The austerity pitfall. Energy coping behaviour as a blind spot in energy poverty classifications.

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Highlights

- We analyse coping as an aspect of hidden energy poverty in two Austrian cities.
- Latent class analysis finds coping and non-coping classes based on multiple items.
- Coping reflects overall frugality, but is unrelated to environmental attitudes.

Abstract

The present paper examines the phenomenon of energy coping behaviour for residential heating, in other words, energy poor or income poor households self-restricting their heating to underconsumption below comfort level to avoid excessive energy bills. Energy poverty definitions predominantly focus on energy expenses relative to household income or theoretically estimated energy needs. We 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 coping and non-coping 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 engage in energy coping behaviours. 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. Energy coping blurs the lines of current classifications as some deprived households may not be recognised in poverty statistics or eligibility criteria of welfare and housing policies. Thus, we propose to consider coping behaviour complementary to the energy poverty triad of above-average energy costs, low income and bad housing conditions in order to avoid recognition injustice.

Keywords

Hidden energy poverty; heat-related coping behaviour; occupant behaviour; household energy consumption; energy justice; latent class analysis

JEL classification

I32, D63, P18, Q4

1. Introduction

Energy poverty is a serious problem across Europe: 7.3% of European households were considered energy poor in 2018, indicated by the inability to keep their home adequately warm (EPOV, 2020a). Even in more affluent countries, energy poverty affects a significant share of the population (OECD, 2020); in Austria, the study region of the present paper, different energy poverty indicators indicate that 3.1% (E-Control, 2016) to 15.2% (Seebauer et al., 2019) of the population are energy poor. This wide range stems from various indicators included in the respective energy poverty definitions; while E-Control recognizes only low income and high energy costs, Seebauer et al. (2019) include the inefficiency of the dwelling. Consequently, energy poverty is a prominent issue, acknowledged on different governmental scales, ranging from the UN SDG 7 (UN, 2018), European (European Commission, 2019a) and national policy strategies (Bundeskanzleramt, 2020). 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, the implementation of policy strategies is still insufficient; for instance, Austria was obligated by the European Commission (2019b) to elaborate in the Integrated National Energy and Climate Plan how transitional aspects will be streamlined in concrete measures and how energy poverty will be defined.

Energy poverty is closely related with energy justice (Chard and Walker, 2016; Jenkins et al., 2017). The element of recognition justice within the energy justice debate directs to vulnerable households that are ignored due to simplistic energy poverty indicators (Gillard et al., 2017); in order to remedy recognition injustice, these households should be provided with active participation in decision-making processes (Jenkins et al., 2017; Walker and Day, 2012). Thus, recognizing energy poverty in a comprehensive manner should take the lived experiences and behaviours of those vulnerable and marginalized households into account (Chard and Walker, 2016; Sovacool et al., 2019).

Yet, for over three decades, energy poverty has been largely studied from an economical angle focusing on the triad of above-average energy costs, low income and bad housing conditions (Boardman, 1991; Fabbri, 2015; Hills, 2012; Rademaekers et al., 2016). 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 households needs. Coping by underconsumption may blur the lines between being classified as energy poor or not (Legendre and Ricci, 2015). 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 (World Health Organization., 1987). For vulnerable groups like elderly or children, 23 °C in the living room are considered appropriate (Ormandy and Ezratty, 2012); 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 (Eurostat, 2020a). By addressing coping as a recognition challenge in tackling energy poverty, the present paper links to the recent academic research strand on socio-economic factors of hidden energy poverty (Betto et al., 2020; Karpinska and Śmiech, 2020; Yip et al., 2020).

The aim of the present paper is to propose an original perspective on hidden energy poverty derived from how residents actively cope with their impaired situation. We illustrate that excluding coping behaviours from the understanding of energy poverty implies overlooking households at risk and potentially incurring recognition injustice. 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 energy coping to previous research on hidden energy poverty, underconsumption and occupant behaviour. 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 energy coping 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 energy coping 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 energy coping behaviours. Note though that the observed size of the blind spot only applies to Austrian cities and does not generalise to other national or regional contexts. We conclude with a proposal to consider coping behaviour complementary to existing formalised energy poverty indicators and direct to future research in section 5.

2. Energy coping 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 (EPOV, 2020b). Hidden energy poverty appears if households consume less energy than they would be expected to do. Previous studies employ three approaches for capturing underconsumption: *First*, households with low energy bills are considered hidden energy poor (e.g. Betto et al., 2020; Karpinska and Śmiech, 2020). In 2015, judged by the low absolute energy expenditure indicator M/2, 14.6% of all Europeans were hidden energy poor (EPOV, 2020b). 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 costs are included in the rent, these households may be erroneously classified as being hidden energy poor (Vondung and Thema, 2019). *Second*, hidden energy poverty is deduced from thermal comfort gaps between actual consumption and theoretically required energy needs (Atsalis et al., 2016; Gouveia et al., 2019; Papada and Kaliampakos, 2020). This approach relies on converting energy needs to expected expenditures which may then be compared to actual energy expenditures or socio-demographic data (Antepara et al., 2020). 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 (Thomson et al., 2017). Notwithstanding the extensive discussion on the advantages and disadvantages of various energy poverty indicators (see for example Tirado-Herrero, 2017; Waddams Price et al., 2012), solely focusing on the monetary dimension with expenditure-based and income-based indicators may cause misleading or even contradictory identification of disadvantaged population segments due to arbitrary threshold values (Heindl and Schüssler, 2015). Thus, we propose a *fourth* approach, leveraging occupant behaviours to bridge the discussion between hidden energy poverty and underconsumption.

Occupant behaviour is a core yet under-researched driver of energy poverty (Kearns et al., 2019; Maxim et al., 2016). Households may restrict their consumption to limit expenditure on energy in order to avoid default of payment or excessive energy bills (Dubois, 2012; Meyer et al., 2018). 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” (Yip et al., 2020, p. 475). In a British study, Hirsch et al. (2011) 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 behaviours of energy poor households tend to be overlooked (Chard and Walker, 2016; Clancy et al., 2017; Harrington et al., 2005; Middlemiss and Gillard, 2015; Willand and Horne, 2018). 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 costs, 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 behaviours 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 (Jansson-Boyd et al., 2017). Some energy poor households use justifications for their underconsumption, for example, sleeping in cold rooms is deemed to be healthy (Harrington et al., 2005). 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 (Anderson et al., 2012; Chard and Walker, 2016; Willand and Horne, 2018). We therefore control for the influence of modesty and pro-environmental motivation on energy coping in section 4.4.

In the present study, we understand *energy coping* as a sufficiency strategy characterized by regularly cutting back everyday energy use below comfort level to keep energy expenses down. Typical energy coping behaviours include self-disconnection from the energy grid or heating only one room and closing doors to the rest of the flat or house (Boemi and Papadopoulos, 2019; Gibbons and Singler, 2008; Rocha et al., 2019). The coping 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 (Middlemiss and Gillard, 2015). The notion of energy poverty as varying rather than fixed circumstance is supported by the Kearns et al. (2019) 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 coping behaviours, but this buffering capacity may be overextended if households are subject to increased external pressure, such as rising energy costs or an exceptionally cold winter. Energy coping behaviours are not yet firmly established in energy poverty debates and interlinkages of daily realities of households living in substandard housing conditions are not addressed to their full potential (Besagni and Borgarello, 2018; Delzendeh et al., 2017; Kearns et al., 2019). 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.

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 occupant behaviours. It poses a challenging task to operationalize and classify energy poor households as the aspects of building, affordability and occupant behaviours intersect. Hence, we employ latent class analysis to segment households by energy coping in order to identify hidden energy poor households.

3. Method

3.1 Study context

Austria is a country of 8.8 Mio. inhabitants of which 1.9 Mio. (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 (Amann and Mundt, 2019). However, buildings constructed between 1945 and 1960, which amount for three quarters of all existing buildings, feature very low energy efficiency between 200-300 kWh/m^{2}a (AHK, 2018; Hagauer et al., 2016). The average Austrian rent incl. operating costs was 7.8 €/m2 in 2018. Privately rented flats have a significantly higher rent (9.1 €/m^2) than limited-profit housing (7.0 €/m^2) and municipal housing (6.6 €/m^2), among other reasons because (semi-)public housing offers long-term and rent-regulated contracts which typically ask for lower rents (Statistik Austria, 2019).

In the cities of Vienna and Graz, the majority 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 (Förster and Menking, 2016). 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%; STATcube, 2020). Similar to other Austrian regions, limited-profit housing associations provide the principal share of the rental housing stock in Vienna and Graz (Statistik Austria, 2019).

The present 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 (Llera-Sastresa et al., 2017). In Graz, energy coping may be necessitated by rent pressure on a largely unregulated rental market, whereas in Viennese social housing, coping may be present despite below-market rent levels. Housing problems (e.g. cold, damp, mould) are frequently experienced among social housing tenants (Boomsma et al., 2019; Pevalin et al., 2008). 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.

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 (Wiener Wohnen, 2020). 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 less than 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 (Reinprecht, 2014)[1]. 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.[2] We chose this segment since they typically feature bad energy efficiency ratings unless renovated (Seebauer et al., 2019). Viennese social housing stock is dispersed over all 23 city districts to counteract segregation processes (Lévy-Vroelant and Reinprecht, 2014) 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 x 25 Euros) 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

[1] https://wohnberatung-wien.at/wiener-wohn-ticket/allgemeines [accessed: 18.12.2020]
[2] https://www.data.gv.at/katalog/dataset/ [accessed: 18.12.2020]

rate of 6.4%. We centre our present analysis on the subsample 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%). Next, we present the selected questionnaire items used in the present analysis.

Energy coping behaviour. Five items captured everyday practices in self-restricting heating demand and in trading cost savings for comfort (Brunner et al., 2012; Butler and Sherriff, 2017; Middlemiss and Gillard, 2015; Sovacool, 2015; Willand and Horne, 2018). 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 (Seebauer and Wolf, 2017).

Energy poverty. The measurement used indicators of the European Union Statistics on Income and Living Conditions (Eurostat, 2020b): 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 were able to reach their preferred indoor temperature. Households stated their monthly expenditures for energy services (heating, electricity).

3.3 Study 2 Graz

Study 2 was conducted among beneficiaries in the SozialCard program[3] 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, household size, income, 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 x 30 Euros) 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 the present 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-storey apartment buildings (93.5% of the sample), have an income

[3] https://www.graz.at/cms/beitrag/10200148/7761791/SozialCard.html [accessed: 18.12.2020]

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 present analysis.

Energy coping behaviour. Four items were replicated from Study 1 with minor changes in phrasing, plus one additional item (Anderson et al., 2012; Chard and Walker, 2016; Sovacool, 2015). 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 (Eurostat, 2020a): 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. Households stated their monthly expenditures for energy services (heating, electricity).

Personal norms. Three items expressed pro-environmental self-identity, as well as feelings of responsibility and obligation to use space heating in an environmentally sound way (Bamberg et al. 2007, Seebauer 2018). Item wordings are given in Table A.1.

Frugality. Two items captured self-restraint and voluntary moderation in the consumption of everyday goods (Goldsmith et al., 2014; Seebauer, 2018). 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 energy coping behaviour, 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 energy coping.

3.4 Analytical approach

In order to identify energy coping subgroups, the parametric model-based clustering technique of latent class analysis (LCA) is employed. LCA is particularly useful in capturing complex constructs when multiple behaviours are measured. It is commonly used in an explorative manner to identify unobserved heterogeneous subpopulations based on a set of observed survey items (Collins and Lanza, 2010). 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-centred 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-centred regression analysis which focuses on associations between attributes). LCA has been utilized in environmental social science research on climate change opinions (Crawley et al., 2020), climate change scepticism (Sibley and Kurz, 2013) and environmental concern (Rhead et al., 2018), but, to the best of our knowledge, only twice in energy poverty research (Llorca et al., 2020; Robinson et al., 2018). LCA is particularly useful for our purpose of comparing the slightly diverging coping 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 as 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 (Collins et al., 1993; Karnowski, 2017): 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 (Morgan, 2015; Nylund et al., 2007). Results on model fit indices are reported in Table 2.

In the present study, model estimation is terminated if by increasing classes, models either turn underidentified 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 (Masyn, 2013). 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 >.7 (high endorsement probability) and <.3 (low endorsement probability) are set as benchmarks for high class homogeneity (Masyn, 2013). 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 .9 in class one and an almost equal probability of .8 in class two. Although this item would indicate a high class homogeneity (>.7), the separation between the two classes is poor. Overall, researchers should also holistically consider how well each item contributes to class separation (Nylund-Gibson and Choi, 2018).

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 coping 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. Sample sizes are too small that each possible response pattern could be observed at least once in the data. Therefore, coping 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, which are more likely to occur with a larger range of response categories (Dziak et al., 2014; Masyn, 2013; Reichert, 2016).

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 >.7 (Nagin, 2005). A probability close to 1.0 indicates 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 show the highest class probability. This class membership is then cross-tabulated with affiliation to various energy poverty and income poverty definitions (Table 4).

In the final analytical step, class membership is regressed on personal norms and frugality in Study 2 to check for further reasons for energy coping 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 .60 and .80; see Appendix A.1). All statistical analysis was carried out using STATA version 15.1.

4. Results

4.1 Energy coping behaviours

Table 1 provides descriptive statistics on the items measuring energy coping behaviour. Mean scores show endorsement of coping in the mid-range of the response scale. In Vienna, more dominant coping behaviours 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. Overall, results indicate high variability in the responses which points to heterogeneity in the degree to which households employ coping behaviour. Therefore, we expect more than one coping class in the LCA.

Table 1. Descriptive statistics of energy coping items.

Study 1 Vienna				Study 2 Graz			
Item wording	**Mean**	**SD**	**N**	**Item wording**	**Mean**	**SD**	**N**
1. Heating that I am comfortable while paying attention to costs	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 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	414
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 energy coping; 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.

4.2 Identification of energy coping in the latent class analysis

According to common LCA procedure, if an a-priori hypothesis on the number of latent classes is not available (Masyn, 2013), 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 (Nylund-Gibson and Choi, 2018). 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 underidentified 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 (2194) and BIC (2238) 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 classifies households to their most likely class, show values above >.85 (Appendix A.2), thereby exceeding the >.7 threshold and indicating well-separated classes and low classification error (Nagin, 2005). Thus, the two-class models in both studies are selected as the best-fitting and most parsimonious solution.

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	-1160	2331	2351	2335
	2	**-1086**	**2194**	**2238**	**2203**
	3	-1173	2194	2261	2208
	4	-1076	2198	2289	2216
	5	-1075	2202	2304	2222

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.

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 the non-coping class, whereas 44% are assigned to the coping class; in Study 2 Graz, 66% of households are considered as non-coping and 34% as coping, respectively (top row in Figure 1). In both studies, a substantial share of households does engage in coping activities; however, the non-coping class is larger than the coping class.

At the item level, coping behaviour shows satisfactory class homogeneity and class separation in the two-class models (Figure 1). In all five coping behaviour items, the coping class shows higher item endorsement rates than the non-coping class (bottom row in Figure 1). Only item 2 in Study 2 does not separate well (0.38 for coping and 0.1 non-coping class). Item-specific endorsement rates differ by approximately 30% between the two classes. The endorsement pattern across coping behaviours (higher endorsement in items 1, 3 and 5; lower endorsement in items 2 and 4) is similar in Study 1 and Study 2, providing further evidence that both studies refer to the same latent construct.

Figure 1. Estimated class probabilities (top row) and conditional responses (bottom row).
Note: The y-axis represents the item response probabilities for the coping and non-coping class. The x-axis represents the endorsement for each item; Study 1 Vienna: N=220. Study 2 Graz: N=433.

4.3 Intersection of energy coping with income poverty and energy poverty

Next, we analyse how the identified latent classes of coping or non-coping households intersect with established classifications of income poverty and energy poverty. Table 3 summarizes the possible combinations: The top left (a.) and bottom right (d.) quadrant indicate correct identifications, either by recognizing coping households as income or energy poor, or by considering non-coping households as not income or energy poor. The bottom left quadrant (c.) indicates the possible blind spot of current classifications and illustrates the share of households at risk of recognition injustice (shaded grey in table 3 and 4): These households do not appear as income poor or energy poor in the traditional statistics, but may be deprived because they self-restrict their heating needs potentially below comfort level. The top right quadrant (b.) comprises households who are income or energy poor but do not engage in energy coping. Group (b.) may have many reasons for their behaviour: they can still afford normal comfort levels; they have high energy needs (e.g. families with small children, old aged) or they do not (yet) consider the curbing of heating demand as a strategy to alleviate their situation. Contingent on their specific needs and vulnerabilities, households in group (b.) might profit from counselling on energy saving practices.

Table 3. Intersection of energy coping, income poverty and energy poverty (interpretation aid).

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

Table 4 applies this 2x2 matrix to six different definitions of income poverty and energy poverty in Study 1 and Study 2. In most cases, the differences between the four quadrants are statistically significant according to Fisher's exact test. A substantial share of households who are captured by current poverty classifications apply energy coping behaviours (quadrant a.). Despite their active effort of thrifty behaviours and sufficiency strategies, coping does not remedy these households' situation to lift them out of poverty. The share is however larger in Study 1 (ca. 50-60% of income poor or energy poor households) compared to Study 2 (ca. 30%).

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 energy coping behaviours (quadrant c.). These households self-restrain their energy consumption below their comfort level to avoid excessive energy costs. Some of these households cut down on heating for other reasons than financial constraints (see Section 4.4). However, as both samples, in particular Study 2, mainly comprise non-affluent households it seems plausible that their coping rather stems from necessity than from modesty.

The share of households who are income or energy poor and do not cope (quadrant b.) ranges from 30-50% in Study 1 to 60-70% in Study 2. This group could potentially benefit from energy counselling or nudges to lower energy consumption; however, energy saving interventions should not conflict with the household's energy needs or vulnerabilities.

Table 4. Intersection of energy coping, income poverty and energy poverty (cross-tabulation).

		Study 1 Vienna			Study 2 Graz		
Poverty indicator	**Categories**	**Coping**	**Non-coping**	**Fisher's exact test**	**Coping**	**Non-Coping**	**Fisher's exact test**
Income poverty: Total income	Lowest quartile	52.6	47.4	p=.030	33.3	66.7	p=.068
	Higher quartiles	35.4	64.6		11.1	88.9	
Income poverty: At risk of poverty	At risk	59.3	40.7	p=.000	34.1	65.9	p=.041
	Not at risk	34.1	65.9		7.1	92.9	
Energy poverty: >10% energy costs	Energy poor	63.0	37.9	p=.013	36.4	63.6	p=.157
	Not energy poor	40.4	59.6		27.9	72.1	
Energy poverty: Cannot keep adequately warm	Energy poor	69.2	30.8	p=.001	23.9	76.1	p=.000
	Not energy poor	38.3	61.7		41.1	58.9	
Energy poverty: Housing deprivation 1	Energy poor	n/a	n/a		29.6	70.4	p=.276
	Not energy poor	n/a	n/a		36.4	63.6	
Energy poverty: Housing deprivation 2	Energy poor	48.5	51.5	p=.040	n/a	n/a	
	Not energy poor	31.5	68.5		n/a	n/a	

Note: Blind spot quadrant c. shaded grey. 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 (EU-SILC, 2019). At risk of poverty: Equivalized disposable income after social transfers below 60% of the national median, <1,286 Euro in 2019 (EU-SILC, 2019). >10% energy costs: Household spending more than 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.

4.4 Further reasons for energy coping

Households may engage in energy coping behaviours for other reasons than forced thriftiness from low income, high heating costs, or energy inefficient housing. Some coping behaviours are similar to energy saving in heating as recommended by guides for climate-friendly action or as analysed as curtailment behaviours (Abrahamse and Schuitema, 2020; Kaiser, 1998). Pursuing a modest lifestyle focusing on quality of life instead of excessive spending for material possessions may result in voluntary restraint (Anderson et al., 2012; Goldsmith et al., 2014). Therefore, Study 2 checks whether personal norms for environmental protection and a mindset of frugality have additional explanatory power for energy coping when controlling for the influence of income poverty and energy poverty.

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 energy coping, suggesting that pro-environmental reasons play a marginal role why the respondents turn down the heating. Valuing frugality however has a unique effect on coping, above and beyond the restraint necessitated by poverty.

Table 5. Logistic regression for energy coping behaviour in Study 2 Graz.

	Odds Ratio
Equalized income	0.999 *
	(0.000398)
Cannot keep adequately warm	2.006 **
	(0.49)
Personal norms	1.197
	(0.186)
Frugality	1.488 **
	(0.217)
Constant	0.146 *
	(0.110)
N	328
Pseudo-R2	0.0751
Chi2	31.22

Note: Standard errors in parentheses. * p<0.05, ** p<0.01. Study 2 Graz: N=433.

5. Discussion

This study addresses hidden energy poverty by analysing energy coping behaviours 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 operationalizing energy coping with a compact set of quantitative survey items which address specific underconsumption behaviours. Latent class analysis (LCA) finds two distinct groups of households: on the one hand, households showing unobtrusive energy consumption behaviour; on the other hand, households engaging in energy coping, in other words, underconsuming heating below comfortable indoor temperatures to avoid exceeding energy costs. We confirm a substantial blind spot of households who cope 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 spot applies across a range of common income poverty and energy poverty definitions. Replicating both groups of non-coping and coping 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, and how class membership may change over time through aging, life events (e.g. unemployment, pension), or cohort effects. Our results point to methodological 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 coping behaviours most likely refer to ingrained habits rather than momentary reactions. The extent of energy coping observed in Study 1 and 2 may be seen as the lower limit of actual coping, as presumably respondents would have stated even more energy coping had we surveyed during the heating season when these behaviours were 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 analyse the prevalence of energy coping. By modelling 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 expenses or energy needs as economic approaches for capturing hidden energy poverty do. However, understanding the reasons for energy coping in depth should go beyond cross-tabulating with income poverty and energy poverty classifications. Intersectional analysis could explore related characteristics such as building type, tenure type, household composition, or presence of persons with higher energy needs (toddlers, elderly, disabled persons) to provide a more comprehensive picture of potential recognition injustice.

Nonetheless, when addressing hidden energy poverty as underconsumption, the elephant-in-the-room question remains: What constitutes a normal comfort level, and how much does it have to be undercut to qualify as deprivation? “Normal” heating behaviour 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. A certain degree of conscientious heating is desirable for climate-friendly energy saving, even among low-income households. Thresholds for “normal” indoor temperatures may be set at uniform values such as 18-21°C (World Health Organization., 1987), or at temperatures achievable within a specific building’s technical specifications at reasonable costs. Identifying latent classes from self-reported, consensual measures of occupant behaviours helps in segmenting those at risk of hidden energy poverty who are often overlooked in retrofitting schemes or heating allowances and consequently cannot equally participate in the transition to a carbon-free Europe. However, self-reported energy coping cannot substitute for a political debate on the objective comfort level every citizen is entitled to.

6. Conclusions and policy implications

The present study does not intend to make the prolonged debate on energy poverty definitions and generic indicators even more complicated (Doukas and Marinakis, 2020). However, observing only partial overlap between energy poverty and energy coping suggests that the binary logic of being energy poor or not used in prevalent comparative European indicators might be too simplistic. Instead, common expenditure-based and income-based indicators should be complemented by measures of how occupants actively deal with their deprived situation in order to capture the full spectrum and variability of experienced energy poverty. We would welcome future research which establishes occupant behaviour as the fourth driver of energy poverty in addition to the traditional triad of above-average energy costs, low income and bad housing conditions.

Nonetheless, energy coping is not a clear-cut, easily operationalizable characteristic. It seems to be a reflection of an overall lifestyle of frugality and self-sufficiency (Kollmuss and Agyeman, 2002). The regression results (see Section 4.4) caution against a narrow understanding of energy coping as an exclusively forced reaction, as some households may (partially) adopt coping behaviours as a natural expression of their sufficient and modest way of living. However, the influence of frugality on energy coping may only apply to households in the lowest income quartile as in the Study 2 sample and need not generalise to higher-income segments. Among the low-income households analysed in Study 2, energy coping 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 behaviours (Brounen et al., 2013; Sapci and Considine, 2014). Households may turn to coping as a response to structural lock-in and a tenant-landlord dilemma, 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.

Thus, painting the full picture of energy poverty calls for multiple top-down technical and economic as well as bottom-up every day-practices perspectives on deprivation in the access to energy services. Focusing on energy coping 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. Social workers or non-profit charity organizations may be familiar with the difficulties of vulnerable households; energy suppliers may draw on customer information on payment difficulties and the amount of energy used.

A major step to advancing action on the ground contains the recast of the Renewable Energy Directive 2018/2001: it proposes energy communities, which reinforce citizen participation in the energy system as “energy prosumers” who participate actively in the energy market by generating and selling energy (Milčiuvienė et al., 2019). Referring to recognition justice of vulnerable groups, 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 (Creutzfeldt et al., 2020). As energy poverty is a cross-cutting issue, touching upon different policy fields, tackling energy poverty needs to be done on concert with other problems vulnerable households have to deal with in their every-day lives.

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. Households may turn to energy coping 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, precluding extraordinary situations such as the Covid-19 pandemic, energy coping could be seen as desirable under specific circumstances. A substantial share of households is identified as income or energy poor but does not show energy coping behaviours (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 behavioural change requires to disrupt energy habits, which constitutes a difficult task (Kurz et al., 2015; Verplanken and Roy, 2016). On the other hand, households may refrain from coping because of higher energy needs and intersections of vulnerabilities (Großmann et al., 2017). 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 possibly disappear from being identified as a policy priority under current classifications.

Tackling the root causes of energy poverty however calls for more structural efforts than energy counselling. Large-scale building renovation plans have been issued recently by the Renovation Wave for Europe (European Commission, 2020) and the Austrian government (Bundeskanzleramt, 2020; IIBW, 2020), the latter setting an annual renovation rate of 3% in order to reach the 2030 decarbonization targets in the housing sector. In recent years, Vienna introduced innovative environmental policies (e.g. Smart City Program (Step 2025), Vienna's Climate Protection Programme-KliP), City of Vienna, 2020, 2014). Vienna has a long-standing policy of fostering social housing and keeping the rents down, and is well-equipped to tackle energy poverty more autonomously than other Austrian cities (Brandl and Zielinska, 2020; Mocca et al., 2020). If affordable and energy-efficient housing were provided for all, involuntary energy coping would no longer be necessary.

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Appendix

Table A.1. Item descriptives on personal norms and frugality in Study 2 Graz.

Factor	Item	Mean	SD	Item-total correlation	Cronbach's Alpha
Personal norms	I am a person who considers the environment when heating.	4.04	1.08	.64	.80
	I feel obliged to protect the environment when heating.	3.84	1.13	.65	
	I see myself as a person who cares about the environment when heating.	3.78	1.13	.64	
Frugality	I resist buying things today so I can save for tomorrow.	3.35	1.24	.42	.60
	When shopping, I discipline myself not to exceed my financial capabilities.	4.07	1.14	.42	

Note: Study 2 Graz: All items translated from German and measured on a five-step response scale from 1=fully disagree to 5=fully agree. N=433.

Table A.2. Probability of latent class membership for Study 1 and Study 2.

Study 1 Vienna			**Study 2 Graz**		
Item wording	**Coping class**	**Non-Coping class**	**Item wording**	**Coping class**	**Non-coping class**
1. Heating that I am comfortable while paying attention to costs	0.62	0.29	1. Heating less warm than I feel comfortable with	0.74	0.16
2. Sitting close to the radiator to keep warm	0.56	0.03	2. Sitting close to the radiator to keep warm	0.38	0.1
3. Putting on a pullover instead of turning on the heating	0.81	0.26	3. Wearing warm clothing, use a hot-water bottle or a blanket instead of turning on the heating	0.92	0.38
4. Turning off the heating when leaving the flat	0.54	0.11	4. Turning off the heating when leaving the flat	0.62	0.07
5. Closing doors between heated and not heated rooms	0.67	0.36	n/a		
n/a			5. Heating only selected rooms to save money	0.68	0.28
Class membership probability	0.56	0.44		0.66	0.34
Average posterior probability	0.86			0.89	

Note: Estimated conditional response probabilities for the two class LCA model and class membership probabilities and average posterior probability; Study 1 Vienna: N=220. Study 2 Graz: N=433.

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