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Students' perception of energy poverty—A comparative analysis between local and exchange university students from Montevideo, Lisbon, and Padua

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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 and 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 44 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

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) and 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, 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, toward 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.

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.

Case studies and energy poverty

The map of Figure 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).

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 3,092 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, 1.8–3 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.

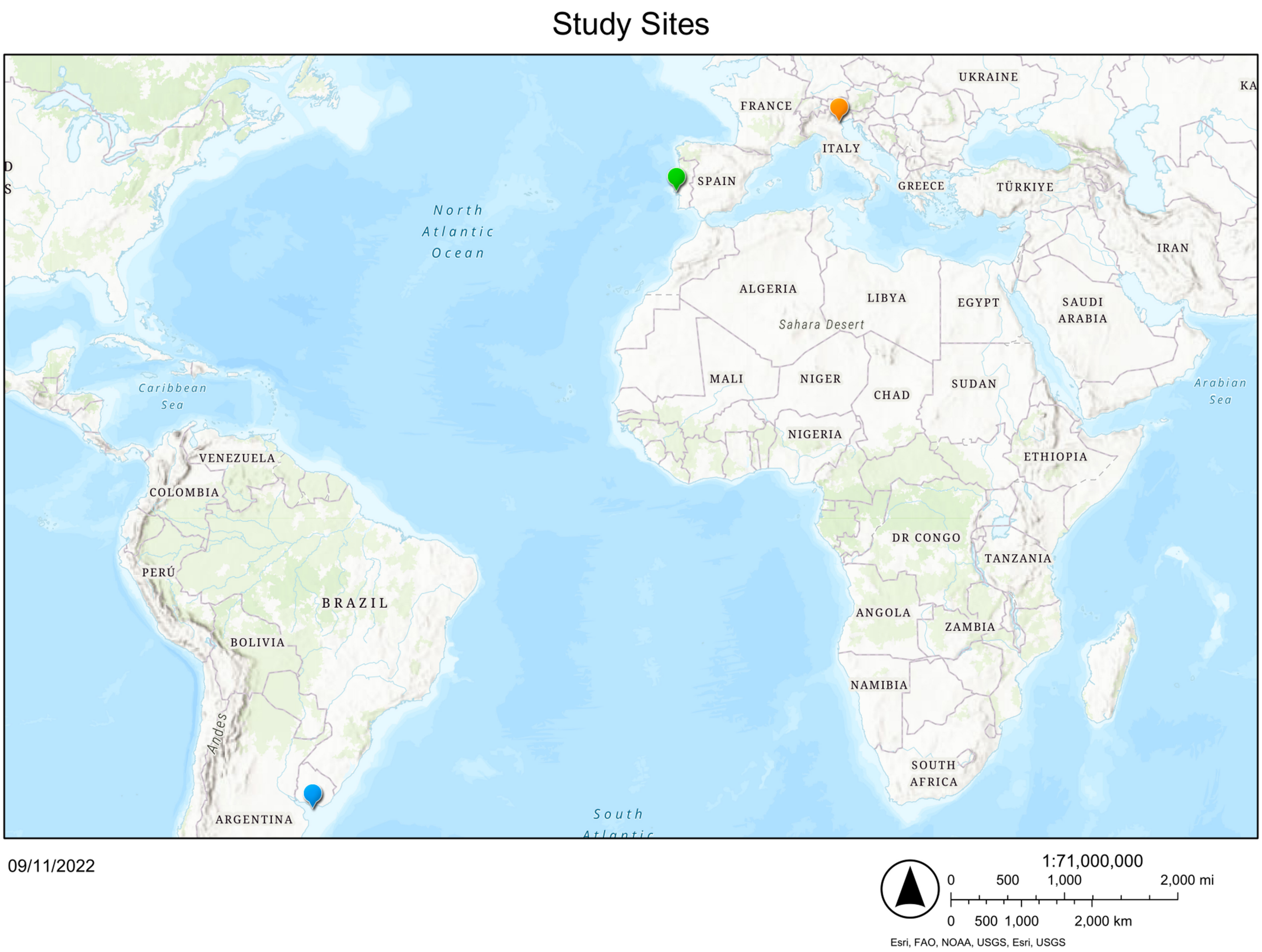

FIGURE 1
Representation of the study sites: Montevideo (capital of Uruguay) is represented in blue; Lisbon (capital of Portugal) in green; Padua (city in northern Italy) in orange.

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 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 km 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.

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 Supplementary material). 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 44 questions and 11 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

TABLE 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

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.

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 Morris and Genovese, 2018; Kousis et al., 2020). 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.

Results

The results are divided into 10 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

TABLE 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%

of concern about the problem, and the solutions and policies they suggested to minimize EP.

Sample characterization

The samples of the present study are characterized in Table 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.

House hunting choices

The structure of the responses to the house-hunting choices was significantly different among locations and type of students (Table 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 3). Pair-wise test to factor location indicated that all locations differed (Table 3). Students from Lisbon gave more importance to several housing decisions (Table 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").

General description of accommodation and satisfaction with accommodation

Table 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 4). Of all ES, those in Lisbon seem to have spent more money on accommodation (Table 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 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 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.

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. In Montevideo, 53% of the ES considered themselves uncomfortable, while 51% of the LS were comfortable (Figure 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).

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 Supplementary Figures 1–6). 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 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.

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 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 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.

Cooling devices are present in students' accommodations during summer (Supplementary Figures 7–10). 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 5).

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

TABLE 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. (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).

Effect	*df*	MS	Pseudo-*F*	*p*-value
a) PERMANOVA				
Location	2	1325.20	5.2634	**0.001**
Type of student	1	854.32	3.3931	**0.015**
Location × 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 vs. Montevideo	**0.007**			
Lisbon vs. Padua	**0.001**			
Montevideo vs. Padua	**0.013**			
c) Simper analysis				
Factor	Variables that explained >70% of cumulative dissimilarity			
Location:				
Lisbon vs. 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 vs. 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 vs. 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 vs. 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 ($p \leq 0.05$).

TABLE 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; FandF, 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€–399€ (33%); 200€–299€ (28%)	nothing (55%); 200€–299€ (12%); 400€–499€ (12%)	300€ to 399€ (28%); 400€–499€ (21%); nothing (21%)	nothing (68%); 200€–299€ (10%)	200€–299€ (36%); 300€–399€ (25%)	nothing (57%); 200€–299€ (26%)
Type of housing	privately rented house/flat DFO (56%); rented room DFO (4%)	FandF (51%); privately rented house/flat from a LA (22%)	privately rented house/flat DFO (26%); rented room through a HA (21%)	FandF (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%)	FandF (52%); rented room DFO (26%)
Satisfied/very satisfied	78%	86%	67%	82%	82%	91%

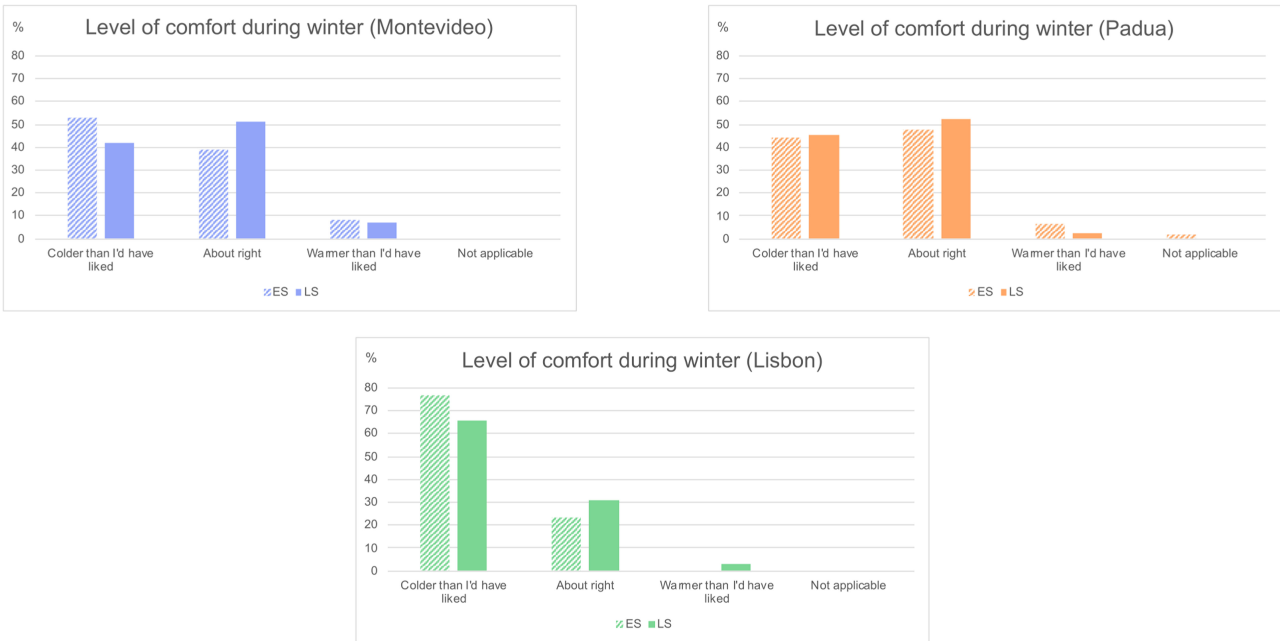

FIGURE 2
Perception of energy comfort during winter of ES and LS of Montevideo, Lisbon, and Padua.

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).

Housing conditions and impacts

Figure 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 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 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 6).

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%) (Supplementary Figure 14). From Supplementary Figures 13–18, 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

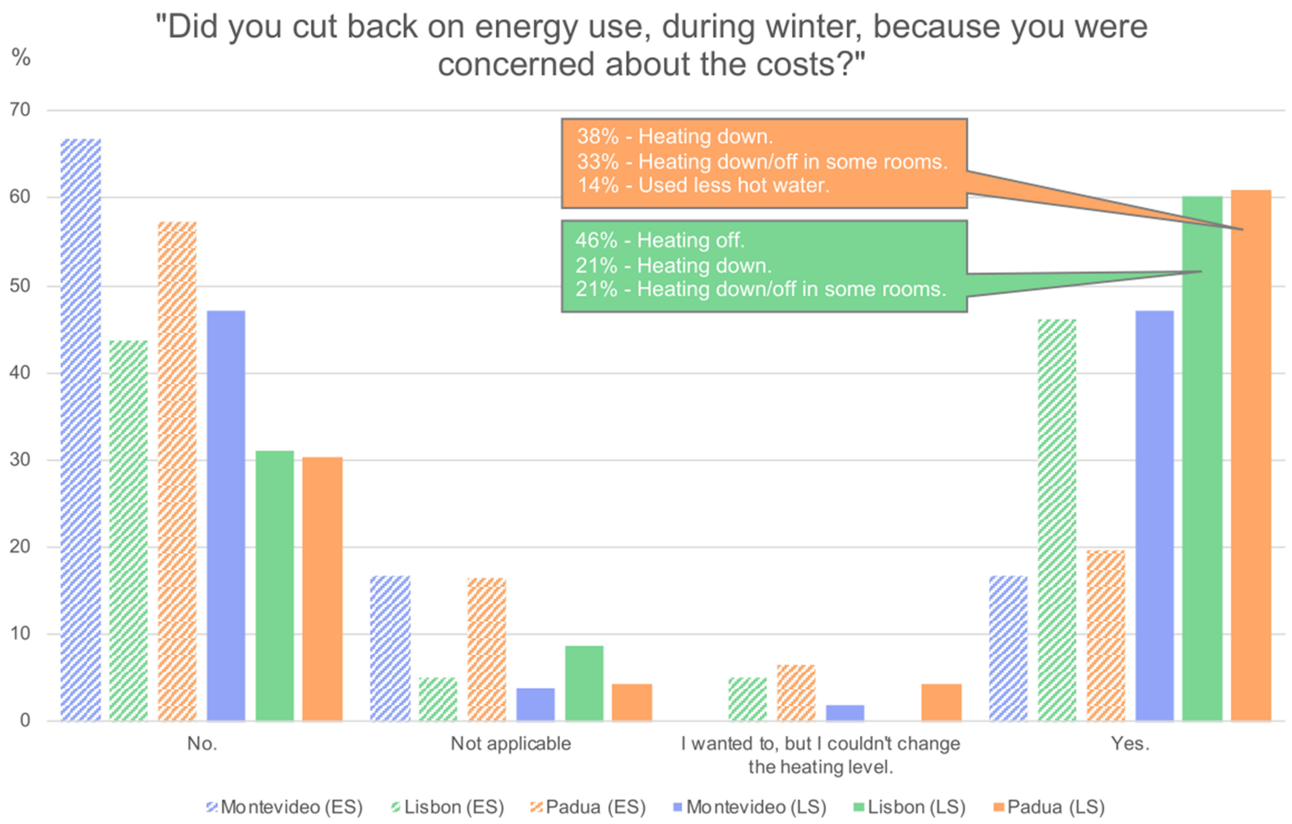

FIGURE 3
Energy costs challenges for each population during winter.

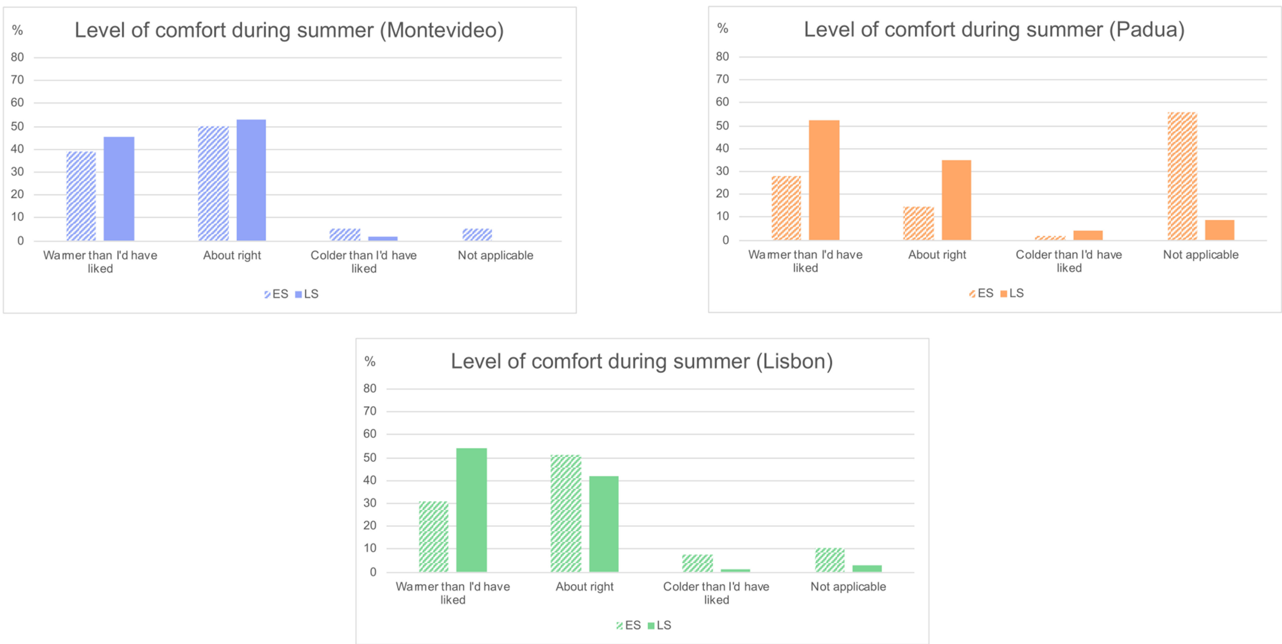

FIGURE 4
Perception of energy comfort during summer of ES and LS of Montevideo, Lisbon, and Padua.

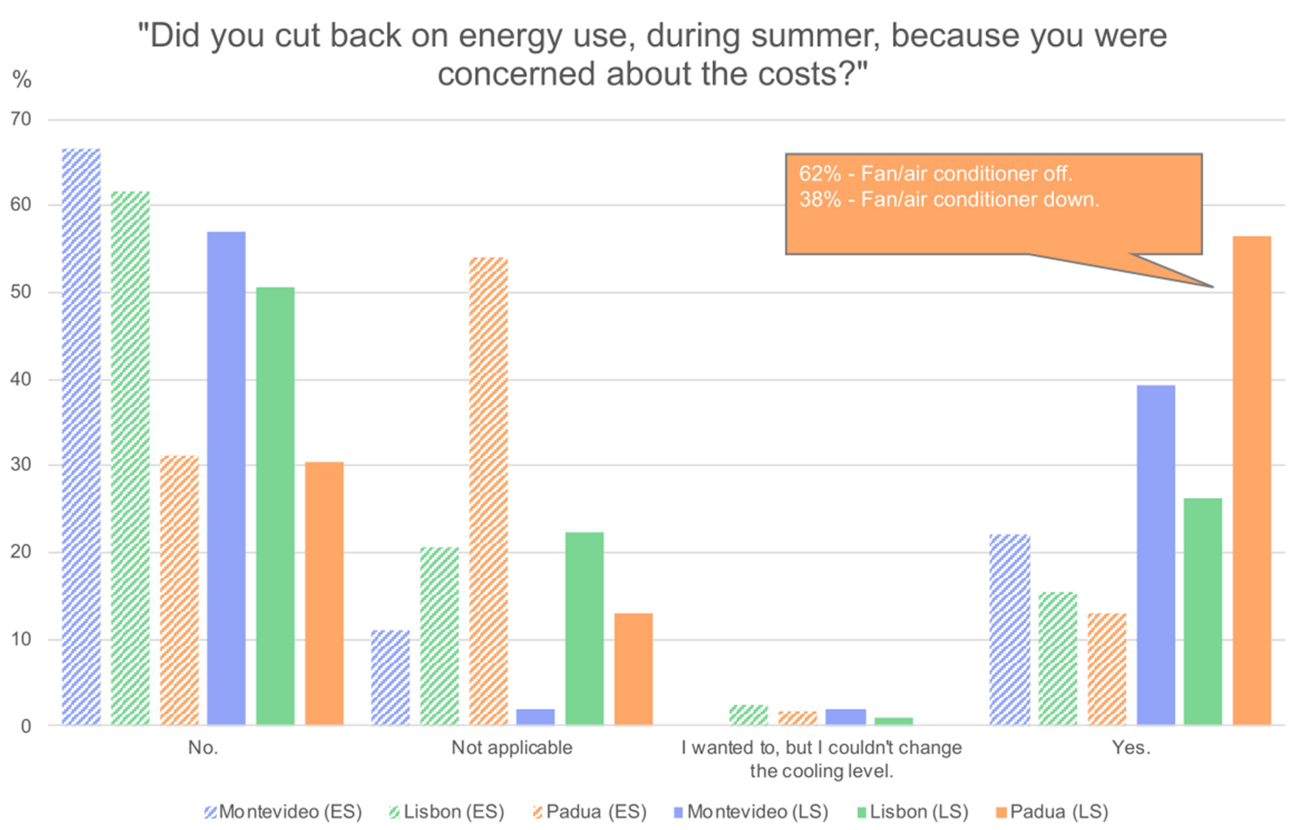

FIGURE 5
Energy costs challenges for each population during summer.

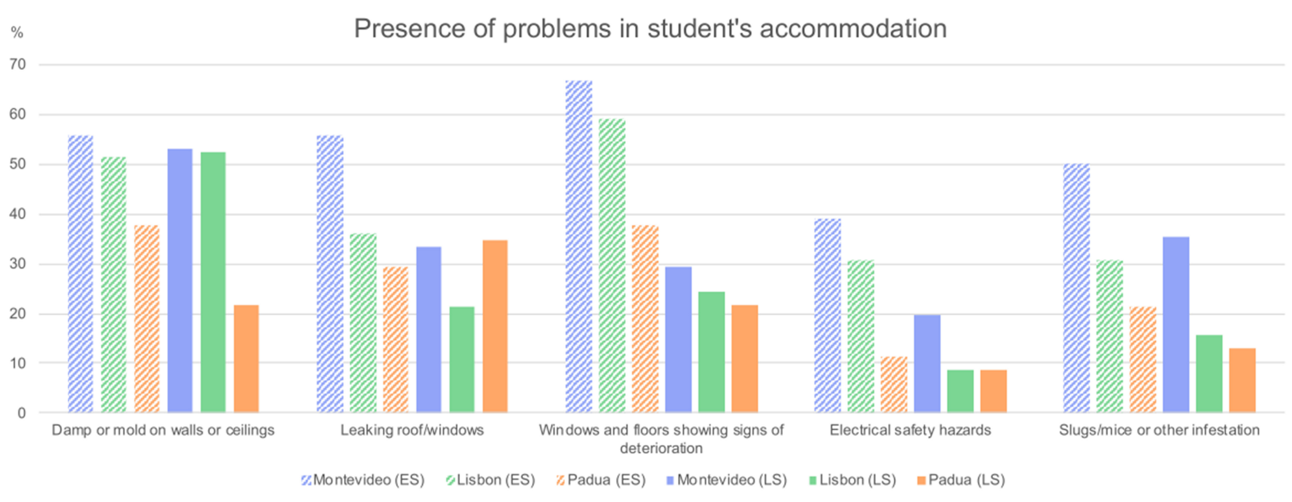

FIGURE 6
Presence of problems in student accommodation in each population.

conditions affected them, the most frequent way they were affected was "It made me feel uncomfortable".

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.

Solutions and policies

Finally, 30% 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 7. The category that had the highest percentage (35%) of the suggestions of solutions/policies from the students is public policies (Figure 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".

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 1% 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.

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 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 5 systematizes the information given in Figures 2, 4.

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 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

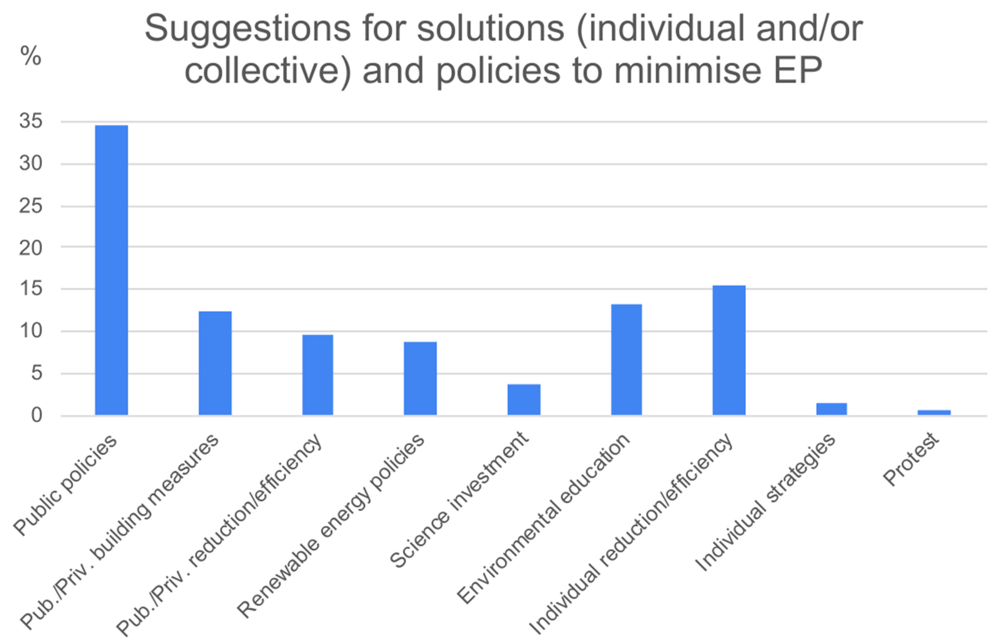

FIGURE 7
Answers from 30% of all populations to the question "What solutions (individual and/or collective) and policies do you use/suggest to minimize the problem?".

TABLE 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.

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.

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 accommodation, 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. JG: overall methodology, analysis of results, and review and editing of the manuscript. Both 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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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frsc.2023.1114540/full#supplementary-material

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