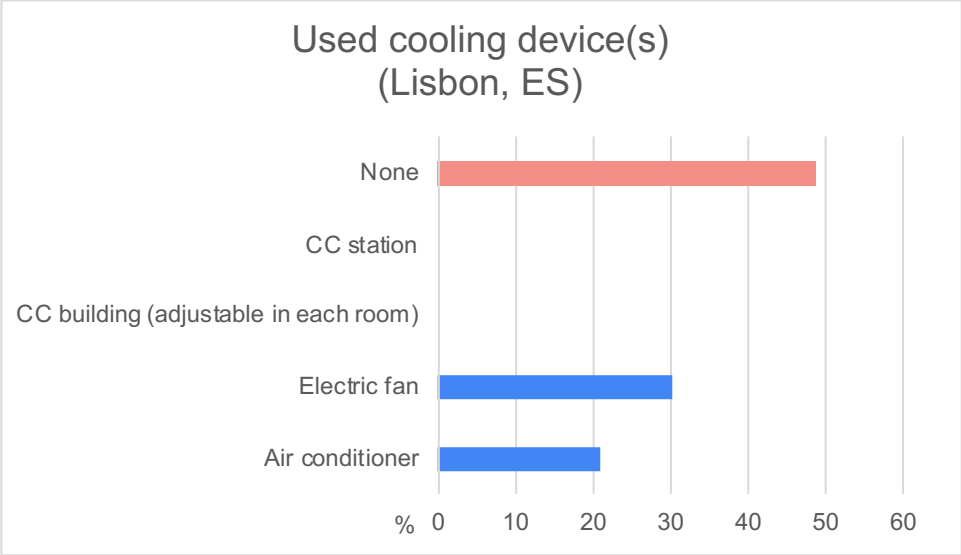

Figure B.0.9- Accommodation specifications related to the device(s) used for cooling (ES of Lisbon).

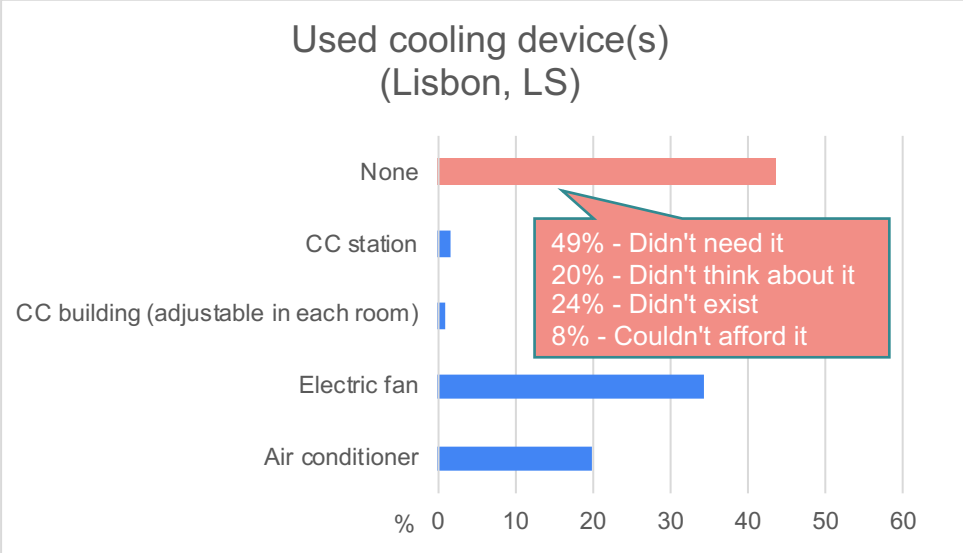

Figure B.0.10- Accommodation specifications related to the device(s) used for cooling (LS of Lisbon).

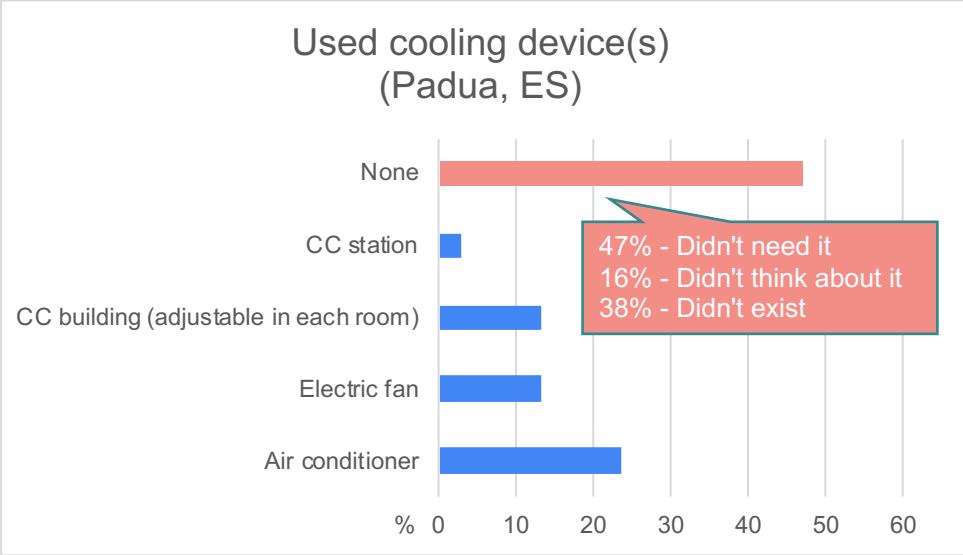

Figure B.0.11- Accommodation specifications related to the device(s) used for cooling (ES of Padua).

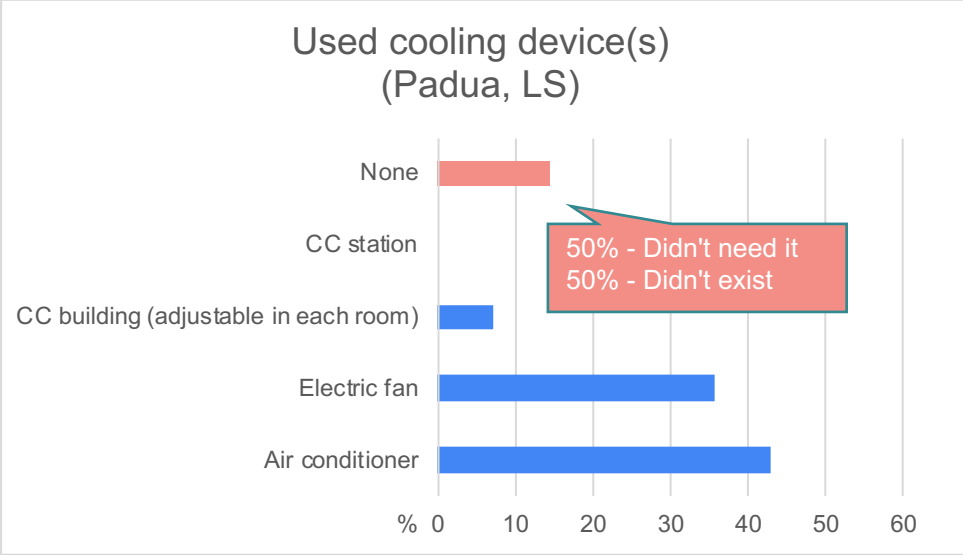

Figure B.0.12- Accommodation specifications related to the device(s) used for cooling (LS of Padua).

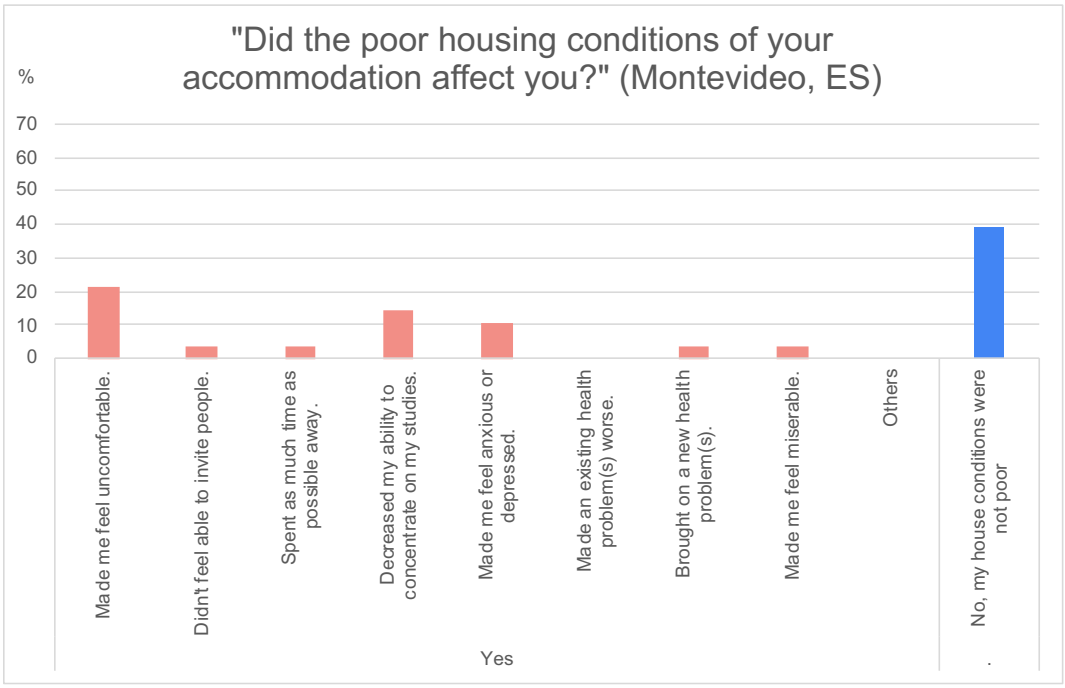

Figure B.0.13- Answers to the question "Did the poor housing conditions of your accommodation affect you?" (Montevideo, ES).

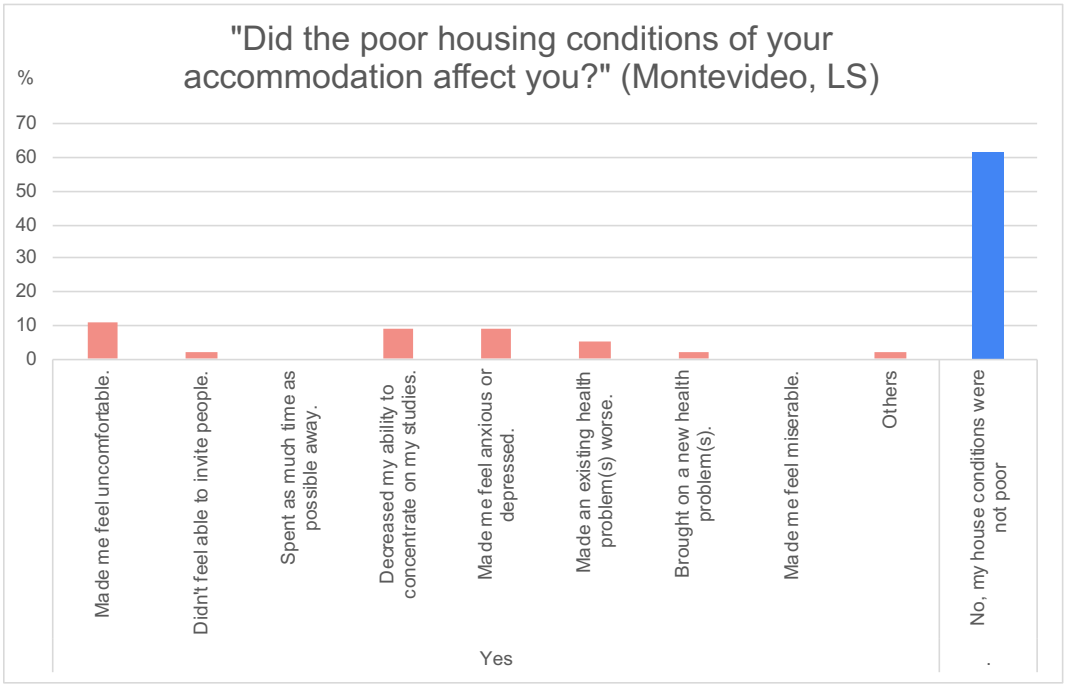

Figure B.0.14- Answers to the question "Did the poor housing conditions of your accommodation affect you?" (Montevideo, LS).

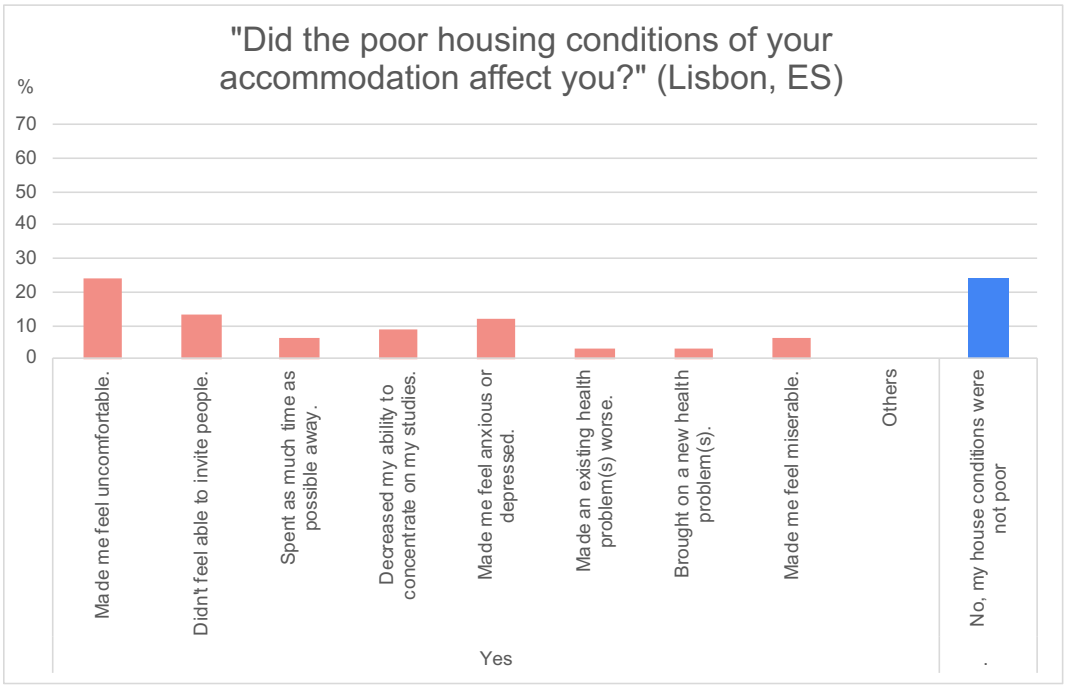

Figure B.0.15- Answers to the question "Did the poor housing conditions of your accommodation affect you?" (Lisbon, ES).

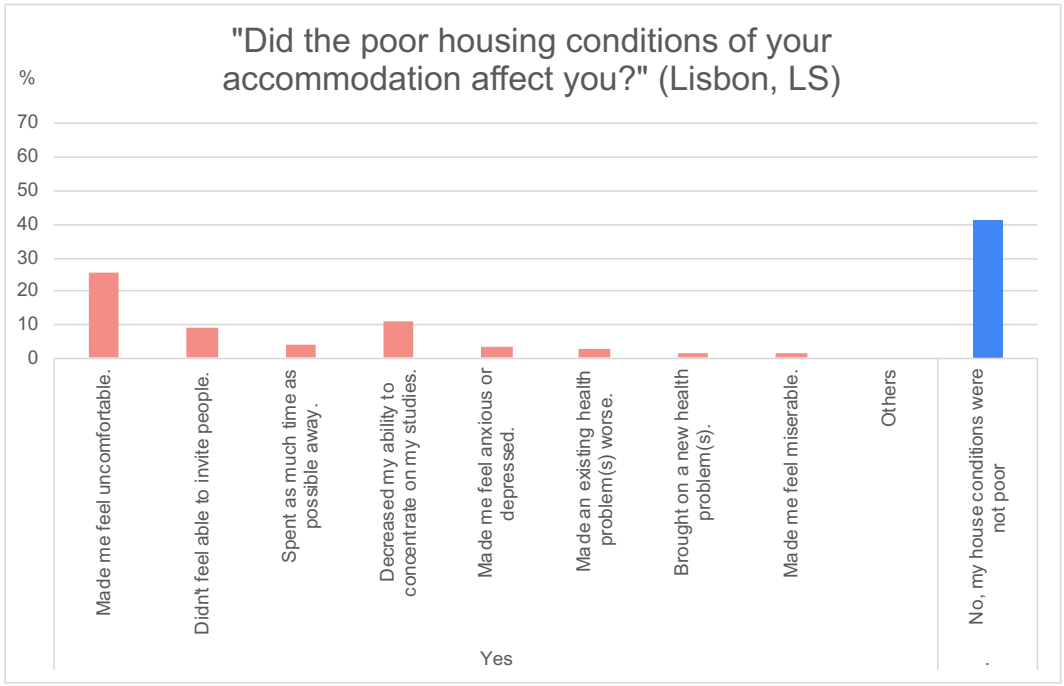

Figure B.0.16- Answers to the question "Did the poor housing conditions of your accommodation affect you?" (Lisbon, LS).

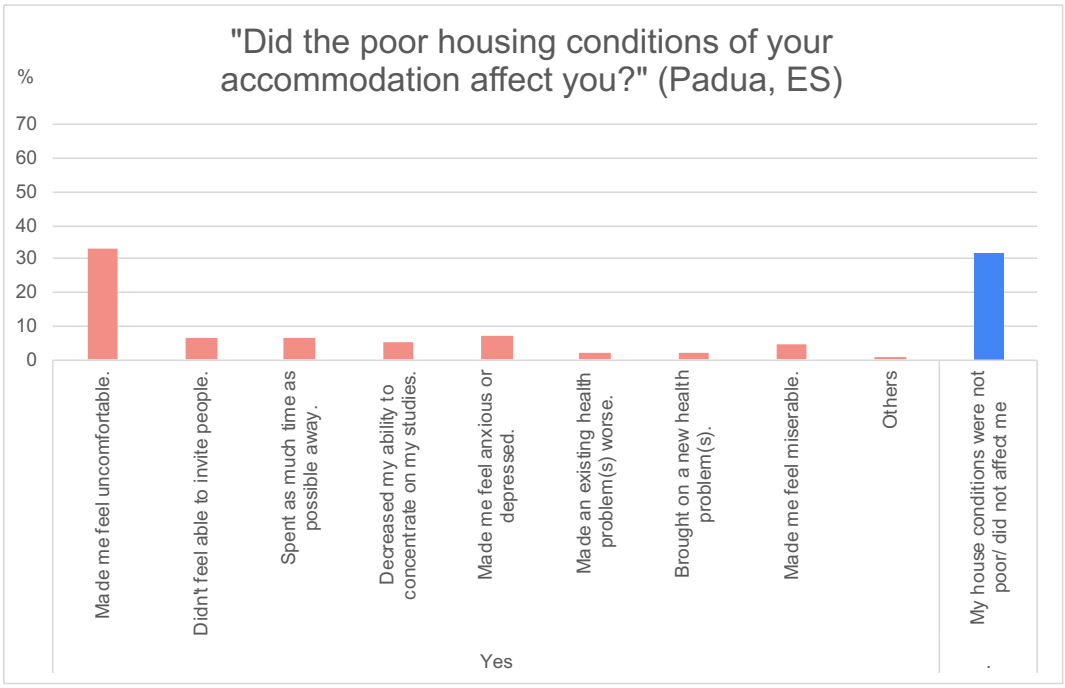

Figure B.0.17- Answers to the question "Did the poor housing conditions of your accommodation affect you?" (Padua, ES).

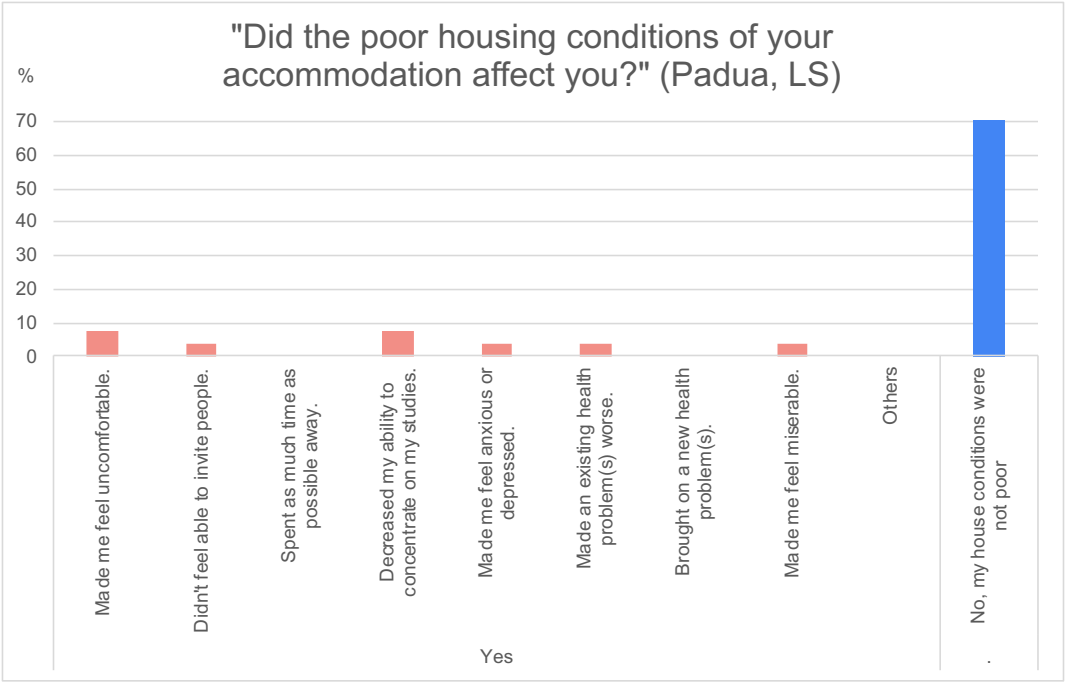

Figure B.0.18- Answers to the question "Did the poor housing conditions of your accommodation affect you?" (Padua, LS).

C.
Annex C - Survey - Chapter 3

C.1. Survey | Student Survey- Thermal Comfort & Energy Poverty

This survey was developed in the scope of research activities in the areas of energy poverty and thermal comfort conducted by a team of researchers from the Center of Environmental and Sustainability Research (CENSE) at NOVA School of Science and Technology of NOVA University of Lisbon (FCT NOVA).

The objective of this study is to evaluate the vulnerability of higher education students who live in Portugal to energy poverty. The survey takes approximately 5 minutes to complete.

Thank you for your availability and for helping us to evaluate this highly important social issue.

* Mandatory

1. **This survey is anonymous and information about your personal data is requested only for statistical purposes (in accordance with the General Data Protection Regulation - REGULATION (EU) 2016/679 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 April 2016).** *

Select only one option.

- I accept the processing of my personal data.
- I don't accept the processing of my personal data.

C.2. Student identification

2. **Age** *

Select only one option.

- Under 18
- 18-20
- 21-24
- 25-29
- 30-34
- 35-44
- 45 or over

3. **Sex** *

Select only one option.

- Male

- Female
- Non binary

4. **Country of origin** *
Select only one option.
- Portugal
- Other

5. **Municipality where you currently reside**
Please stipulate municipality below

6. **Education**
Select only one option.
- 12th year
- Bachelor´s degree
- Master´s degree
- PhD

7. **Employment status**
Select only one option.
- Full time student
- Working student

8. **Do you have a chronic illness or long-term condition**
Select all that apply.
- No
- Yes, cardiovascular illness
- Yes, respiratory illness
- Yes, depression
- Prefer not to answer

C.3. Student information

9. **Are you a student living away from home?** *
Select only one option.
- Yes, nationally in Portugal
- Yes, from within EU
- Yes, outside EU
- No

10. **Area of study** *
Select only one option.
- Architecture/Engineering/Technology
- Arts/Humanities
- Life sciences/Medicine

- Mathematics / Exact sciences
- Social Sciences

11. Name of your Higher Education Institution in Portugal *

12. Is your Higher Education Institution public or private? *

Select only one option.

- Public
- Private

13. Do you/did you benefit from any financial social support or bursary for your studies? *

Select only one option.

- Yes, social support
- Yes, a student bursary (e.g., for a Bachelor's degree)
- Yes, a doctoral bursary (based on merit or for research purposes)
- No

C.4. Thermal comfort/Energy poverty

14. I feel cold at home in the winter

Select only one option.

	1	2	3	4	5	
Never						**Always**

15. I feel hot at home in the summer

Select only one option.

	1	2	3	4	5	
Never						**Always**

16. I avoid using heating and/or cooling equipment to reduce my energy bills *

Select only one option.

	1	2	3	4	5	
Never						**Always**

17. Did you cut or reduce energy consumption for heating your residence during the winter due to energy costs? *

Select only one option.

- No
- Yes, I turned off the heating although I would have preferred to leave it on
- Yes, I reduced the heating although I would have preferred it to be warmer
- I don't have heating equipment
- Not applicable

18. Did you cut or reduce energy consumption for cooling your residence during the summer due to energy costs? *

Select only one option.

- No
- Yes, I turned off the fan or air conditioning although I would have preferred to leave it on
- Yes, I turned down the fan or air conditioning although I would have preferred it to be cooler
- I don't have cooling equipment
- Not applicable

19. I adopt measures to cope with the heat or the cold rather than using heating or cooling equipment (e.g., blankets, jumpers, leaving the house) *

Select only one option.

	1	2	3	4	5	
Never						**Always**

20. The poor building conditions in my residence affect me *

Select all that apply.

- By making me feel uncomfortable
- By reducing my capacity to concentrate on my work or studies
- By aggravating my existing health problems
- By causing new health problems
- By making me feel anxious or depressed
- By making me feel that I can't invite friends or relatives to my home
- By making me spend the maximum time possible out of the house
- I don't have problems with the building quality of my residence

21. I feel that the thermal comfort conditions in my residence have an impact on my capacity to concentrate and/or educational attainment *

Select only one option.

	1	2	3	4	5	
Never						**Always**

22. I feel that thermal discomfort in my residence affects my health (e.g., frequent colds in winter, respiratory problems) *

Select only one option.

	1	2	3	4	5	
Never						**Always**

23. Do you pay for your domestic energy costs? *

Select only one option.

- Yes, all of the bills
- Yes, some bills
- No, they were/are included in the rent
- No, I do not/did not contribute to these costs

C.5. Energy bills

24. I have difficulty in paying my energy bills *

Select only one option.

1	2	3	4	5
Never				**Always**

25. Paying my energy bills limits my ability to acquire other goods and services (e.g., medicines, internet) *

Select only one option.

1	2	3	4	5
Never				**Always**

C.6. Building characteristics and inhabitant profile

26. Tenure *

Select only one option.

- Owner of building
- Relative of building owner
- Long term renter
- Short term renter
- Social housing

27. Which of these options best describes your residence? *

Select only one option.

- House/apartment rented through an agency
- House/apartment rented directly from owner
- Room rented through an agency
- Room rented directly from owner
- I live in dormitory or other accommodation provided by the university
- I live in a residence that I own, or that is owned by family or friends

28. Is this a full-time residence or do you spend time in another residence at the week-ends?

Select only one option.

- Yes, it's a full-time residence
- No, sometimes I spend time in another residence at the weekends
- No, I always spend time in another residence at the weekends

29. I find the thermal comfort conditions most comfortable in

Select only one option.

- The residence I rent to facilitate my studies
- Another residence where I frequently spend time in Portugal (at the weekend with family or similar)
- Another residence where I frequently spend time abroad (with family or similar)
- Doesn't apply

C.7. Building construction characteristics

30. Year in which the building you inhabit was built *
Select only one option.

- Pre 1920
- 1920-1990
- 1991-2006
- Post 2006
- Don't know

31. My building has draughts, cracks, humidity or mould
Select only one option.

- Yes
- No
- No, but other problems

32. How do you heat/cool your residence? *
Select all that apply.

- Wood burning fire
- Wood burning fire with heat recuperation facility
- Heat pump/air conditioning
- Electric radiator
- Oil heater
- Gas radiator
- Thermoventilator
- Fan
- I don't have heating equipment

D.
Annex D - Supplementary Tables - Chapter 3

Table D.0.1- For each original question, a representation is made of the original survey categories and the corresponding revised categories, as well as the revised title of that question.

Sub section and Original question	Original survey categories	New categories	New title of the question
3.3. Students' perception of thermal comfort during winter and during summer			
I feel cold at home in the winter	Never	Comfort	Level of thermal comfort during winter
	Rarely		
	Seldom	Mild Discomfort	
	Often	High Discomfort	
	Always		
I feel hot at home in the summer	Never	Comfort	Level of thermal comfort during summer
	Rarely		
	Seldom	Mild Discomfort	
	Often	High Discomfort	
	Always		
3.6. Energy costs challenges			
Do you pay for your domestic energy costs?	Yes, all of the bills	Yes	Do you pay for your domestic energy costs?
	Yes, some bills		
	No, they were/are included in the rent	No	
	No, I do not/did not contribute to these costs		
I have difficulty in paying my energy bills	Never	Low Difficulty	Level of difficulty in paying their energy bills
	Rarely		
	Seldom	Moderate Difficulty	

	Often	High Difficulty	
	Always		
Paying my energy bills limits my ability to acquire other goods and services (e.g., medicines, internet)	Never	Low Limitation	Level of limitation on ability to purchase other goods and services when paying energy bills
	Rarely		
	Seldom	Moderate Limitation	
	Often	High Limitation	
	Always		
I avoid using heating and/or cooling equipment to reduce my energy bills	Never	Low Cuts In Energy Use	Level of cuts in energy use to reduce energy bills
	Rarely		
	Seldom	Moderate Cuts In Energy Use	
	Often	High Cuts In Energy Use	
	Always		
Did you cut or reduce energy consumption for heating your residence during the winter due to energy costs?	No	No	Did you cut or reduce energy consumption for heating your residence during the winter due to energy costs?
	I don't have heating equipment		
	Not applicable	Not applicable	
	Yes, I turned off the heating although I would have preferred to leave it on	Yes	
	Yes, I reduced the heating although I would have preferred it to be warmer		
Did you cut or reduce energy consumption for cooling your residence during the summer due to energy costs?	No	No	Did you cut or reduce energy consumption for cooling your residence during the summer due to energy costs?
	I don't have cooling equipment		
	Not applicable	Not applicable	
	Yes, I turned off the fan or air conditioning although I would have preferred to leave it on	Yes	
	Yes, I turned down the fan or air conditioning although I would have preferred it to be cooler		
3.7. Energy saving			

I adopt measures to cope with the heat or the cold rather than using heating or cooling equipment (e.g., blankets, jumpers, leaving the house)	Never	Low Adoption of Measures	Level of adoption of measures to cope with heat or cold rather than using heating or cooling equipment
	Rarely		
	Seldom	Moderate Adoption of Measures	
	Often	High Adoption of Measures	
	Always		
3.8. Building conditions			
The poor building conditions in my residence affect me	By making me feel uncomfortable	Yes	Did the poor building conditions of your house affect you?
	By reducing my capacity to concentrate on my work or studies		
	By aggravating my existing health problems		
	By causing new health problems		
	By making me feel anxious or depressed		
	By making me feel that I can't invite friends or relatives to my home		
	By making me spend the maximum time possible out of the house		
	I don't have problems with the building quality of my residence	No	
3.9. Impacts of thermal discomfort and poor building conditions			
I feel that the thermal comfort conditions in my residence have an impact on my capacity to concentrate and/or educational attainment	Never	Low Impact	Level of impact of thermal discomfort on students' capacity to concentrate and/or educational attainment
	Rarely		
	Seldom	Moderate Impact	
	Often	High Impact	
	Always		
I feel that thermal discomfort in my residence affects my health (e.g., frequent colds in winter, respiratory problems)	Never	Low Impact	Level of impact of thermal discomfort on students' health (e.g.: frequent colds in winter, respiratory problems)
	Rarely		
	Seldom	Moderate Impact	
	Often	High Impact	

	Always		
Paying my energy bills limits my ability to acquire other goods and services (e.g., medicines, internet)	Never	Low Limitation	Level of limitation on ability to purchase other goods and services when paying energy bills
	Rarely		
	Seldom	Moderate Limitation	
	Often	High Limitation	
	Always		

Table D.0.2- a) PERMANOVA analysis of factors region (Norte, Centro, AML, and Alentejo) and type of student [Displaced Students (DS) and Local Students (LS)] on the answers to questions about the 3.3, 3.4., 3.6., 3.8, and 3.9. subsections. (b) Pair-wise tests to factor region when significant. (c) Simper results when factor region and/or type of student were significant.

Effect	***df***	**MS**	**Pseudo-*F***	***p*-value**
3.3. Students' perception of thermal comfort during winter and during summer				
a) PERMANOVA				
Region	3	358.44	0.91403	0.4755
Type of student	1	2614.5	6.6669	0.0031
Region x Type of student	3	387.51	0.98815	0.4363
Res	830	392.16		
3.4. Heating and cooling equipment				
a) PERMANOVA				
Region	3	14802	3.8399	0.0001
Type of student	1	9287.3	2.4093	0.0299
Region x Type of student	3	4563.6	1.1839	0.2723
Res	813	3854.7		
b) Pair-wise tests to factor region				
Norte = Centro ≠ AML ≠ Alentejo (significant at the 5% level)				
c) SIMPER analysis to factors region and type of student (variables that explained >67% of cumulative dissimilarity)				
DS vs. LS	The variables that contributed the most (67%, in descending order) are: electric radiator (more important for DS); oil heater (more important for DS); heat pump/air conditioning (more important for LS); thermoventilator (more important for DS); I don't have heating equipment (more important for DS).			

Norte-Centro vs. AML-Alentejo	Norte-Centro students reported less use of heating and cooling equipment and specific use of wood burning fire compared to the other regions.			
AML vs. Alentejo	The main explanation for the differences between the Alentejo and AML regions is the greater use of oil heater, thermoventilator and heat pump/air conditioning in Alentejo and electric radiator and fan in AML.			
3.6. Energy costs challenges				
a) PERMANOVA				
Region	3	1649.5	3.9776	**0.003**
Type of student	1	58.353	0.14071	0.845
Region x Type of student	3	385.14	0.92872	0.5
Res	813	414.7		
b) Pair-wise tests to factor region				
AML ≠ Alentejo = Norte (significant at the 5% level), no defined pattern for Centro				
c) SIMPER analysis to factor type of student (variables that explained >77% of cumulative dissimilarity)				
AML vs. Norte-Alentejo	The variables that contributed the most (77%, in descending order) are: Level of difficulty in paying their energy bills (more important for Norte-Alentejo); Level of cuts in energy use to reduce energy bills (more important for Norte-Alentejo); Did you cut or reduce energy consumption for heating your residence during the winter due to energy costs? (more important for Norte-Alentejo).			
3.8. Building conditions				
a) PERMANOVA				
Region	3	1231.6	4.3592	**0.0009**
Type of student	1	1466.5	5.1906	0.0118
Region x Type of student	3	579.46	2.051	0.0791
Res	830	282.53		
a) Pair-wise tests to factor region				
AML ≠ Alentejo (significant at the 5% level), no defined pattern for Centro and Norte				
b) SIMPER analysis to factors region and type of student (variables that explained >81% of cumulative dissimilarity)				

AML vs. Alentejo	The variables that contributed the most (81%, in descending order) are: Year of construction of the building they live in (older buildings for Alentejo); Presence of problems in students' accommodation (draughts, cracks, humidity, or mould) (more important for Alentejo).			
DS vs. LS	The variables that contributed the most (81%, in descending order) are: Year of construction of the building they live in (older buildings for DS); Presence of problems in students' accommodation (draughts, cracks, humidity, or mould) (more important for DS).			
3.9. Impacts of thermal discomfort and poor building conditions				
a) PERMANOVA				
Region	3	2798.3	4.6831	**0.0004**
Type of student	1	863.07	1.4444	0.2399
Region x Type of student	3	476.72	0.79782	0.5614
Res	830	597.53		
b) Pair-wise tests to factor region				
AML ≠ Alentejo = Centro (significant at the 5% level), no defined pattern for Norte				
c) SIMPER analysis to factor region (variables that explained >70% of cumulative dissimilarity)				
AML vs. Centro-Alentejo	The variables that contributed the most (70%, in descending order) are: Level of limitation on ability to purchase other goods and services when paying energy bills (more important for Centro-Alentejo); Level of impact of thermal discomfort on students' capacity to concentrate and/or educational attainment (more important for Centro-Alentejo).			

Bold—significant p-values ($p \leq 0.05$).

2023

CAROLINA CRUZ DE CASTRO

ENERGY POVERTY AMONG HIGHER EDUCATION STUDENTS FROM MONTEVIDEO, PADUA, AND PORTUGAL: A COMPARISON BETWEEN LOCAL AND DISPLACED STUDENTS

NOVA SCHOOL OF SCIENCE & TECHNOLOGY