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The energy austerity pitfall: Linking hidden energy poverty with self-restriction in household use in Austria

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ABSTRACT

This paper investigates whether energy poor households may be overlooked because they self-restrict their residential heating to underconsumption. Energy poverty definitions predominantly focus on energy expenses relative to household income or theoretically estimated energy needs. Deprived households may accept colder room temperatures to avoid excessive energy bills, but this austerity reaction may backfire if they are no longer classified as energy poor. We thus propose a complementary perspective, highlighting hidden energy poverty emerging from residents' reactions to their impaired situation. Drawing on survey data of predominantly low-income residents in energy inefficient housing in the cities of Vienna (N = 220) and Graz (N = 433), Austria, latent class analysis identifies two distinct classes of self-restricting and non-restricting households. Cross-tabulating these classes with current poverty definitions indicates a blind spot: about a third of those not considered income poor or energy poor cope by self-imposed restriction in energy use. This blind spot applies across a range of common income poverty and energy poverty definitions, and is replicated in both the Vienna and Graz samples reflecting different housing contexts. Self-restriction blurs the lines of current classifications, as some deprived households may not be recognized in poverty statistics or eligibility criteria of welfare and housing policies. Thus, we propose to consider self-restriction in energy use complementary to the energy poverty triad of high energy expenditures, low income and poor housing conditions in order to avoid misidentification.

1. Introduction

Energy poverty is a serious problem across Europe: 7.0% of European households were considered energy poor in 2019, indicated by the inability to keep their home adequately warm [1]. Even in more affluent countries, energy poverty affects a significant share of the population [2]; in Austria, the study region of this paper, different energy poverty indicators indicate that 3.1% [3] to 15.2% [4] of the population are energy poor. This wide range stems from various indicators included in the respective energy poverty definitions; while E-Control [3] recognizes only low income and high energy expenditures, Seebauer et al. [4] include the inefficiency of the dwelling. Consequently, energy poverty is a prominent issue, acknowledged on different governmental scales, ranging from the UN SDG 7 [5], European [6] and national policy strategies [7].

Effective policy action needs precise targeting of those in need; insufficient recognition could lead to underrepresentation in the policy process or misallocations of welfare payments; rent or heating benefits; or housing renovation schemes. However, Austrian policy strategies to tackle energy poverty are insufficient; for instance, Austria was obligated by the European Commission [8] to elaborate in the Integrated National Energy and Climate Plan how transitional aspects will be streamlined in concrete measures, how energy poverty will be defined, and how to intersect social and climate policies. Moreover, only half of the low-income households in Austria who are eligible for exemption from the green electricity surcharge actually apply for this relief; in accordance with the Energy Efficiency Directive (2018/2002/EU), Austrian energy utilities established ombudsman offices, but these offices only step in if households default on energy bills and do not engage in energy poverty prevention [9]; furthermore, this support is targeted to all clients and is not a dedicated energy poverty instrument. Subsidy programs for building renovation issued by the Austrian government favor mid-income homeowners and fail to reach energy poor households [4]. In the Austrian political arena, an energy poverty definition is still

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outstanding and the working definition outlined in the Integrated National Energy and Climate Plan only focuses on high energy expenditures and low income, neglecting inefficient buildings.

Thus, for lack of effective governmental support, many energy poor households have to cut their home energy use to a bare minimum. While saving energy at home is a key tool for reducing carbon emissions for all citizens, deprived and marginalized groups, who struggle to afford energy or live in insufficiently insulated homes, may find themselves in jeopardy when (further) constraining daily heating routines and in turn experiencing a variety of consequences and severe health outcomes. The element of recognition justice within the energy justice debate directs to vulnerable households that are ignored because of simplistic energy poverty indicators [10–12]. Here, we illustrate self-restriction in energy use by focusing on the lived experiences and behaviors of those vulnerable and marginalized households [11,13].

For over three decades, energy poverty has been largely studied from an economic angle, focusing on the triad of above-average energy expenditures, low income and poor housing conditions [14–17]. Using energy expenditures as a proxy can lead to a blind spot as households may underconsume to keep their energy bill manageable, i.e. by cutting down on everyday heating and by self-restricting their needs. Restricting household energy use may blur the lines between being classified as energy poor or not [18]. For instance, accepting colder room temperatures in order to save costs may make a household pass just below the eligibility threshold for receiving winter fuel payments even though this household does not achieve an adequate level of warmth. Indoor temperatures below 18–21 °C have serious implications for human health [19]. For vulnerable groups like elderly or children, 23 °C in the living room is considered appropriate [20]; these particular groups of elderly and single mothers with dependent children are also disproportionately affected by energy poverty in Austria, rendering them even less capable of reaching comfortable indoor temperatures [1]. By addressing self-restrictions in tackling energy poverty, this paper links to the recent academic research strand on socio-economic factors of hidden energy poverty [21–23].

The aim of the paper is to propose an original perspective on hidden energy poverty derived from how vulnerable residents actively restrict their energy use in order to cope with their impaired situation. We illustrate that excluding self-restrictions from the understanding of energy poverty implies overlooking households at risk and potentially incurring misidentification in policy strategies. Additionally, we introduce latent class analysis as an innovative clustering technique for household segmentation in energy poverty research, as it specifically caters to multi-item scales common in consensual or subjective measures of energy poverty.

The paper proceeds as follows: the next Section 2 links self-restriction to previous research on hidden energy poverty, underconsumption and energy use. The Method Section 3 presents the housing context and data collection among low-income households living in energy inefficient buildings in the cities of Vienna and Graz, Austria, resulting in survey samples of 220 and 433 respondents, respectively. We compare both cities as consecutive Study 1 and Study 2 in order to show that the blind spot in energy poverty recognition arising from self-restrictions similarly appears in different contexts. The Analytical approach Subsection 3.4 gives detailed background on the latent class analysis procedure. The Results Section 4 identifies distinct self-restricting classes and shows that these groups only partially intersect with energy poverty and income poverty. This points to a substantial blind spot of about a third of those not considered income poor or energy poor who engage in self-restriction behaviors. Note though that the observed size of the blind spot only applies to Austrian cities and does not generalize to other national or regional contexts; however, the employed energy and income poverty indicators are well-established for cross-country comparisons. We conclude with a proposal to consider self-restricting behavior complementary to existing formalized energy poverty indicators and direct to future research in Section 5. Section 6 concludes with policy implications to approach hidden energy poverty by means of energy counselling and the establishment of a coordination platform which distributes a dedicated energy poverty fund.

2. Self-restriction as a component of hidden energy poverty

Hidden energy poverty refers to scarcity and deprivation in home energy services that is severely experienced by those affected, but insufficiently reflected in established indicators [24]. Hidden energy poverty appears if households consume less energy than they would be expected to do. Underconsumption poses major difficulties in measuring energy poverty, and it has been present since the beginning of the energy poverty discussions in the UK: activist organizations and the movement for affordable warmth in the 1970ies drew attention to increased energy prices, and the inability of households to heat their dwellings at an appropriate temperature level, leading to high incidences of winter mortality [25–27]. Boardman's [14] seminal energy poverty indicator of spending >10% of the income for energy costs originally referred to the theoretical amount of energy needed to keep warm (energy costs a household would have to pay; in the following termed 'energy costs'), rather than the amount of energy used to keep warm (energy costs a household actually pays; in the following termed 'energy expenditures') [18]. Those who underheat their houses as well as those with extremely high fuel costs are thus included in the energy needed criterion. However, because theoretical needs vary between households and energy costs depend on the physical characteristics of the specific building a household lives in, non-UK studies typically utilize actual energy expenditures, which are more easily available [25,28].

Current studies employ three approaches for capturing underconsumption to operationalize hidden energy poverty: *First*, households with low energy bills are considered hidden energy poor [21,22]. In 2015, judged by the low absolute energy expenditure indicator M/2, 14.6% of all Europeans were hidden energy poor [24]. The EPOV M/2 indicator, however, also includes people who live in exceptionally energy-efficient buildings and consequently may overestimate the actual share of hidden energy poor households. Similarly, if energy expenses of low-income households are paid directly by public authorities or energy expenses are included in the rent, these households may be erroneously classified as being hidden energy poor [29]. *Second*, as it had been proposed by Boardman, hidden energy poverty is deduced from thermal comfort gaps between actual consumption and theoretically required energy needs [30,31]. This approach converts energy needs to expected costs, which may then be compared to actual energy expenditures or socio-demographic data [32]. However, this approach relies on idealized rather than realistic energy consumption patterns, as it neglects, for instance, low energy demand resulting from people being out of their homes periodically because they are commuting. *Third*, in-situ direct measurement of indoor temperatures may indicate underconsumption, but automatically metering temperatures in a large number of households is difficult and expensive and therefore scarcely applied [28]. Notwithstanding the extensive discussion on the advantages and disadvantages of various energy poverty indicators (see for example [33,34]), solely focusing on the monetary dimension with expenditure-based and income-based indicators to approach hidden energy poverty may cause misleading or even contradictory identification of disadvantaged population segments due to arbitrary threshold values [35]. Thus, we propose a *fourth* approach, leveraging energy use and self-restrictions to bridge the discussion between hidden energy poverty and underconsumption.

The ways households use energy and reduce their energy consumption is a core yet under-researched aspect of energy poverty [36,37]. Households may restrict their consumption to limit expenditure on energy in order to avoid default of payment or excessive energy bills [37,38]. This adaption may lead to the discrepancy that these "households [do] not reach the 10% income expenditure line but their lived experience suggests that they are energy poor" [23]. In a British study, Hirsch et al. [39] compared actual fuel consumption with fuel needs and found that low-income households consume less fuel than needed. Qualitative research points out that the lived experience and behaviors of energy poor households tend to be overlooked [11,40–42]. These qualitative studies look at a range of negative consequences of self-imposed austerity in heating: social isolation if friends are no longer invited in the cold home, rejecting heating cost support or energy consulting because one can make do, feeling ashamed, embarrassed or humiliated because of less material affordability than others, fear of stigmatization, worry and anxiety caused by high energy expenditures, increased rates of chronic respiratory disease, even excess winter mortality or facing a heat-or-eat dilemma. Thus, self-restricting heating may yield the paradox outcome that the behaviors which were intended as a remedy rather aggravate experienced energy poverty.

However, thrifty heating practices need not solely emerge as a reaction to monetary deprivation. Residents who save energy might consider their actions as common sense and as integral to a frugal, self-sufficient or environmentally conscious way of living. Striving to protect the environment is not a privilege of the affluent; low-income residents in social housing also hold pro-environmental attitudes towards domestic practices [43]. Some energy poor households use justifications for their underconsumption, for example, sleeping in cold rooms is deemed to be healthy [41]. Putting on warm clothes before turning on the heating can be a means of expressing that one is modest, has practical reason and is (still) better off than others [11,40,44]. We therefore control for the influence of modesty and pro-environmental motivation on self-restriction in Section 4.4.

In this study, we draw on predominantly qualitative studies that exposed self-restriction strategies of low-income households to analytically approach the concept of hidden energy poverty [44]. For our study region of Austria, Brunner et al. [45] identify self-restriction strategies in Vienna that lead to deprivation associated with energy poverty. We understand self-restriction as a sufficiency strategy characterized by regular cutting back on everyday energy use below subjectively perceived comfort level to keep energy expenses down. How this strategy manifests in daily cutbacks allows identifying hidden energy poverty. For some households, it represents a challenging and deeply inflicted choice between spending (too much) money on energy or suffering from lower thermal comfort [46]. Typical self-restriction behaviors include self-disconnection from the energy grid or heating only one room and closing doors to the rest of the flat or house [47–49]. The restriction focus on how people deal with energy deprivation highlights energy poverty not as a static condition, but as a dynamic process shaped by adaptive capacity [42]. The notion of energy poverty as varying rather than fixed circumstance is supported by the Kearns et al. [36] panel study, where one third of households transitioned in or out of energy poverty over the course of ten years. Households may succeed in staying out of energy poverty by maintaining self-restriction behaviors, but this buffering capacity may be overextended if households are subject to increased external pressure, such as rising energy or rental costs or an exceptionally cold winter. Energy saving behaviours, e.g. heating only selected rooms, which would be reasonable and unproblematic if undertaken voluntarily by 'normal' households, may add further pressure on already deprived households if they are forced to these behaviors.

Self-restriction behaviors are not yet firmly established in quantitative studies on energy poverty and inter-linkages of daily realities of households living in substandard housing conditions are not addressed to their full potential [36,50]. However, in times of European decarbonization and designing new energy policies such as the European Green New Deal, vulnerable households' perspectives and experiences need to be included into the discussion for a just transition as the costs and the demand for energy services are predicted to increase substantially [51,52]. This may put even more financial pressure on energy poor households, but also for households who were able until now to manage their energy expenditures by self-restricting energy use and formally staying out of energy poverty.

To conclude, energy poverty can manifest through buildings in need of repair and renovation, a lack of means to afford energy and a range of different self-rationing heating behaviors. It poses a challenging task to operationalize and classify energy poor households as the aspects of building, affordability and energy use intersect. Multi-dimensionality of energy poverty is widely acknowledged, but consensus on the most necessary dimensions and thresholds of energy poverty measures has not yet been reached in the academic and political sphere [53]. We advocate including self-restriction in the analysis and monitoring of energy poverty as further means to capture hidden energy poverty. Hence, we employ latent class analysis to segment households by self-restricting energy behaviors in order to identify hidden energy poor households.

3. Method

3.1. Study context

Austria is a country of 8.8 million inhabitants, of which 1.9 million (21.5%) live in Vienna, the largest Austrian city, followed by Graz with about 300,000 inhabitants. In international comparison, Austria has an above-average housing stock in terms of good quality (widespread in-flat central heating and in-flat bathroom facilities) and size [54]. However, buildings constructed between 1945 and 1960, which amount for three quarters of all existing buildings, feature very low energy efficiency between 200 and 300 kWh/m^2a [55,56]. The average Austrian rent incl. operating costs was 8.3 €/m^2 in 2020. Privately rented flats have a significantly higher rent (9.6 €/m^2) than limited-profit housing (7.4 €/m^2) and municipal housing (6.9 €/m^2), among other reasons because (semi-)public housing offers long-term and rent-regulated contracts which typically ask for lower rents [57].

In the cities of Vienna and Graz, the majority of the population resides in rented properties, 78% and 62% respectively. In Vienna, 22% of households are tenants in municipal housing; this exceptionally high share compared to the rest of Austria and Europe traces back to the internationally renowned 'Vienna model of housing' which was adopted since the 1920s to provide affordable and inclusive housing [58]. In Graz, by contrast, only 4% of households are renters in municipal housing, with a respectively higher share of rental housing traded on the private market (39% compared to Vienna 12%; [59]). Similar to other Austrian regions, limited-profit housing associations provide the principal share of the rental housing stock in Vienna and Graz [55,57].

This study focuses on the cities of Vienna and Graz for several reasons: Renting in public energy inefficient housing is a common characteristic of energy poor households, not just in Vienna [60]. In Graz, self-restrictions may be necessitated by rent pressure on a largely unregulated rental market, whereas in Viennese social housing, self-restrictions may occur despite below-market rent levels. Housing problems (e.g. cold, damp, mould) are frequently experienced among social housing tenants [61]. Due to Austria's federal governance structure, most policy instruments to alleviate energy poverty are allocated at the provincial or city level (e.g. housing benefits, heating allowances, social assistance). This constitutes a diversified policy landscape that makes joint coordination on the national level challenging. In both cities, we purposefully selected survey samples of predominantly low-income households living in energy inefficient housing because, contrary to the better-off majority, this population segment is a priori at risk of energy poverty and may therefore also be at risk of hidden energy poverty.

3.2. Study 1 Vienna

Study 1 data was collected between July and October 2019 by administering print and online questionnaires to residents of 'Wiener Wohnen', Vienna's biggest publicly owned municipal housing association that provides approximately 220,000 homes to approximately

500,000 people [62]. To be eligible for social housing, applicants need to be Austrian citizens or have a permanent residence permit, have their primary residence in Vienna for two years or longer, and earn an annual net income of < 47,210 € (for a single household in 2020). Rents fall under the Tenancy Act and are regulated and capped, securing affordable housing depending on construction year and housing quality [63,64]. Based on open data information on renovation activities of buildings and construction years of municipal housing estates, it was possible to target buildings constructed in the 1945–1980 period for the survey [65]. We chose this segment since they typically feature bad energy efficiency ratings unless renovated [4]. Viennese social housing stock is dispersed over all 23 city districts to counteract segregation processes [66] which is why we distributed 6,500 print questionnaires to a random sample of non-retrofitted and retrofitted buildings stratified by district to follow the geographical distribution of social housing. Questionnaires were handed over personally at the doorstep, or dropped in the mailbox. Respondents were offered participation in a lottery of gift vouchers (100 × 25 Euro) as an incentive to take part in the survey.

The questionnaire was pre-tested by experts from academia, with 20 residents living in social housing, and in a n = 154 convenience sample of students and their families. After pre-testing, unclear item wordings and if-then relations between items in the online questionnaire were corrected. In total, 330 print and 85 online questionnaires were returned, amounting to a response rate of 6.4%. We center this analysis on the sub-sample of 220 households who live in non-renovated buildings. Compared to the overall Viennese population, the sample includes a higher share of women (65.1%), pensioners (45.9%), and households disposing of no more than means-tested minimum income or unemployment benefit (15.4%). The sample is characterized by a large proportion of low-income households: the equivalized median household income in the study amounts to 1133 € per month, while in the Austrian population it was 2213 € per month in 2019 [67].

Next, we present the selected questionnaire items used in the analysis.

Self-restriction behavior. Five items captured everyday practices in self-restricting heating demand and in trading cost savings for comfort [40,42,44,45,68,69]. Item wordings are given in Table 1.

Income poverty. Socio-demographic characteristics included household size and structure. Monthly disposable income after social transfers was assessed in six categories; income responses were then converted into a metric scale using the respective category midpoints [70].

Energy poverty. The measurement used indicators of the European Union Statistics on Income and Living Conditions [71]: has a leaking roof, damp walls or rotten windows; has had arrears on utility bills in the last twelve months. As a proxy for the SILC indicator 'inability to keep home adequately warm', households were asked whether they could reach their preferred indoor temperature. For Boardman's indicator of spending>10% of the income for energy costs, after-tax non-equivalized household income and monthly expenditures for energy services (heating, electricity) are utilized. One of the primary indicators of the Energy Poverty Observatory (EPOV) is used, which is households whose energy expenditures are more than twice the national median (2M) of energy expenditures. Median equivalized energy expenditure in Austria was 83.2 € in 2019. Accordingly, the 2M threshold is set at 166.3 € per month.

3.3. Study 2 Graz

Study 2 was conducted among beneficiaries in the SozialCard program [72] of the city of Graz. The SozialCard entitles to discounts for public services (e.g. public transport, libraries, and public swimming pools) and to benefit payments for winter fuel or school supplies. Eligibility for the SozialCard is determined by permanent residence in Graz, low income weighted by household size, and whether the household receives other social security benefits. Between July and September 2020, standardized self-completion questionnaires were distributed postal to all current 9,815 SozialCard beneficiaries. These households received a direct, personally addressed mailing with the header of the city's social welfare office. Responses could be returned by post with a prepaid return envelope or entered in an identical online survey. As in Study 1, a lottery of gift vouchers (10 × 30 Euro) incentivized survey participation. Individual support in completing the questionnaire was offered by welfare officers and the study team, either in person or via phone.

With 96 misspelt or out-dated addresses and 1,062 valid responses, the response rate amounts to 10.9%. For this analysis, we use a subsample of 433 households who live in non-renovated, energy inefficient housing in order to mirror the Study 1 sample. These households almost exclusively live in multi-story apartment buildings (93.5% of the sample), have an income in the lowest quartile of the Austrian income distribution (95.2%), and are tenants (94.4%); however, only 24.7% are pensioner households; 60.1% of the respondents are women.

The questionnaire was extensively pre-tested with experts from academia and social workers to ensure unambiguous language and comprehensibility, and translated by external experts to simple German to facilitate access for people with learning difficulties, language barriers or semi-literacy. Items were presented in mixed order in the questionnaire, so that it was not transparent to the respondents which item was assigned to which factor. The following survey variables were used in the analysis.

Self-restriction behavior. Four items were replicated from Study 1 with minor changes in phrasing, plus one additional item [11,44,68]. Item wordings are given in Table 1.

Income poverty. Measured similarly to Study 1 by employing six income categories; note that these categories differed from Study 1. Income responses were also converted into a metric scale using the respective category midpoints, thereby enabling joint analysis with Study 1.

Energy poverty. Measured similarly to Study 1, using indicators of the European Union Statistics on Income and Living Conditions [1]: whether a household can afford to keep its home adequately warm; has a leaking roof, damp walls or rotten windows; has had arrears on utility bills in the last twelve months. Boardman's 10% indicator and EPOV's 2M indicator were operationalized as in Study 1.

Personal norms. Three items expressed pro-environmental self-identity, as well as feelings of responsibility and obligation to use space heating environmentally soundly [73,74]. Item wordings are given in Table A.1 in the Appendix.

Frugality. Two items captured self-restraint and voluntary moderation in the consumption of everyday goods [73,75]. Item wordings are given in Table A.1.

Study 1 in Vienna and Study 2 in Graz followed up and built on each other: Study 1 developed questionnaire items for self-restriction behavior, which were refined in Study 2. Study 2 implemented accompanying measures to facilitate survey access for all members of the study population. Study 2 explored personal norms and frugality as further reasons for self-restrictions.

3.4. Analytical approach

In order to identify self-restricting subgroups, the parametric model-based clustering technique of latent class analysis (LCA) is employed. LCA is particularly useful in capturing complex constructs when multiple behaviors are measured. It is commonly used in an explorative manner to identify unobserved heterogeneous subpopulations based on a set of observed survey items [76]. It allocates individuals into mutually exclusive and exhaustive subgroups, each subgroup comprising households similar to members of the same subgroup and dissimilar to households in other subgroups. LCA is a person-centered technique that assumes that the population consists of different types of classes and identifies attributes the households in the same class have in common (compared to, e.g. variable-centered regression analysis which focuses on associations between attributes). LCA has been utilized in environmental social science research on climate change opinions [77], climate change scepticism [78] and environmental concern [79], but, to the best of our knowledge, only twice in energy poverty research [80,81]. LCA is useful for our purpose of comparing the slightly diverging items assessed in Study 1 and 2 because LCA identifies unobserved classes. Therefore, it does not need to use identical observed items for estimating the same latent classes in both studies, provided that all items are traceable to the same latent construct.

LCA holds several methodological advantages over common cluster analysis: it is probability-based, which enables to allocate households to the cluster to which they most likely belong to, and it is not sample dependent, meaning that results can be replicated in other samples. Moreover, it allows for missing responses in items, does not rely on scaling and measurement assumptions (e.g., linear relations, normal distribution, homogeneity), flawed questionnaire items can be identified (high standard errors), and it is a model-based approach assuming an underlying probability distribution. LCA is less subjective than cluster analysis as goodness-of-fit criteria allow comparing model solutions with different numbers of classes based on [82]: the minimum Akaike Information Criterion (AIC), the minimum Bayesian Information Criterion (BIC) and the sample-size adjusted Bayesian Information Criterion (SSABIC). Smaller model fit values indicate better model fit and model parsimony. However, the BIC is considered most reliable for obtaining parsimonious models and is used as benchmark index [83,84]. Results on model fit indices are reported in Table 2.

In this study, model estimation is terminated if, by increasing classes, models either turn under-identified or convergence issues arise. In practice, the decision on the optimal number of classes also takes into account theoretical meaning, model parsimony, conceptual interpretability, and classification diagnoses, such as class homogeneity and class separation [85]. High class homogeneity implies that for a given item, households in the same class are likely to respond similarly to the item, indicated by item-response probabilities close to 0 or 1, but not in the mid-range of response probabilities. Item probabilities between > 0.7 (high endorsement probability) and < 0.3 (low endorsement probability) are set as benchmarks for high class homogeneity [85]. The degree to which the classes can be distinguished from each other is called class separation. Low class separation is present if, for instance, a two-class model solution estimates for a specific item an item-probability of 0.9 in class one and an almost equal probability of 0.8 in class two. Although this item would indicate a high class homogeneity (>0.7), the separation between the two classes is poor. Overall, researchers should also holistically consider how well each item contributes to class separation [86].

LCA assigns households to classes based on their observed response patterns. Using several items ensures that the latent construct is captured with sufficient depth. However, five self-restriction items with a four- or five-step response scale each would amount to $4^5 = 1{,}024$ and $5^5 = 3{,}125$ response patterns in Study 1 and 2, respectively. The sample sizes available in the present study are too small that each possible response pattern could be observed at least once in the data. Therefore, items are recoded to binary variables, bringing down the number of response patterns to max. $2^5 = 32$ (see footnote in Table 1). Recoding to binary variables also avoids potential difficulties in estimation and convergence, which are more likely to occur with a larger range of response categories [85,87]. After recoding to binary variables, the Study 1 and 2 samples of 220 and 433 cases conform with the LCA rule of thumb for a minimum required sample size of $n = 70$ [88].

Once the optimal number of classes is determined, a further classification diagnostic assesses how well a model classifies households to their most likely class via the households' average posterior class probability: The minimum criterion for acceptable class membership classification is an average posterior probability of > 0.7 [89]. A probability close to 1.0 indicates a low likelihood of misclassification of that household. In the best-fitting model, posterior class probabilities are calculated to indicate each household's probability of being in each of the latent classes based on the parameter estimates and the household's item responses. A binary variable then indicates the class membership of each household to the respective class, where this household shows the highest class probability. This class membership is then cross-tabulated with affiliation to various energy poverty and income poverty definitions (Table 4). For this analysis, we employ most commonly pan-European agreed energy poverty and income poverty indicators [90]. For Boardman's 10% indicator, we use actual energy expenditures instead of theoretical energy costs due to data limitations of the study, as it is typical in various European contexts outside the UK. We, however, acknowledge the limitations of this approach and include other indicators extensively discussed in the literature [28,91,92].

In the final analytical step, class membership is regressed on sociodemographic characteristics, personal norms and frugality to check for further reasons for self-restrictions when controlling for energy poverty and income poverty (Table 5). Personal norms and frugality enter the logistic regression as mean indices comprising the respective items, in order to reduce measurement error and to control for missing responses. Both indices reach satisfactory reliability (Cronbach's Alpha 0.60 and 0.80; see Table A.1). All statistical analysis was carried out using STATA version 15.1.

4. Results

4.1. Self-restricting energy behaviors

Table 1 provides descriptive statistics on the items measuring self-restriction behaviors. Mean scores show endorsement of self-restriction in the mid-range of the response scale. In Vienna, more dominant self-restricting behaviors are closing doors between heated and not heated rooms, wearing a pullover instead of turning on the heating, and paying attention to costs while heating. In Graz, heating below comfort level, turning off the heating when leaving the flat, and restricting heating to selected rooms to save money stand out. In both study regions, sitting next to the radiator is endorsed least.

The energy behaviors listed in Table 1, especially items 3 and 4, may appear as energy saving activities that can be implemented with little effort or sacrifice and thus could be reasonably expected from any household. However, we presume that for the low-income households in our study samples, implementing these behaviors means additional pressure on their already overstretched coping capabilities and therefore indicates underconsumption. Overall, results indicate high variability in the responses, which points to heterogeneity in the degree to which households employ self-restrictions. Therefore, we expect more than one class in the LCA.

4.2. Identification of self-restrictions in the latent class analysis

According to common LCA procedure, if an a-priori hypothesis on the number of latent classes is not available [85], the number of latent classes is increased stepwise until the best-fitting model is identified. The expectation–maximization algorithm was used for the model estimation. A one-class model serves as a baseline to obtain the endorsement probability [86]. For the two- to five-class model estimation, 50 starting values and 150 iterations ensure initial random class assignments to avoid local maxima in determining likelihood parameters. The models constituting six and more classes are empirically under-identified and do not converge; therefore, they are omitted from Table 2.

The two-class model has significantly better fit indices than the one-class model with lower values of AIC (1249) and BIC (1286) in Study 1, and also lower values of AIC (2383) and BIC (2427) in Study 2. Comparing the best fitting models in both studies, the two-class model has the lowest BIC as benchmark index and performs better or equal than the other models on the LL, AIC and SSABIC goodness-of-fit criteria (Table 2). Furthermore, households' average posterior probabilities, which provide information about how well the two-class model

Table 1
Descriptive statistics of self-restricting items.

Study 1 Vienna Item wording	Mean	SD	N	Study 2 Graz Item wording	Mean	SD	N
1. Heating up to comfortable temperatures without paying attention to the costs (reversed direction)	2.36	1.03	198	1. Heating less warm than I feel comfortable with	2.97	1.25	413
2. Sitting close to the radiator to keep warm	1.87	1.00	199	2. Sitting close to the radiator to keep warm	2.27	1.25	414
3. Putting on a pullover first instead of turning on the heating	2.46	1.18	194	3. Wearing warm clothing, use a hot-water bottle or a blanket instead of turning on the heating	2.46	1.34	411
4. Turning off the heating when leaving the flat	1.98	1.12	189	4. Turning off the heating when leaving the flat	3.00	1.56	414
5. Closing doors between heated and not heated rooms	2.57	1.12	209	n/a	n/a	n/a	n/a
n/a	n/a	n/a	n/a	5. Heating only selected rooms to save money	3.41	1.49	417

Note: n/a: not included in the respective study. Original response scale in Study 1 Vienna 4-step Likert metric from 1 = strongly disagree to 4 = strongly agree, in Study 2 Graz five-step from 1 = never to 5 = always. For Latent Class Analysis, scale steps are recoded to 0/1 with 1 indicating endorsement of self-restriction; in Study 1 Vienna, scale steps 1–2 combined to 0 and steps 3–4 combined to 1; in Study 2 Graz, steps 1–3 combined to 0 and steps 4–5 combined to 1.

Table 2
Model fit criteria of one- to five-class models.

	Number of latent classes	LL	AIC	BIC	SSABIC
Study 1 Vienna	1	−646	1302	1319	1303
	2	**−614**	**1249**	**1286**	**1251**
	3	−605	1244	1301	1247
	4	−601	1249	1326	1253
	5	−599	1252	1343	1257
Study 2 Graz	1	−1268	2546	2567	2551
	2	**−1180**	**2383**	**2427**	**2393**
	3	−1173	2380	2449	2395
	4	−1170	2387	2480	2407
	5	−1170	2394	2504	2417

Note: LL: Log-Likelihood; AIC: Akaike information criterion BIC: Bayesian information criterion; SSABIC: Sample-size adjusted Bayesian information criterion; Study 1 Vienna: N = 220. Study 2 Graz: N = 433.

classifies households to their most likely class, show values above > 0.85 (Table A.2), thereby exceeding the > 0.7 threshold and indicating well-separated classes and low classification error [89]. Thus, the two-class models in both studies are selected as the best-fitting and most parsimonious solution.

Posterior class probabilities are utilized to assign observed cases to latent classes. Each household is assigned to the respective class where it has the higher estimated posterior probability. In Study 1 Vienna, 56% of the sample are assigned to class 1, whereas 44% are assigned to the class 2; in Study 2 Graz, 67% of households are belong to class 1 and 33% to class 2, respectively (top row in Fig. 1). Similar to factor analysis, it remains the task of the researcher to provide a label for the extracted classes. According to the estimated conditional class responses within the two classes, we name class 1 'not self-restricting group' and class 2 'self-restriction group'. In both studies, a substantial share of households does engage in self-restricting activities; however, the non-restricting class is larger than the self-restricting class.

At the item level, self-restricting behavior shows satisfactory class homogeneity and class separation in the two-class models (Fig. 1). In all five self-restriction items, class 2 shows higher item endorsement rates

Fig. 1. Estimated class probabilities (top row) and conditional responses (bottom row). Note: The y-axis represents the item response probabilities for the self-restricting and not self-restricting class. The x-axis represents the endorsement for each item; Study 1 Vienna: N = 220. Study 2 Graz: N = 433.

than class 1 (bottom row in Fig. 1). Only item 2 in Study 2 does not separate well (0.38 for self-restricting and 0.1 for not self-restricting class). Item-specific endorsement rates differ by approximately 30% between the two classes.

4.3. Intersection of self-restricting energy behavior with income poverty and energy poverty

Next, we analyze how the identified latent classes of self-restricting or not self-restricting households intersect with established classifications of income poverty and energy poverty. Table 3 illustrates the four possible combinations for the example of energy poverty: The top left (a.) and bottom right (d.) quadrant indicate correct identifications, either by recognizing self-restricting households as energy poor, or by considering not self-restricting households as not energy poor. The bottom left quadrant (c.) indicates the possible blind spot of current classifications and illustrates the share of households at risk of insufficient recognition: These households do not appear as energy poor when applying traditional indicators, but may be deprived because they self-restrict their heating needs potentially below comfort level. The top right quadrant (b.) comprises households who are energy poor but do not engage in self-restricting activities. Group (b.) may have many reasons for their behavior: they can still afford normal comfort levels; they have high energy needs (e.g. families with small children, old aged), they do not (yet) consider the curbing of heating demand as a strategy to ease their situation, or they rather ration other basic needs (e.g. food) than heating. Contingent on their specific needs and vulnerabilities, households in group (b.) might profit from targeted retrofitting subsidies or counselling on energy saving practices.

In Table 4, the logic of the 2x2 matrix presented in Table 3 is applied to two different definitions of income poverty and five different definitions of energy poverty. For each of these seven definitions, arranged by line in Table 4, we calculate 2x2 cross-tables separately for Study 1 and Study 2, arranged by column in Table 4. In eight out of twelve 2x2 cross-tables, the differences between the four quadrants are statistically significant at $p < .05$ according to Fisher's exact test. A substantial share of households who are captured by predominant poverty classifications apply self-restricting energy behaviors (quadrant a.). This result indicates that despite their active effort of thrifty behaviors and sufficiency strategies, self-restricting does not remedy these households' situation to lift them out of poverty. Presumably, this group comprises the most severe energy poor households, and it captures the multi-dimensional nature of energy poverty by focusing on unmet basic needs and deprivation. The share is however larger in Study 1 (ca. 50–60% of income poor or energy poor households) compared to Study 2 (ca. 30–40%).

Table 3
Intersection of energy poverty and self-restricting energy behavior (interpretation aid).

	Self-restricting	Not self-restricting
Energy poor	*a.) Correctly identified (recognized by policy)* Disadvantaged households who are captured by current definitions. These households self-restrict their energy use to remedy their situation, but this does not suffice to lift them out of energy poverty.	*b.) Energy needs not curtailed (potential target group)* Disadvantaged households who are captured by current definitions and who might benefit from retrofitting subsidies and counselling how to decrease energy consumption, dependent on their specific energy needs and vulnerabilities.
Not energy poor	*c.) Blind spot (lack of identification)* Self-restricting households, who are overlooked in current definitions. Self-restricting may keep some of these households barely over the energy poverty threshold.	*d.) Correctly identified (no aid needed)* Households who do not have problems with heating expenses and with maintaining comfortable indoor temperatures.

The cross-tabulation draws attention to a significant blind spot in current poverty classifications: Across various poverty definitions, of those not considered income poor or energy poor, 30–40% do engage in self-restricting energy behaviors (quadrant c.). These households self-restrain their energy consumption below their subjective comfort level to avoid excessive energy expenditures. Some of these households cut down on heating for other reasons than financial constraints (see Section 4.4). However, as both samples mainly comprise non-affluent households, it seems plausible that their self-restricting behavior rather stems from necessity than from modesty.

The share of households who are income or energy poor and do not self-restrict (quadrant b.) ranges from 30 to 65% in Study 1 to 40–70% in Study 2. This group might benefit from energy or debt counseling, nudges to lower energy consumption, exchange of energy inefficient devices, or, as is emphasized throughout the energy poverty literature, energy efficiency upgrades of their housing conditions. However, energy saving interventions which encourage sensible use of energy should not conflict with the household's energy needs or vulnerabilities.

Quadrant d. includes the largest group in both samples that neither are classified as energy poor, income poor nor employ self-restriction behaviors. Note that both study samples comprise predominantly deprived and low-income households; therefore, the counter categories in Table 4 (i.e. higher quartiles, not at risk, not energy poor) refer to the remainder of the study samples, not the general Austrian population.

4.4. Further reasons for self-restrictions

Households may engage in self-restriction behaviors for other reasons than forced thriftiness from low income, high heating expenditures, or energy inefficient housing. Some self-restriction behaviors are similar to energy saving in heating as recommended by guides for climate-friendly action or as analyzed as curtailment behaviors [94,95]. Pursuing a modest lifestyle focusing on quality of life instead of excessive spending on material possessions may cause voluntary restraint [44,75]. Socio-demographic characteristics may be associated with energy consumption [96,97]. Therefore, we check whether personal norms for environmental protection and a mindset of frugality have additional explanatory power for self-restriction when controlling for the influence of income poverty, energy poverty and selected socio-demographic characteristics.

Table 5 confirms the effect of income poverty (indicated by equalized income) and energy poverty (indicated by the inability to keep the home adequately warm) established in the previous Section 4.3. Personal norms are not related to self-restriction, suggesting that pro-environmental reasons play a marginal role in why the respondents turn down the heating. Valuing frugality, however, has a unique effect on self-restrictions, above and beyond the restraint necessitated by poverty. Neither gender nor education is related to self-restricting energy behaviors.

5. Discussion

This study addresses hidden energy poverty by analyzing self-restricting energy behaviors among low-income households living in non-renovated, energy inefficient housing. We expand on previous, predominantly qualitative research, which illustrates the lived experiences of underconsumption by measuring self-restrictions with a compact set of quantitative survey items. LCA finds two distinct groups of households: On the one hand, households showing unobtrusive energy use; on the other hand, households engaging in self-imposed energy restrictions, in other words, underconsuming heating to avoid exceeding energy expenditures and consequently accepting residential discomfort besides material deprivation. We confirm a substantial blind spot of households who self-restrict but are not classified as income poor or energy poor, and therefore are not recognized in poverty statistics or eligibility criteria of welfare and housing policies. This detected blind

Table 4
Intersection of self-restricting behavior, income poverty and energy poverty (cross-tabulation).

		Study 1 Vienna			Study 2 Graz		
Poverty indicator	**Categories**	**Self-restricting**	**Not self-restricting**	**Fisher's exact test**	**Self-restricting**	**Not self-restricting**	**Fisher's exact test**
Income poverty: Total income	Lowest quartile	52.6	47.4	p = .030	34.8	65.2	p = .041
	Higher quartiles	35.4	64.6		11.1	88.9	
Income poverty: At risk of poverty	At risk	58.5	41.5	p = .001	35.3	64.7	p = .040
	Not at risk	31.5	68.5		7.1	92.9	
Energy poverty: >10% energy expenditures	Energy poor	63.0	37.0	p = .013	38.6	61.4	p = .09
	Not energy poor	40.4	59.6		28.6	71.3	
Energy poverty: 2M	Energy poor	34.6	65.4	p = .812	57.1	42.9	p = .247
	Not energy poor	33.2	66.8		43.8	56.2	
Energy poverty: Cannot keep adequately warm	Energy poor	69.2	30.8	p = .001	44.0	56.0	p = .000
	Not energy poor	38.3	61.7		26.3	73.7	
Energy poverty: Housing deprivation 1	Energy poor	n/a	n/a	n/a	31.8	68.2	p = .182
	Not energy poor	n/a	n/a		40.3	59.7	
Energy poverty: Housing deprivation 2	Energy poor	48.5	51.5	p = .040	n/a	n/a	n/a
	Not energy poor	31.5	68.5		n/a	n/a	

Note: Table provides valid row wise percent and two-sided p-levels in Fisher's Exact Test. Total income: Non-equivalized household income in the lowest quartile of the national income distribution, < 1,965 Euro in 2019 [93]. At risk of poverty: Equivalized disposable income after social transfers below 60% of the national median, < 1,286 Euro in 2019 [93]. 2M: Equivalized energy expenditure (electricity and heat) is more than twice the national median of energy expenditures, 166.3 € in 2019. > 10% energy expenditures: Household spending > 10% of its non-equivalized household income for energy services. Cannot keep adequately warm: Household agrees to the item: "cannot afford to keep home adequately warm". Housing deprivation 1: Household agrees to one of the three following items: "presence of a leaking roof, damp walls or rotten windows" or "cannot afford to keep home adequately warm" or "arrears on utility bills (one, two or more payments delayed in the last 12 month)". Housing deprivation 2: Household agrees to one of the seven following items: presence of 1. damp walls, rotten windows or floor (mould), 2. leaking roof, 3. cold outer walls, 4. cold floor, 5. leaky windows, 6. poorly insulated building envelope, 7. absent heating regulation. Study 1 Vienna: N = 220. Study 2 Graz: N = 433. n/a: not included in the respective study.

Table 5
Logistic regression for energy self-restriction behavior in Study 1 and Study 2.

	Study 1 Vienna	Study 2 Graz
Equalized income	0.99 (0.01; 0.004)	0.99 (0.01; 0.074)
Cannot keep adequately warm	3.35 (1.55; 0.009)	1.92 (0.48; 0.010)
Personal norms	–	1.13 (0.18; 0.449)
Frugality	–	1.58 (0.24; 0.003)
Gender (Female)	0.64 (0.23; 0.225)	1.17 (0.30; 0.528)
Education 1. Low	0.63 (0.31; 0.352)	–
2. Middle (ref.)	–	–
3. High	2.37 (1.11; 0.064)	–
Constant	0.76 (0.56; 0.709)	0.06 (0.05; 0.001)
Pseudo-R^2	0.11	0.08
Chi^2	24.13	30.34

Note: Logistic regression with odds ratios. Standard errors and exact p-values in parentheses. Education: Low = Compulsory school or apprenticeship, Middle = School-leaving exam (reference category), High = University degree. Study 1 Vienna: N = 158, Study 2 Graz: N = 322.

spot applies across a range of income poverty and energy poverty definitions common in Austria and Europe. Replicating both groups of self-restricting and not self-restricting households in two separate samples reflecting different housing contexts in the cities of Vienna and Graz speaks for the reliability of our results. We may infer that the estimated classes represent subgroups that are not only sample-specific but occur in the entire population of low-income households in Austria. However, further research is needed to establish whether these findings also hold in other national contexts, in particular in poorer countries than Austria, and how class membership may change over time through aging, life events (e.g. unemployment, pension), or cohort effects.

The findings underlie the methodological caveat that under-consumption is operationalized as the adoption of specific self-restrictions in heating behaviors. Taken verbatim at face value, these behaviors seem similar to common energy saving (particularly the Study 1 items). However, low-income households, as in our two samples, already live under severe material constraints, and we may presume that they experience substantially higher inconvenience when adopting heating cutbacks than higher-income households. This presumption is supported by the regression results where material factors outweigh pro-environmental norms as an alternative motivation for self-imposed restrictions. Nevertheless, future studies could validate whether this self-restraint actually decreases the standard of living, e.g. by thermal discomfort, incidence of hypothermia or respiratory disease, or even a heat-or-eat dilemma. We expect that self-restriction strategies and hidden energy poverty are more prevalent in countries with less favorable economic conditions and higher incidence of manifest energy poverty than Austria.

Our results point to further implications for future studies regarding survey period, intersectional analysis and defining underconsumption. Both survey samples were collected in the non-heating season, therefore, the stated self-restriction behaviors most likely refer to ingrained habits rather than momentary reactions. The extent of self-restrictions observed in Study 1 and 2 may be seen as the lower limit of actual restriction, as presumably respondents would have stated even more self-restricting behaviors had we surveyed during the heating season, when these behaviors are more salient from being enacted every day. The Vienna survey was conducted before, the Graz survey was conducted after the Spring 2020 lockdown phase of the Covid-19 pandemic. That the findings hold in absence as well as presence of this additional pressing layer of social insecurity lends further credibility to our results.

This study is the first to apply the LCA method in hidden energy poverty research to analyze the prevalence of rationing energy use in a vulnerable population segment that is generally hard-to reach by means of public surveys. By modeling latent classes, and assigning households to classes based on posterior class probabilities, the LCA method may classify underconsumption without referring to normative thresholds of energy costs or energy needs as economic approaches for capturing hidden energy poverty do. However, understanding the reasons for self-restrictions in depth should go beyond cross-tabulating with income poverty and energy poverty classifications or regressing on socio-demographic characteristics. Intersectional analysis could explore characteristics such as building type, tenure type, presence of persons with higher energy needs (toddlers, elderly, disabled persons), persons with higher thermal sensitivity, or persons who spend most of the day at home to provide a more comprehensive picture of potential misidentification of energy poverty [98].

Nonetheless, when addressing hidden energy poverty as underconsumption, the question remains: What constitutes a normal comfort level, and how much does it have to be undercut to qualify as deprivation? When does self-restriction shift from voluntary saving to forced cutback? 'Normal' heating behavior may vary between warmer and colder climatic zones, between regions with different efficiency standards and availability of central heating in the housing stock, even between individual residents with different thermal sensitivity and subjective temperature tolerance. The assessment of adequate comfort levels and recognized heating standards has a normative component and results, inter alia, from personal judgment; even countries within the same temperature zones show significant differences in satisfaction with thermal comfort [99]. A certain degree of conscientious heating is desirable for climate-friendly energy saving, even among low-income households. Possible thresholds for 'normal' indoor temperatures may be set at uniform absolute benchmarks such as 18–21 °C, as suggested by the WHO [19], or at temperatures achievable within a specific building's technical specifications at reasonable costs. Identifying latent classes from self-reported, consensual measures of energy use helps in segmenting those at risk of hidden energy poverty who are overlooked in economic eligibility criteria of retrofitting schemes or heating allowances and consequently cannot overcome structural disadvantage from, for instance, bad housing conditions. However, self-reported restrictions cannot substitute for a political debate on the right to energy and an objective comfort level every citizen is entitled to.

6. Conclusions and policy implications

The study does not intend to make the prolonged debate on energy poverty definitions and generic indicators even more complicated, as several reviews already exist [34,53,100,101]. However, observing partial overlap between energy poverty and self-restricting energy behavior suggests that a binary logic of being energy poor or not might be too simplistic. Instead of single, supposedly catch-all indicators, measurements need to account for multiple facets of energy poverty and for the dynamic reactions of those affected [53,101]. Expenditure-based and income-based indicators as in Table 4, which are common in European comparative databases for reasons of data availability [90] and which are favored by the Austrian energy market regulator E-Control, should be complemented by measures of how low-income residents actively deal with their deprived situation in order to capture the full spectrum and variability of experienced energy poverty. We would welcome future efforts at identifying energy poor households which include self-imposed heating restrictions in addition to the traditional triad of high energy expenditures, low income and bad housing conditions. Self-restriction may, but need not substitute for the expenditure indicator of energy poverty, as e.g. households living in highly inefficient buildings could still pay above-average for energy despite their efforts at reducing their bill by means of underconsumption. Including items on self-restriction in large-scale surveys (e.g., ISSP, Eurobarometer) could provide a more comprehensive picture of the situation of energy poor households in the EU. Instead of aggregating to a single composite indicator, the Alkire Foster method [102,103] allows accounting for multi-dimensionality by setting minima for a range of diverse expenditure-based and consensual indicators [104]. If the current energy poverty working definition outlined in the Austrian National Energy and Climate Plan or by E-Control is utilized that focuses exclusively on low income and high energy expenses, households in large detached homes outside the city are at highest risk to be energy poor; if housing faults and inefficiency is included, the picture suddenly looks entirely different: Households living in multifamily buildings in cities are at highest risk to be energy poor [4]. Therefore, a combination of both subjective (e.g. self-restricting strategies and housing faults) and objective indicators is superior to single metrics to generate an unbiased picture of energy poverty incidences.

Nonetheless, self-restriction behavior is not a clear-cut, easily operationalizable characteristic. It seems to be a reflection of an overall lifestyle of frugality and self-sufficiency [105]. The regression results (see Section 4.4) caution against a narrow understanding of self-restriction as an exclusively forced reaction, as some households may (partially) adopt self-restriction behaviors as a natural expression of their sufficient and modest way of living. However, the influence of frugality on self-restriction may only apply to the socio-economically disadvantaged households who are represented in the Study 2 sample and need not generalize to the general population. Among the low-income households analyzed in Study 2, self-restriction is unrelated to pro-environmental motivations for curtailment in energy consumption; by contrast, in the general population, pro-environmental attitudes are significantly associated with energy consumption and energy saving behaviors [106,107]. Households may turn to self-restriction as a response to structural lock-in and to split incentives between tenants and landlords, if they cannot afford or do not have the negotiation power to insulate the building envelope or switch to a cheaper, non-fossil fuel-based heating system. Households may reduce their energy usage in order to compensate for a lack of insufficient or inefficient governmental welfare support; this may apply to Study 2 participants, who are entitled to an annual lump-sum energy costs support of just 65 Euro. Finally, in a hypothetical scenario of an accomplished right to affordable energy for all, self-restrictions would no longer reflect a reaction to scarcity and deprivation, but energy saving efforts in contributing to overall efficiency and emission reduction targets.

Thus, painting the full picture of energy poverty calls for technical and economic as well as bottom-up every day-practices perspectives on deprivation in the access to energy services. Focusing on self-restriction behavior as an outcome of lived experiences and personal livelihoods suggests a shift from formalized indicators to local expertise in identifying and approaching those in need. Referring to existing energy counseling projects offered by non-profit charity organizations and energy utilities in Austria, identification of clients can be enhanced by focusing not only on utility costs debts or/and the inability to pay for excessive energy expenses, but also on clients approaching NGOs (e.g. because of social or health reasons) that do not have high energy bills, but live in too cold derelict homes and who apply self-restricting strategies. Energy suppliers may draw on customer information on payment frequency and energy consumption to prevent forced disconnection after payment arrears. Acknowledging energy poverty as a responsibility on different levels of governance, of multiple stakeholders, governmental arenas, and as a multidimensional problem enlarges the spectrum for action. As an exemplary 'nodal governance' structure [108], a coordination platform supplied with a dedicated fund might be the first stepping-stone for tackling energy poverty. Grass-root initiatives and multi-stakeholder platforms including welfare organizations, NGOs, energy utilities and others may offer help, advice, possibilities for policy dialogue and targeted support across policy spheres as they have context-sensitive knowledge on the difficulties faced by vulnerable households and hear their voice.

At the time of writing this article, the Covid-19 pandemic puts additional pressure on vulnerable households in terms of job insecurity, increasing rates of unemployment and a decrease in regular household income. Households spend more time at home during the winter months due to lockdown restrictions, leading to higher energy bills for heating, cooking and other domestic energy uses, possibly exacerbating inequalities. At the same time, energy prices increased in the EU and Austria [109]. Households may turn to self-restriction in order to mitigate the economic impacts of the pandemic on their personal budgets. Thus, as one of many conceivable consequences of the pandemic, the blind spot of energy poverty classifications may become even bigger than estimated here.

Yet, as mentioned above, self-restrictions could be seen as desirable under specific circumstances, such as advancing overall efficiency and emission reduction targets. A substantial share of households is identified as income or energy poor but does not show self-restricting behaviors (see Section 4.3). This group could be approached in targeted interventions for enhancing energy literacy or for empowering energy-saving practices in order to save energy expenses and cushion poverty. However, this comes with two important caveats: On the one hand, instigating lasting behavioral change requires disrupting energy habits, which constitutes a hard task [110,111]. On the other hand, households may refrain from self-restrictions because of higher energy needs and intersections of vulnerabilities [88,98]. A certain degree of thriftiness may be reasonable and (still) healthy, exceeding efforts however might push these households into the blind spot quadrant so that they are no longer identified as a policy priority under current classifications. Tackling the root causes of energy poverty, however, calls for more structural long-term efforts than individual short-term energy counseling. Large-scale building renovation plans have been issued recently by the Renovation Wave for Europe [112] and the Austrian government [7,113], the latter setting an annual renovation rate of 3% in order to reach the 2030 decarbonisation targets in the housing sector. If affordable and energy-efficient housing were provided for all, involuntary self-restriction would no longer be necessary.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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References

[1] Eurostat. Inability to keep home adequately warm - EU-SILC survey. [July 19, 2021]; Available from: https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_mdes01&lang=en.
[2] OECD. GDP and spending: Gross domestic product (GDP). OECD.
[3] E-Control. Energiearmut in Österreich.: Definitionen und Indikatoren.
[4] S. Seebauer, M. Friesenecker, K. Eisfeld, Integrating climate and social housing policy to alleviate energy poverty: an analysis of targets and instruments in Austria, Energy Sources Part B 14 (7–9) (2019) 304–326, https://doi.org/10.1080/15567249.2019.1693665.
[5] United Nations. Accelerating SDG 7 Achievement Policy Brief 01. Achieving universal access to electricity. [July 19, 2021]; Available from: https://sustainabledevelopment.un.org/content/documents/17462PB1.pdf.
[6] European Commission. Clean energy for all Europeans Package. [July 19, 2021]; Available from: https://op.europa.eu/en/publication-detail/-/publication/b4e46873-7528-11e9-9f05-01aa75ed71a1/language-en?WT.mc_id=Searchresult&WT.ria_c=null&WT.ria_f=3608&WT.ria_ev=search.
[7] Bundeskanzleramt. Aus Verantwortungfür Österreich.: Regierungsprogramm 2020-2024. [July 19, 2021]; Available from: https://www.bundeskanzleramt.gv.at/bundeskanzleramt/die-bundesregierung/regierungsdokumente.html.
[8] European Commission. Commission recommendation of 18.6.2019 on the draft integrated National Energy and Climate Plan of Austria covering the period 2021-2030. [July 19, 2021]; Available from: https://ec.europa.eu/energy/sites/ener/files/documents/at_rec_en.pdf.
[9] Europen Parliament and the Council of the European Union. DIRECTIVE (EU) 2018/2002 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 amending Directive 2012/27/EU on energy efficiency; 2018.
[10] K. Jenkins, D. McCauley, A. Forman, Energy justice: A policy approach, Energy Policy 105 (2017) 631–634, https://doi.org/10.1016/j.enpol.2017.01.052.
[11] R. Chard, G. Walker, Living with fuel poverty in older age: Coping strategies and their problematic implications, Energy Res. Social Sci. 18 (2016) 62–70, https://doi.org/10.1016/j.erss.2016.03.004.
[12] R. Gillard, C. Snell, M. Bevan, Advancing an energy justice perspective of fuel poverty: Household vulnerability and domestic retrofit policy in the United Kingdom, Energy Res. Social Sci. 29 (2017) 53–61, https://doi.org/10.1016/j.erss.2017.05.012.
[13] B.K. Sovacool, M. Martiskainen, A. Hook, L. Baker, Decarbonization and its discontents: a critical energy justice perspective on four low-carbon transitions, Clim. Change 155 (4) (2019) 581–619, https://doi.org/10.1007/s10584-019-02521-7.
[14] B. Boardman. Fuel poverty: From cold homes to affordable warmth. 1st ed. London; 1991.
[15] J. Hills. Getting the measure of fuel poverty. Final report of the Fuel Poverty Review.: GOV UK; 2012.
[16] K. Fabbri, Building and fuel poverty, an index to measure fuel poverty: An Italian case study, Energy 89 (2015) 244–258, https://doi.org/10.1016/j.energy.2015.07.073.
[17] K. Rademaekers, J. Yearwood, A. Ferreira, S. Pye, I. Hamilton, P. Agnolucci et al. Selecting Indicators to Measure Energy Poverty; 2014.
[18] B. Legendre, O. Ricci, Measuring fuel poverty in France: Which households are the most fuel vulnerable? Energy Econ. 49 (2015) 620–628, https://doi.org/10.1016/j.eneco.2015.01.022.
[19] World Health Organization Regional Office for Europe. Health impact of low indoor temperatures report on a WHO meeting Copenhagen, 11-14 November 1985. Copenhagen; 1987.
[20] D. Ormandy, V. Ezratty, Health and thermal comfort: From WHO guidance to housing strategies, Energy Policy 49 (2012) 116–121, https://doi.org/10.1016/j.enpol.2011.09.003.
[21] L. Karpinska, S. Śmiech, Invisible energy poverty? Analysing housing costs in Central and Eastern Europe, Energy Res. Social Sci. 70 (2020) 101670, https://doi.org/10.1016/j.erss.2020.101670.
[22] F. Betto, P. Garengo, A. Lorenzoni, A new measure of Italian hidden energy poverty, Energy Policy 138 (2020) 111237, https://doi.org/10.1016/j.enpol.2019.111237.
[23] A.O. Yip, D.N. Mah, L.B. Barber, Revealing hidden energy poverty in Hong Kong: a multi-dimensional framework for examining and understanding energy poverty, Local Environment 25 (7) (2020) 473–491, https://doi.org/10.1080/13549839.2020.1778661.
[24] EPOV. Low absolute energy expenditure (M/2); 2021.
[25] F. Fizaine, S. Kahouli, On the power of indicators: how the choice of fuel poverty indicator affects the identification of the target population, Appl. Econ. 51 (11) (2019) 1081–1110, https://doi.org/10.1080/00036846.2018.1524975.
[26] B.C. Isherwood, Hancock RM. Household expenditure on fuel: distributional aspects. London, UK; 1979.
[27] G. Owen. Review of the UK fuel poverty measure: Report for Ofgem. London; 2010.
[28] H. Thomson, S. Bouzarovski, C. Snell, Rethinking the measurement of energy poverty in Europe: A critical analysis of indicators and data, Indoor Built Environ 26 (7) (2017) 879–901, https://doi.org/10.1177/1420326X17699260.
[29] F. Vondung, J. Thema. Energy poverty in the EU – indicators as a base for policy action; 2019.
[30] J.P. Gouveia, P. Palma, S.G. Simoes, Energy poverty vulnerability index: A multidimensional tool to identify hotspots for local action, Energy Rep. 5 (2019) 187–201, https://doi.org/10.1016/j.egyr.2018.12.004.

[31] L. Papada, D. Kaliampakos, Being forced to skimp on energy needs: A new look at energy poverty in Greece, Energy Res. Social Sci. 64 (2020) 101450, https://doi.org/10.1016/j.erss.2020.101450.
[32] I. Antepara, L. Papada, J.P. Gouveia, N. Katsoulakos, D. Kaliampakos, Improving Energy Poverty Measurement in Southern European Regions through Equivalization of Modeled Energy Costs, Sustainability 12 (14) (2020) 5721, https://doi.org/10.3390/su12145721.
[33] C. Waddams Price, K. Brazier, W. Wang, Objective and subjective measures of fuel poverty, Energy Policy 49 (2012) 33–39, https://doi.org/10.1016/j.enpol.2011.11.095.
[34] S. Tirado-Herrero, Energy poverty indicators: A critical review of methods, Indoor Built Environ 26 (7) (2017) 1018–1031, https://doi.org/10.1177/1420326X17718054.
[35] P. Heindl, R. Schüssler. Dynamic Properties of Energy Affordability Measures; 2015.
[36] A. Kearns, E. Whitley, A. Curl, Occupant behaviour as a fourth driver of fuel poverty (aka warmth & energy deprivation), Energy Policy 129 (2019) 1143–1155, https://doi.org/10.1016/j.enpol.2019.03.023.
[37] S. Meyer, H. Laurence, D. Bart, L. Middlemiss, K. Maréchal, Capturing the multifaceted nature of energy poverty: Lessons from Belgium, Energy Res. Social Sci. 40 (2018) 273–283, https://doi.org/10.1016/j.erss.2018.01.017.
[38] U. Dubois, From targeting to implementation: The role of identification of fuel poor households, Energy Policy 49 (2012) 107–115, https://doi.org/10.1016/j.enpol.2011.11.087.
[39] D. Hirsch, I. Preston, V. White, Understanding fuel expenditure. Fuel poverty and spending on fuel, 2011.
[40] N. Willand, R. Horne, "They are grinding us into the ground" – The lived experience of (in)energy justice amongst low-income older households, Appl. Energy 226 (2018) 61–70, https://doi.org/10.1016/j.apenergy.2018.05.079.
[41] B.E. Harrington, B. Heyman, N. Merleau-Ponty, H. Stockton, N. Ritchie, A. Heyman, Keeping warm and staying well: findings from the qualitative arm of the Warm Homes Project, Health Soc Care Community 13 (3) (2005) 259–267, https://doi.org/10.1111/hsc.2005.13.issue-310.1111/j.1365-2524.2005.00558.x.
[42] L. Middlemiss, R. Gillard, Fuel poverty from the bottom-up: Characterising household energy vulnerability through the lived experience of the fuel poor, Energy Res. Social Sci. 6 (2015) 146–154, https://doi.org/10.1016/j.erss.2015.02.001.
[43] C.V. Jansson-Boyd, R.A.V. Robison, R. Cloherty, C. Jimenez-Bescos, Complementing retrofit with engagement: exploring energy consumption with social housing tenants, Int. J. Energy Res. 41 (8) (2017) 1150–1163, https://doi.org/10.1002/er.v41.810.1002/er.3698.
[44] W. Anderson, V. White, A. Finney, Coping with low incomes and cold homes, Energy Policy 49 (2012) 40–52, https://doi.org/10.1016/j.enpol.2012.01.002.
[45] K.-M. Brunner, M. Spitzer, A. Christanell, Experiencing fuel poverty. Coping strategies of low-income households in Vienna/Austria, Energy Policy 49 (2012) 53–59, https://doi.org/10.1016/j.enpol.2011.11.076.
[46] B. Karlin, N. Davis, A. Sanguinetti, K. Gamble, D. Kirkby, D. Stokols, Dimensions of Conservation, Environment and Behavior 46 (4) (2014) 423–452, https://doi.org/10.1177/0013916512467532.
[47] D. Gibbons, R. Singler. Cold Comfort: A Review of Coping Strategies Employed by Households in Fuel Poverty; 2008.
[48] S.-N. Boemi, A.M. Papadopoulos, Energy poverty and energy efficiency improvements: A longitudinal approach of the Hellenic households, Energy Build. 197 (2019) 242–250, https://doi.org/10.1016/j.enbuild.2019.05.027.
[49] M. Rocha, M. Baddeley, M. Pollitt, M. Weeks, Addressing self-disconnection among prepayment energy consumers: A behavioural approach, Energy Econ. 81 (2019) 273–286, https://doi.org/10.1016/j.eneco.2019.03.025.
[50] G. Besagni, M. Borgarello, The determinants of residential energy expenditure in Italy, Energy 165 (2018) 369–386, https://doi.org/10.1016/j.energy.2018.09.108.
[51] S&P Global Ratings. The Energy Transition And What It Means For European Power Prices And Producers: January 2021 Update; 2021.
[52] European Commission. EU Reference Scenario: EU energy, transport and GHG emissions - trends to 2050; 2016.
[53] C. Lowans, D. Del Furszyfer Rio, Sovacool BK, Rooney D, Foley AM. What is the state of the art in energy and transport poverty metrics? A critical and comprehensive review. Energy Economics 2021;101:105360. 10.1016/j.eneco.2021.105360.
[54] W. Amann, A. Mund, Rahmenbedingungen und Handlungs-optionen für qualitätsvolles, dauerhaftes, leistbares und inklusives Wohnen (2019).
[55] AHK. Österreich Energieeffizienz im Gebäudesektor -Neubau und Sanierung Zielmarktanalyse 2018; 2018.
[56] A. Hagauer, Rettensteiner G, Prabitz D, F., Zitz, E. Wohnungsbericht der Stadt Graz, Winkler, 2016.
[57] S. Austria, Wohnen, Zahlen, Daten und Indikatoren der Wohnstatistik, 2020.
[58] Förster W, Menking W (eds.). Das Wiener Modell: Wohnbau für die Stadt des 21. Jahrhunderts = The @Vienna model ; housing for the twenty-first-century city. Berlin: Jovis; 2016.
[59] STATcube. Registerzählung 2011 - GWZ: Wohnungen (QSW); 2020.
[60] E. Llera-Sastresa, S. Scarpellini, P. Rivera-Torres, J. Aranda, I. Zabalza-Bribián, A. Aranda-Usón, Energy vulnerability composite index in social housing, from a household energy poverty perspective, Sustainability 9 (5) (2017) 691, https://doi.org/10.3390/su9050691.
[61] C. Boomsma, R.V. Jones, S. Pahl, A. Fuertes, Do psychological factors relate to energy saving behaviours in inefficient and damp homes? A study among English social housing residents, Energy Res. Social Sci. 47 (2019) 146–155, https://doi.org/10.1016/j.erss.2018.09.007.
[62] Stadt Wien. Über Wiener Wohnen; 2021.
[63] C. Reinprecht, Social Housing in Austria, in: C.M.E. Whitehead, K. Scanlon, M. F. Arrigoitia (Eds.), Social housing in Europe, Wiley Blackwell, Chichester, West Sussex, 2014, pp. 61–73.
[64] Stadt Wien. Wiener Wohn Ticket; 2021.
[65] Open Data Österreich. Open Data Österreich; 2021.
[66] C. Lévy-Vroelant, C. Reinprecht, Housing the Poor in Paris and Vienna: The Changing Understanding of the 'Social', in: C.M.E. Whitehead, K. Scanlon, M. F. Arrigoitia (Eds.), Social housing in Europe, Wiley Blackwell, Chichester, West Sussex, 2014, pp. 297–313.
[67] Statistik Austria. Household Income. [July 20, 2021].
[68] B.K. Sovacool, Fuel poverty, affordability, and energy justice in England: Policy insights from the Warm Front Program, Energy 93 (2015) 361–371, https://doi.org/10.1016/j.energy.2015.09.016.
[69] D. Butler, G. Sherriff, 'It's normal to have damp': Using a qualitative psychological approach to analyse the lived experience of energy vulnerability among young adult households, Indoor Built Environ 26 (7) (2017) 964–979, https://doi.org/10.1177/1420326X17708018.
[70] S. Seebauer, A. Wolf, Disentangling household and individual actors in explaining private electricity consumption, Energ. Effi. 10 (1) (2017) 1–20, https://doi.org/10.1007/s12053-016-9435-x.
[71] Eurostat. Total population living in a dwelling with a leaking roof, damp walls, floors or foundation, or rot in window frames or floor - EU-SILC survey.
[72] Stadt Graz. SozialCard; 2021.
[73] S. Seebauer, The psychology of rebound effects: Explaining energy efficiency rebound behaviours with electric vehicles and building insulation in Austria, Energy Res. Social Sci. 46 (2018) 311–320, https://doi.org/10.1016/j.erss.2018.08.006.
[74] S. Bamberg, M. Hunecke, A. Blöbaum, Social context, personal norms and the use of public transportation: Two field studies, J. Environ. Psychol. 27 (3) (2007) 190–203, https://doi.org/10.1016/j.jenvp.2007.04.001.
[75] R.E. Goldsmith, L. Reinecke Flynn, R.A. Clark, The etiology of the frugal consumer, J. Retailing and Consumer Serv. 21 (2) (2014) 175–184, https://doi.org/10.1016/j.jretconser.2013.11.005.
[76] L.M. Collins, S.T. Lanza, Latent Class and Latent Transition Analysis: With applications in the social, behavioral, and health sciences, John Wiley & Sons, Inc, Hoboken, NJ, USA, 2009.
[77] S. Crawley, H. Coffé, R. Chapman, Public opinion on climate change: Belief and concern, issue salience and support for government action, The British Journal of Politics and International Relations 22 (1) (2020) 102–121, https://doi.org/10.1177/1369148119888827.
[78] C.G. Sibley, T. Kurz, A Model of Climate Belief Profiles: How Much Does It Matter If People Question Human Causation? Analyses of Social Issues and Public Policy 13 (1) (2013) 245–261, https://doi.org/10.1111/asap.2013.13.issue-110.1111/asap.12008.
[79] R. Rhead, M. Elliot, P. Upham, Using latent class analysis to produce a typology of environmental concern in the UK, Soc Sci Res 74 (2018) 210–222, https://doi.org/10.1016/j.ssresearch.2018.06.001.
[80] C. Robinson, D.a. Yan, S. Bouzarovski, Y. Zhang, Energy poverty and thermal comfort in northern urban China: A household-scale typology of infrastructural inequalities, Energy Build. 177 (2018) 363–374, https://doi.org/10.1016/j.enbuild.2018.07.047.
[81] M. Llorca, A. Rodriguez-Alvarez, T. Jamasb, Objective vs. subjective fuel poverty and self-assessed health, Energy Econ. 87 (2020) 104736, https://doi.org/10.1016/j.eneco.2020.104736.
[82] L.M. Collins, P.L. Fidler, S.E. Wugalter, J.D. Long, Goodness-of-Fit Testing for Latent Class Models, Multivariate Behav Res 28 (3) (1993) 375–389, https://doi.org/10.1207/s15327906mbr2803_4.
[83] K.L. Nylund, T. Asparouhov, B.O. Muthén, Deciding on the Number of Classes in Latent Class Analysis and Growth Mixture Modeling: A Monte Carlo Simulation Study, Structural Equation Modeling: A Multidisciplinary Journal 14 (4) (2007) 535–569, https://doi.org/10.1080/10705510701575396.
[84] G.B. Morgan, Mixed Mode Latent Class Analysis: An Examination of Fit Index Performance for Classification, Structural Equation Modeling: A Multidisciplinary Journal 22 (1) (2015) 76–86, https://doi.org/10.1080/10705511.2014.935751.
[85] K.E. Masyn, Latent Class Analysis and Finite Mixture Modeling, Oxford University Press, 2013.
[86] K. Nylund-Gibson, A.Y. Choi, Ten frequently asked questions about latent class analysis, Translational Issues in Psychological Science 4 (4) (2018) 440–461, https://doi.org/10.1037/tps0000176.
[87] F. Reichert, Students' perceptions of good citizenship: a person-centred approach, Soc Psychol Educ 19 (3) (2016) 661–693, https://doi.org/10.1007/s11218-016-9342-1.
[88] I.C. Wurpts, C. Geiser, Is adding more indicators to a latent class analysis beneficial or detrimental? Results of a Monte-Carlo study, Front Psychol 5 (2014) 920, https://doi.org/10.3389/fpsyg.2014.00920.
[89] D. Nagin, Group-Based Modeling of Development, Harvard University Press, Cambridge, Mass, 2005.
[90] EU Energy Poverty Observatory. Indicators & Data. [July 20, 2021]; Available from: https://www.energypoverty.eu/indicators-data.
[91] J. Thema, F. Vondung, Expenditure-Based Indicators of Energy Poverty—An Analysis of Income and Expenditure Elasticities, Energies 14 (1) (2021) 8, https://doi.org/10.3390/en14010008.

[92] R. Schuessler, Energy Poverty Indicators: Conceptual Issues - Part I: The Ten-Percent-Rule and Double Median/Mean Indicators, SSRN Journal (2014), https://doi.org/10.2139/ssrn.2459404.
[93] Eurostat. EU-SILC. Translate EU statistics on income and living conditions (EU-SILC) methodology - distribution of income.
[94] W. Abrahamse, G. Schuitema, Psychology and energy conservation: Contributions from theory and practice, in: M. Lopes, C. Antunes, K. Janda (Eds.), Energy and Behavior: Towards a Low Carbon Future, San Diego Elsevier Science & Technology, 2019, pp. 19–44.
[95] F.G. Kaiser, A General Measure of Ecological Behavior, J Appl Social Pyschol 28 (5) (1998) 395–422, https://doi.org/10.1111/j.1559-1816.1998.tb01712.x.
[96] Statistics Austria. Modeling electricity consumption in private households in Austria by purpose of use: [Modellierung des Stromverbrauchs in den privaten Haushalten Österreichs nach unterschiedlichen Verwendungszwecken.]. [July 20, 2021].
[97] E. Frederiks, K. Stenner, E. Hobman, The Socio-Demographic and Psychological Predictors of Residential Energy Consumption: A Comprehensive Review, Energies 8 (1) (2015) 573–609, https://doi.org/10.3390/en8010573.
[98] K. Großman, A. Kahlheber, Energy poverty in an intersectional perspective: On multiple deprivation, discriminatory systems and the effects of policies, in: N. Simcock, H. Thomson, S. Petrova, S. Bouzarovski (Eds.), Energy poverty and vulnerability: A global perspective, Routledge, London, 2018, pp. 12–32.
[99] N. Zhang, B. Cao, Z. Wang, Y. Zhu, B. Lin, A comparison of winter indoor thermal environment and thermal comfort between regions in Europe, North America, and Asia, Build. Environ. 117 (2017) 208–217, https://doi.org/10.1016/j.buildenv.2017.03.006.
[100] H. Doukas, V. Marinakis, Energy poverty alleviation: effective policies, best practices and innovative schemes, Energy Sources Part B 15 (2) (2020) 45–48, https://doi.org/10.1080/15567249.2020.1756689.
[101] R. Castaño-Rosa, J. Solís-Guzmán, C. Rubio-Bellido, M. Marrero, Towards a multiple-indicator approach to energy poverty in the European Union: A review, Energy Build. 193 (2019) 36–48, https://doi.org/10.1016/j.enbuild.2019.03.039.
[102] S. Alkire, S. Seth, Measuring Multidimensional Poverty in India, A New Proposal (2008).
[103] S. Alkire, J. Foster, Counting and multidimensional poverty measurement, Journal of Public Economics 95 (7–8) (2011) 476–487, https://doi.org/10.1016/j.jpubeco.2010.11.006.
[104] J. Sokołowski, P. Lewandowski, A. Kiełczewska, S. Bouzarovski, A multidimensional index to measure energy poverty: the Polish case, Energy Sources Part B 15 (2) (2020) 92–112, https://doi.org/10.1080/15567249.2020.1742817.
[105] A. Kollmuss, J. Agyeman, Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? Environmental Education Research 8 (3) (2002) 239–260, https://doi.org/10.1080/13504620220145401.
[106] O. Sapci, T. Considine, The link between environmental attitudes and energy consumption behavior, Journal of Behavioral and Experimental Economics 52 (2014) 29–34, https://doi.org/10.1016/j.socec.2014.06.001.
[107] D. Brounen, N. Kok, J.M. Quigley, Energy literacy, awareness, and conservation behavior of residential households, Energy Econ. 38 (2013) 42–50, https://doi.org/10.1016/j.eneco.2013.02.008.
[108] N. Creutzfeldt, C. Gill, R. McPherson, M. Cornelis, The Social and Local Dimensions of Governance of Energy Poverty: Adaptive Responses to State Remoteness, J Consum Policy 43 (3) (2020) 635–658, https://doi.org/10.1007/s10603-019-09442-z.
[109] Eurostat. Electricity prices for household consumers - bi-annual data (from 2007 onwards). [July 20, 2021]; Available from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Strompreisstatistik&oldid=496130#Strompreise_f.C3.BCr_Haushaltskunden.
[110] T. Kurz, B. Gardner, B. Verplanken, C. Abraham, Habitual behaviors or patterns of practice? Explaining and changing repetitive climate-relevant actions, WIREs Clim Change 6 (1) (2015) 113–128, https://doi.org/10.1002/wcc.2015.6.issue-110.1002/wcc.327.
[111] B. Verplanken, D. Roy, Empowering interventions to promote sustainable lifestyles: Testing the habit discontinuity hypothesis in a field experiment, Journal of Environmental Psychology 45 (2016) 127–134, https://doi.org/10.1016/j.jenvp.2015.11.008.
[112] European Commission. A Renovation Wave for Europe - greening our buildings, creating jobs, improving lives: {SWD(2020) 550 final}; 2020.
[113] IIBW. Definition und Messung der thermisch-energetischen Sanierungsrate in Österreich; 2021.