Energy Research & Social Science 115 (2024) 103612

Contents lists available at ScienceDirect

Energy Research & Social Science

journal homepage: www.elsevier.com/locate/erss

Original research article

(Dis)comfortably numb in energy transitions: Gauging residential hard-to-reach energy users in the European Union

Miguel Macias Sequeira *, João Pedro Gouveia, João Joanaz de Melo

CENSE – Center for Environmental and Sustainability Research & CHANGE – Global Change and Sustainability Institute, NOVA School of Science and Technology, NOVA University of Lisbon, 2829-516 Caparica, Portugal

ARTICLE INFO

Keywords:
Energy justice
Energy policy
Energy poverty
Vulnerable households
High-income households
Tenants and landlords

ABSTRACT

Hard-to-reach energy users – those who are difficult to reach, underserved, or hard to engage or motivate – are a vital concern for just energy transitions. Previous studies in the Global North have suggested three major residential groups, namely vulnerable households, high-income households, and tenants and landlords, for which one-size-fits-all policies have proven largely unsuccessful. Still, more research is needed to identify hard-to-reach groups and to understand households' decision-making processes. In this context, we review the literature to systematise a theoretical framework, proposing thirteen profiles for vulnerable households (low-income, low education, rural, multi-family, elderly, young, single parents, migrants, unemployed, ill-health and disabilities, ethnic minorities and indigenous groups, homeless and informal settlements, travellers and nomadic communities), two for high-income households (high-income, sumptuous spenders), and two for tenants and landlords (tenants, landlords). We select indicators to gauge these audiences in the European Union. Results suggest that a substantial share of households may be hard-to-reach, with several profiles (*e.g.*, low-income, tenants) individually accounting for 30 % of the population. Relevant variations are found across Member States. Furthermore, a significant population share intersects at least two profiles, compounding the barriers to their engagement. These households require targeted and tailored policies and interventions to address their needs, which are broadly discussed. The hard-to-reach concept can be useful to inform policymakers and practitioners. Data gaps emerge for marginalised and wealthy groups. Heterogeneity and intersectionality add further complexity. Future research can fill these gaps while taking on multi-scalar, plural, and inclusive approaches to identify and engage hard-to-reach households.

1. Introduction

Against the background of climate change, energy transitions are at the top of the agenda [1]. Notwithstanding the role of technology, energy transitions also demand the engagement of citizens [2]. Simultaneously, several authors (*e.g.*, [3–6]) have warned about risks in meeting potentially conflicting agendas of decarbonisation and poverty eradication while arguing for a well-balanced course of action. Energy poverty is a key concern, defined by the European Union's (EU) Energy Efficiency Directive as the "lack of access to essential energy services […] caused by a combination of factors, including at least non-affordability, insufficient disposable income, high energy expenditure and poor energy efficiency of homes" [7]. Its consequences on health and well-being can be particularly severe for vulnerable groups [8,9].

The concept of hard-to-reach (HTR) energy users – broadly defined as those who are difficult to reach, underserved, or hard to engage or motivate by energy policies, programs, or interventions – has been receiving growing attention among researchers, policymakers, and practitioners (*e.g.*, [10–13]). It should be noted that the HTR terminology was already used in several areas – *e.g.*, poverty measurement (*e.g.*, [14–16]), crime prevention (*e.g.*, [17]), education, social services, and health (*e.g.*, [18–21]) – before being applied to the energy field. For instance, UNECE [15] refers to populations that are hard to sample, identify, find, contact, persuade, and interview. In this context, the Users-Centred Energy Systems Technology Collaboration Platform, working under the auspices of the International Energy Agency, launched the Task on Hard-To-Reach Energy Users aiming to identify, define, and prioritise HTR groups and to design, evaluate, and share strategies to engage them [22].

The emergence of the HTR energy users concept stems from a stream

* Corresponding author.
E-mail addresses: m.sequeira@campus.fct.unl.pt (M.M. Sequeira), jplg@fct.inl.pt (J.P. Gouveia), jjm@fct.unl.pt (J.J. Melo).

https://doi.org/10.1016/j.erss.2024.103612
Received 6 February 2024; Received in revised form 13 April 2024; Accepted 22 May 2024
Available online 20 June 2024

of literature across a wide span of disciplines that challenges the assumption of energy users as one-dimensional rational agents, moved solely by economic and technical drivers, highlighting the existence of multiple characteristics, circumstances, vulnerabilities, preferences, cognitive routines, and belief systems, as well as cultural, social, and political factors, that influence engagement [11,23,24]. Rotmann *et al.* [12] label five major HTR groups: vulnerable households (*e.g.*, low-income, elderly, single parents, among other subgroups), high-income households, tenants and landlords, commercial sub-sectors, and small and medium enterprises. The difficulty in reaching and engaging these groups in energy interventions seems to arise more from market, policy, and legislative failures than from technical barriers [25–27].

The engagement of HTR groups is crucial to achieve the goals of climate change mitigation and energy poverty alleviation but faces severe and persistent barriers. These are well-researched for vulnerable households and tenants, including split incentives, insufficient knowledge, high transaction costs, market fragmentation, shortage of finance, upfront costs, lack of information, competing priorities, and mistrust [28–31]. High-income households have not been extensively researched, but interest has risen recently [32–34]. Although barriers are known, several authors (*e.g.*, [23,35,36]) emphasise the need for an in-depth understanding of the decision-making processes of different energy users as a challenge for research.

Existing research finds that significant population groups are not reached with traditional one-size-fits-all policies and interventions [11,36,37]. Likewise, recent studies suggest that these consumer profiles will also be HTR to innovative approaches such as energy sharing and digitalisation [38,39]. In a just transition, all groups must participate, and the energy system fairly disseminates its benefits and costs while ensuring representative and impartial decision-making [36,40]. Aligned with the principle of "leaving no one behind", there is increasing pressure on policymakers and practitioners to find ways to engage the HTR; however, practical approaches are still under-researched [13,16,41]. Mundaca *et al.* [13] addressed this gap with an *ex-post* cross-country assessment of nineteen energy interventions that aimed explicitly or implicitly at engaging HTR groups. Poor targeting can also be due to a lack of disaggregated data (or insufficient operationalisation of existing data). Raslan and Ambrose [26] and Houghton *et al.* [27] highlight that establishing precise profiles of HTR households and tailoring approaches are key gaps to be filled by research.

The goals of this manuscript are i) to systematise a set of potential HTR profiles in the residential sector, ii) to suggest an indicator set and gauge the size of HTR groups in the EU-27 and its Member States (MS), iii) to evaluate the heterogeneity within groups and the intersectionality between groups, and iv) to derive insights for energy policies tailored to the needs of the HTR. While there is extensive work implicitly researching energy users that may be regarded as HTR, there is still scarce research explicitly conducted under this framing. Whereas most research on HTR energy users has remained broad and conceptual, the novelty of this manuscript lies in the systematisation and quantification of specific profiles of HTR households, which further advances this concept towards its operationalisation as a tool for the design of energy policies and interventions. To our knowledge, this is the first study to attempt this endeavour in the EU. Non-residential groups have been assessed by [42].

The structure of this manuscript is as follows. Section 2 reviews the state-of-the-art on HTR energy users, the criticism of the terminology, and its connection to energy justice. Section 3 lays out the methods. Section 4 details and discusses the outputs, including the theoretical framework, selection of indicators, analysis of results for the EU and its MS, and evaluation of intersectionality and heterogeneity for the EU. Section 5 derives implications for just energy policies and illustrates how to use our research for enhanced policy design. Section 6 assesses limitations and suggests perspectives for future research. Finally, Section 7 concludes the work.

2. Literature review: residential hard-to-reach energy users

In this literature review, we examine academic and grey literature from several interconnected strands of research – *e.g.*, energy poverty, clean energy uptake, and energy justice – that delve into the three residential HTR groups defined by Rotmann *et al.* [12] – vulnerable households, high-income households, and tenants and landlords. A systematic review has already been performed by [12]. Furthermore, Ashby *et al.* [43] have interviewed international experts regarding their perspectives on how to identify and engage HTR energy users in their countries.

Building on this work, our literature review follows the realist synthesis method [44] by identifying the question "who is considered as being a HTR energy user and for what reasons?" and drawing from a wide-ranging review of the literature – implicitly or explicitly reporting on HTR profiles – aiming for theoretical saturation in each defined profile (as also performed by [45]). The realist synthesis approach is useful for reviewing evidence on complex social interventions, such as households' participation in energy transitions, aiming to explain how and why interventions work (or do not work) in specific contexts [44].

This literature review of relevant papers follows a combination of convenience and snowball sampling focused on HTR groups (*e.g.*, [34,46]), providing reasoning for the proposal of a theoretical framework. It is disaggregated according to characteristics found in the literature; for instance, UNECE's [15] guide for measuring poverty stresses the need for disaggregation by income, gender, age, ethnicity, migratory status, disability, tenure status, employment status, educational level, and degree of urbanisation.

2.1. Hard-to-reach terminology

Although the HTR terminology is contested, it has long been applied to education, health, social services, and criminal justice, where authors have mapped inequalities and explored approaches for increased participation in support programmes [18,19,47]. For instance, in 1993, Griffiths *et al.* [48] researched how to reach hidden populations of drug users, and in 1996, Shaw *et al.* [49] used the term HTR to refer to homelessness and social welfare policies. Since the emergence of the concept, its meaning and intensity have varied widely between studies. For example, Liljas *et al.* [21] reviewed barriers and strategies for engaging HTR older people in health promotion. Bonevski *et al.* [20] reviewed challenges to sampling, recruitment, participation, and retention of socioeconomically disadvantaged persons. Researching an empirical case, Roberts [17] detailed insights from a programme offering HTR young people a route back into employment and education. Finally, in an early recognition of both the vulnerable and the elites as being HTR, Atkinson and Flint [50] suggested snowball sampling as a way of accessing groups that are typically impenetrable for social research.

In the context of the ongoing overhauling of the global energy system, the HTR terminology has made its way into the energy sector. Rotmann *et al.* [12] provide the following definition – "a hard-to-reach energy user is any energy user from the residential & non-residential sectors, who uses any type of energy or fuel, and who is typically either hard-to-reach physically, underserved, or hard-to-engage or motivate in behaviour change, energy efficiency and demand response interventions that are intended to serve our mutual needs". This definition is purposely broad to avoid leaving out relevant groups. Furthermore, Ambrose *et al.* [10] argue that the HTR concept is context-specific and should not consist of a rigid list of target groups, highlighting a range of vulnerabilities, circumstances and/or characteristics that present barriers to participation in energy issues. Other terms used in the literature to describe the HTR include underserved, disadvantaged, hard-to-help, hidden, illegalised, stigmatised, under-represented, invisible, unchangeable, hard-to-count, hard-to-engage or motivate, understudied, hard-to-treat, hard-to-heat or cool, hard-to-decarbonise,

and complex-to-decarbonise [12,27]. All these terms have their own critiques and challenges, for instance, for being too focused on research, on marginalised groups, on heating and cooling, or on decarbonisation.

We also acknowledge that the terminology of HTR energy users is subject to criticism. First, it can be considered as (deliberately) too broad, encompassing a wide range of users with distinct characteristics. Second, Baker *et al.* [25] and Gillard *et al.* [37] are critical of labelling individuals and grouping them into a limited number of archetypes, recognising issues of heterogeneity and intersectionality, and contesting that it excludes other information and reinforces biases. Furthermore, Houghton *et al.* [27] prefer to use the term "complex" instead of "hard" to avoid a binary categorisation. Third, the literature mostly presupposes that engaging HTR households is mutually beneficial, neglecting to account for the fact that some families may have their reasons for wishing to avoid involvement [18]. Fourth, this concept can shift the focus away from the structural social, economic, and political norms that compound to make some households harder-to-reach than others [37,46,51]. It should be clearly stated that these groups may not be HTR in themselves, but the approaches currently used to engage them may not be adequate and should be improved [12,25].

While acknowledging these limitations, we argue that the HTR energy users concept can be useful for guiding the development of policies that foster just energy transitions. It clearly identifies population groups that are likely at risk of being left behind, highlights the multiple and distinct barriers that hinder engagement, and provides insights for targeted and tailored interventions. In this work, we follow the broad definition by Rotmann *et al.* [12] to explore household profiles that may fit the HTR concept.

2.2. Vulnerable households

Vulnerable households are found by Rotmann *et al.* [12] to be the most mentioned HTR group. In this regard, the European Commission [52] states that vulnerability can be seen as a highly diverse, often hidden, and rapidly mutable condition that arises from personal and demographic characteristics, behavioural and situational drivers, deficiencies in access, and complex market features. Thus, it should be noted that HTR and vulnerable households are two different concepts with distinct definitions; in practice, these may often overlap on a case-by-case basis. Ambrose *et al.* [10] identified three dimensions of vulnerability: financial, health and capacity, and location. Building on these, Rotmann *et al.* [12] added cultural issues, attitudinal barriers, gender, ethnicity, sexuality, timing, perceptions of relevance, and involvement methods.

A breath of research in the Global North has focused on the interactions between the energy system and specific vulnerable households' profiles (*e.g.*, [45,46,53]). Typically, these refer to people over a certain age, disabled or with long-term illnesses, low-income, single parents, rural, unemployed, and/or ethnic minorities [25,54,55]. Going further, UNECE [14] and Rotmann *et al.* [12] report on marginalised groups, including illegal migrants, refugees, criminalised communities, ex-convicts, drug users, the homeless, and sex workers, among others. For some of these groups, energy research seems extremely scarce or even inexistent. Table 1 summarises the reasoning that may indicate a HTR nature for a set of vulnerable households' profiles.

2.3. High-income households

A particularity of the HTR energy users concept by Rotmann *et al.* [12] is the inclusion of other groups beyond the often-mentioned vulnerable households, namely high-income households. This perspective is uncommon but not unique, for instance, in 2001, Atkinson and Flint [50] placed vulnerable households and elites under the umbrella of HTR. High-income households have been receiving increasing attention, and the HTR lens can provide a comprehensive reframing of their role in energy transitions. This is relevant particularly as income and wealth

Table 1
Review of vulnerable households' reasons for potentially being HTR.

Proposed HTR profile	Reasoning to be considered HTR	Evidence
Low-income	Tend to spend a greater share of their income on energy leading to higher vulnerability to energy poverty. Additional vulnerabilities due to income instability and reliance on state benefits.	[9,45,46,54–57]
	Consistently less likely to invest in new technologies than the average household, even when the return on investment is in the short term.	[31,53,58,59]
	Behavioural and informational barriers can lead to lack of awareness of interventions, even when financial support exists. Other barriers linked to home ownership, housing burdens, poverty stressors, chaotic lifestyles, lack of access to information technology, and social isolation.	[16,31,53,56,59,60]
	Lack of peer diffusion effects in low-income areas hinders technology adoption.	[31,59]
Low education	Higher vulnerability to energy poverty compared with highly educated households.	[61,62]
	Low awareness, lack of access to information, and poor energy literacy. Potentially insufficient literacy levels and/or digital skills to understand the intervention and apply to funding.	[16,39,53,63]
	Less likely to adopt new technologies than highly educated households.	[31,53]
Rural	Mixed evidence regarding energy poverty vulnerability, but in some countries rural households face higher energy burdens than urban households. Potential vulnerabilities due to lack of employment, seasonal and part-time jobs, aging population, and more severe climate.	[46,62,64–66]
	Geographical isolation, dispersion, and lack of available energy services. Limited offerings for interventions, lack of information about funding, and lack of trained contractors.	[16,43,65]
	Lack of access to gas and heating networks and reliance on expensive fuels. Use of unregulated and unreported energy carriers, such as biomass. In remote	[46,64,67]

(*continued on next page*)

Table 1 (*continued*)

Proposed HTR profile	Reasoning to be considered HTR	Evidence
	areas, issues of security of supply.	
Multi-family	Evidence is not conclusive regarding energy poverty vulnerability in multi-family buildings, but some authors find a higher prevalence than in detached homes.	[9]
	Organizational barriers and highly fragmented ownership structures. Decisions on investment need to be approved by multiple owners and tenants, hindering whole building solutions.	[12,25,26,68–72]
	Multi-family buildings have been poorly addressed by policies, funding schemes, and market solutions. Most building professionals are not prepared for the complexity of condominiums.	[69–72]
Elderly	Elderly people living outside institutional homes are particularly vulnerable to energy poverty. Single or widowed female pensioners can be disadvantaged due to smaller pensions. They do not necessarily recognise their energy-poor situation and lack awareness about improvements.	[11,15,46,60,61,73–75]
	Research finds that households whose family head is above 65 years old are less prone to invest in improving energy performance.	[76,77]
	Limited information and poor trust in new technologies. Lack of energy literacy and poor digital skills. Limited capability to engage in the energy market and vulnerability to unethical marketing.	[16,46,74,78–80]
	Limited social interactions, lack of autonomy, and feelings of loneliness. Rigid lifestyles and higher amount of time spent at home leading to higher energy use.	[78,79,81]
	Deteriorating health, illness, failing eyesight, loss of earing, and uncertainty over lifespan.	[46,78,80]
Young	The available evidence is scarce but suggests that young adults face increased energy poverty vulnerability. Cultural norms consider acceptable for young people to inhabit low-quality housing. Lack of awareness of energy poverty.	[82–86]
	Unstable and transient housing and employment patterns. Young adults regularly live in poor quality, privately rented, multioccupancy housing where bills are shared among multiple tenants.	[82,83]
	Irregular incomes, shortage of funds, lack of experience and knowledge, and conflicting life priorities hinder energy interventions.	[76,87–89]
Single parents	Single parent households, most of which are headed by women, are more likely to suffer energy poverty. Women typically have lower incomes and smaller pensions due to structural disadvantages that deprive them of opportunities and of decent work.	[9,15,57,58,60,61,90,91]
	Difficulty of maintaining a full-time job, economic precariousness, reliance on a single income to support children, and high dependency on state support. Little time available and other priorities, more time spent indoors, and lack of control over choices.	[78,81]
	Entrenched gender inequality and socio-cultural norms on traditional gender roles place the decision-making on energy issues in the male sphere of interest, leading to low technology adoption rates in female-led households.	[46,53,89,91,92]
Migrants	Scarce research is available, but migrants seem more vulnerable to energy poverty. Most affected are those born in low/middle income countries, asylum seekers, refugees, and illegal migrants, which are also vulnerable to discrimination.	[9,29,46,55,73,93]
	Lower incomes and occupation of poor quality and rented dwellings resulting from residential segregation and job discrimination and leading to lower uptake of clean energy solutions.	[46,72,81,93]
	Migrant status generates concerns related to legal issues in their host country and to the provision of financial support for their family in the country of origin.	[81]
	People with recent migrant background can face barriers due to being unfamiliar with the local language and other taken-for-granted competences (*e.g.*, communication with energy	[31,46,89,93]

(*continued on next page*)

Table 1 (*continued*)

Proposed HTR profile	Reasoning to be considered HTR	Evidence
	companies and applying to funding), leading to low levels of technology adoption.	
Unemployed	Unemployed people and people outside the workforce (*e.g.*, performing family and home care work) are likely to be more vulnerable to energy poverty.	[9,46]
	Additional vulnerabilities linked to precarious and low-wage employment, unstable household income, and performance of non-productive and unpaid work.	[9,46,78]
	Less motivation to implement energy performance improvement measures.	[12,62]
Ill-health and disabilities	Energy poverty has consequences on physical and mental health and there is evidence that pre-existing health conditions and higher medical needs increase the likelihood of energy poverty.	[9,46,54,57,73,81,94,95]
	Disabilities and ill-health include a wide range of short-term, chronic, and terminal impairments, such as autism spectrum conditions, long-term health illness, mental health conditions, physical or mobility impairments, sensory impairments, and learning difficulties.	[95,96]
	Dependence on healthcare and support services, lack of social relations, and moving limitations. Increased amount of time spent at home and higher energy needs (*e.g.*, room temperatures, energy intensive medical equipment, laundry).	[46,54,57,73,74,78,81,94–97]
	Households having a person with ill-health or disabilities often have lower income levels and different employment profiles than the general population.	[46,60,94]
	Additional cognitive, sensory or communication impairments can make access to information and support difficult and hinder technology adoption. Reluctance to accept support except from trusted sources, such as family or social organisations, who may have limited knowledge themselves. Lack of recognition in energy policies.	[15,31,96,98]
Ethnic minorities and Indigenous groups	Scarce research and data are available, but ethnic minorities seem more vulnerable to energy poverty. Global North studies point to higher vulnerability for people of colour (*e.g.*, Black or Hispanic in the US).	[9,29,46,57,73,99]
	Ethnic minorities in vulnerable neighbourhoods may be disengaged and uninformed, with little knowledge and trust of energy interventions. In a specific case, other authors have challenged this assumption uncovering ethnicity as a positive driver of uptake.	[29,81,93,99,100]
	Ethnic minorities, Gypsies, Roma, and Indigenous communities suffer from an historical and structural pattern of marginalization, discrimination, institutional racism, and exclusion, which explains their lack of recognition in energy policies.	[15,36,51,93,99,101]
Homeless and informal settlements	Populations living in informal and illegal settlements are often perceived as problematic and may be treated as invisible or as criminals by policymakers.	[51,102]
	Homeless persons, persons living in improper housing conditions (*e.g.* without doors or windows, no access to electricity, or presence of infestations), and persons living in illegal housing or with irregular connections to the grid may be unresponsive and distrustful of energy support while also perceiving little effect from interventions (or these would even be wholly non-applicable) especially as basic living conditions are of much greater worry.	[12,14,60,78,81,83,102]
Travellers and nomadic communities	Traveller communities can face restrictions over energy suppliers and heating systems, leaving them reliant on more expensive tariffs and fuels and more susceptible to energy poverty. Low literacy levels, language barriers, isolation from support services, transience between locations, mistrust in authorities, non-eligibility to support schemes, and discrimination may pose further barriers.	[101,103]

inequality have been increasing, enabling high-wealth individuals' influence to grow [58,104].

A few authors note that the top income groups should be disaggregated, highlighting variations in the energy use patterns of the top 20 %, top 10 %, top 1 %, and even top 0.1 % or top 0.01 % [33,104–106]. These have disproportionate energy use and carbon footprints, for instance, the top quintile of income in the EU-27 is responsible for 37 % of emissions, the top 10 % for 27 % of emissions, and the top 1 % for 6 % of emissions [105,107]. Going further, Barros and Wilk [106] suggest that billionaires have thousands of times higher carbon footprints than average citizens. Their growing number jeopardises the remaining global carbon budget [108]. A wide range of terminologies is used in the literature to refer to this subgroup which lies at the top of the social ladder regarding income and wealth levels - *e.g.*, super-rich, high consumers, millionaires, billionaires, and super-affluent [32,34,109]. Since the commonality in these studies appears to be the sumptuous consumption of energy-intensive luxury goods and services, we have derived the term "sumptuous spenders" to refer to this subgroup. Table 2 summarises the reasoning that may indicate an HTR profile for high-income groups.

2.4. Tenants and landlords

The third major residential HTR group mentioned by Rotmann *et al.* [12] are tenants and landlords. While some authors may place tenants under vulnerable households in other contexts, such as energy poverty assessment (*e.g.*, [54]), this separate classification reflected in the HTR framing highlights the specific nature of the overarching challenges that both tenants and landlords face when acting to improve energy performance. Tenants and vulnerable households will occasionally overlap on a case-by-case basis.

Some authors consider households living in the private-rented sector arguably the hardest group to reach in energy policies, mainly due to the split incentives dilemma where neither the tenant nor the landlord is motivated to invest in energy performance (*e.g.*, [82]). Social housing, where the landlord is a single organisation, could present a different situation altogether, with an easier-to-reach profile if sufficient funds were allocated [27,117]. People living in rented houses can be quite heterogeneous, *e.g.*, varying levels of income, types of contracts (or lack thereof), and rental durations, and often experience split incentives and other constraints [93,118,119]. Landlords can be a similarly diverse group [120]. Table 3 summarises the characteristics that may indicate an HTR profile for tenants and landlords.

2.5. A case of energy injustice

Sovacool and Dworkin [40] define energy justice as an energy system that fairly disseminates the benefits and costs of energy services and has representative and impartial decision-making. Most authors delve into energy justice by accounting for three tenets: distributional, recognitional, and procedural [123]. While this is not consensual and may fail to incorporate more plural perspectives [124–126], we apply this three-pronged lens to the HTR concept.

First, distributional justice recognises the unequal allocation of energy-related benefits and ills [40,123]. We argue that vulnerable households and tenants bear the brunt of energy poverty, exacerbated by intersectional vulnerabilities, while high-income households over-consume [97,102,104]. Furthermore, vulnerable families are often excluded from the opportunities to benefit from energy transitions [38,77,101]. Policies that require upfront costs or do not consider the needs of vulnerable households may prove regressive in numerous ways [59,127].

Second, recognition justice states that all individuals must be fairly represented and offered complete and equal political rights [123]. From this perspective, an HTR profile can be seen as a lack of recognition of their attributes, limiting policy effectiveness, eroding public support, and harming marginalised groups [113]. Vulnerable households are often addressed through general communication that does not match their needs [38]. Grossmann and Trubina [128] add that vulnerable households experience dignity violations in the form of disrespect, humiliation, shame, stigma, and dependence.

Third, procedural justice relates to the decision-making processes, manifesting as equitable procedures and non-discriminatory participation [40,123]. The perspectives of less powerful HTR groups, such as

Table 2
Review of high-income households' reasons for potentially being HTR.

Proposed HTR profile	Reasoning to be considered HTR	Evidence
High-income	Use more energy even, mostly due to air travel and motor vehicles followed by housing. Housing is an area of high consumption due to ownership and occupancy of larger homes, multiple residences, multiple sets of energy intensive equipment, and luxury items.	[12,32–34,97,104,107,110]
	Inequalities within countries are significative and undermine public consensus on the energy transition. Higher income households drive consumption norms across the population by setting societal material aspirations, particularly for the middle class.	[23,32–34,58,106,109,111]
	High-income households can easily invest in energy interventions and may disproportionately benefit from support. However, this evidence appears to tail off at the upper-middle income groups, suggesting that more affluent brackets are less likely to be persuaded by energy savings.	[33,53,59,89,110]
	Little incentive to reduce their energy use since they can afford higher expenditure and are less vulnerable to price hikes, making price mechanisms and taxes ineffective.	[34,110,112]
Sumptuous spenders	One of the most hidden groups regarding income, lifestyles, resource use, consumption patterns, mobility, and social networks. Data is scarce due to under-representation in national and global analysis, difficulty in recruitment, data privacy laws, accounting tricks, and vested ownership.	[32,33,104–106]
	Highest energy footprints, mostly from transportation and yachting followed by ownership of multiple large houses. No incentive to moderate consumption as they take for granted energy-intensive lifestyles. First adopters of energy-intensive innovations that can later massify.	[58,106,112–115]
	Exert disproportionate power through policymaking and investment. They can use their wealth to bypass policies aiming at reducing energy use. Billionaires are twice as likely as the average investor to invest in polluting industries.	[112–114,116]
	Affluent people can more easily disconnect themselves and adapt to climate change.	[32,106,112]

Table 3
Review of tenants' and landlords' reasons for potentially being HTR.

Proposed HTR profile	Reasoning to be considered HTR	Evidence
Tenants	Studies find that tenants are more vulnerable to energy poverty. Evidence that poor housing conditions are prevalent in rented homes, especially those for low-income households, and that vulnerable families are more likely to be tenants.	[9,15,46,55,57,61,119]
	Split incentives: tenants are not property owners and do not have direct influence over decisions. This challenge is particularly acute for low-income tenants since these have the least choice over properties and the least agency to improve conditions.	[26,93,118–121]
	Tenants often face home insecurity making high upfront investment risky. While transience in rental markets has been marked as a barrier, it can also encourage improvements as new tenants can demand higher standards. However, tenants rarely factor-in energy costs in their decision.	[26,81,119–121]
	Other barriers, such as limited tenants' rights, absence of minimum energy performance standards, and power imbalances, are relevant depending on audience segment and building type. Fear, embarrassment, and stigma can also stand between a tenant and support.	[12,26,46,54,119,122]
	For illegal or informal shared housing, where tenants have reduced housing rights, no control over energy services, and more pressing priorities, data is unavailable in most countries. Typically, these include students, young adults, and vulnerable persons, such as newly released from prison, leaving the care system, with mental health or substance misuse problems, homeless, new immigrants, and asylum seekers. Stigma and lack of capabilities deters tenants from complaining.	[60,82–84]
Landlords	Split incentives: the landlord does not pay for energy and has few incentives to invest.	[26,93,118–121]
	Landlords are less likely to invest in energy performance than owner-occupiers or social housing providers. Landlords are less likely to dedicate time to gain knowledge on interventions and support schemes. Tenants are unable to carry out formalities that must be done by landlords.	[29,53,58,72,77,81,119]
	Market factors, where high demand and low supply leave tenants in a weak position, provide little incentive to invest in more than cosmetic repairs. Landlords also mention the weakness of the housing market and low rental yields as a barrier. Cultural factors may emerge where poorly performing properties are the norm leading to a lack of incentive to provide better quality.	[82,119,120]

vulnerable households and tenants, are often underrepresented in policies, with barriers such as insufficient access to information and decider bias contributing to unfair policy outcomes [23,96,126]. For instance, the barriers to disabled people's participation are manifold, including that they may be dependent on others to represent their interests [37]. In contrast, high-income households are better represented in governance circles while having more power to challenge undesired outcomes [112,113].

The persistence of these inequities points towards the need for specific mechanisms to accelerate energy transitions while acting on the injustices identified [53,72]. Currently, energy policies often rely on top-down and one-size-fits-all approaches targeted at the average consumer [34,93,94]. Several authors (*e.g.*, [83,94,96,129]) argue for improved recognition and engagement of HTR groups, implying that structural and targeted policies are needed.

3. Methods and data selection

The methodological approach consists of i) proposal of a theoretical framework for residential HTR energy users, ii) selection of an indicator set for the EU and its MS, iii) assessment of results to gauge the size of potential HTR groups in the EU's population, and iv) evaluation of the heterogeneity within groups and of the intersectionality across groups.

3.1. Proposing a theoretical framework for residential hard-to-reach energy users

First, we build on the literature review to systematise a theoretical framework for residential HTR energy users. In this context, the theoretical framework provides a structure to organise, interpret, assess, and discuss data, substantiating it with well-established research [130]. This framework considers the literature review of socio-economic, demographic, and other characteristics that can act as markers of HTR profiles by hindering the identification and engagement of specific household types and slowing the uptake of interventions.

The framework intentionally highlights a single characteristic for each profile, drawing on the commonalities uncovered in the literature. Therefore, it does not consider the heterogeneity within profiles, where people have distinct experiences even if they share a prominent characteristic, nor the intersectionality between profiles, where people have more than one characteristic at once. This is addressed in Subsection 3.4. The terminologies used to describe HTR profiles align with those employed by the sources from which the evidence was collected.

3.2. Selecting an indicator set

We operationalise the proposed theoretical framework by selecting a set of indicators for the EU-27 (reported in Eurostat as a geographical entity "EU-27 from 2020") and for its 27 current MS. We thoroughly analysed the Eurostat database to compile and process a basket of indicators relevant to each proposed HTR profile (this analysis was concluded in December 2023). These rely on publicly available secondary data in the Eurostat database (*e.g.*, income and living conditions statistics, labour force surveys, and demographic data). Data processing included extracting from the Eurostat database, calculating indicators based on two or more datasets, and normalising results to the total population of the EU and its MS. Appendix A presents the entire basket of indicators, their respective sources, and the data processing methods used. A similar operationalisation of existing statistics has been performed to assess energy poverty, including by the EU Energy Poverty Advisory Hub [131–133].

For each proposed HTR profile, a main indicator was selected from the surveyed basket based on the following five sequential prioritisation criteria: i) data is collected annually, ii) data is available for the last 10-year period (from 2013 to 2022), iii) data is reported for all MS, iv) its relevance to each HTR profile while avoiding co-linearity, and v) when

multiple relevant indicators are available at EU-level the highest value for 2022 is chosen to include the broadest number of persons possible in each HTR group. Nevertheless, other relevant indicators from Eurostat (*e.g.*, modules collected every 3 or 6 years and thematic *ad-hoc* modules collected only once or in longer-term periods) are also discussed.

For specific profiles without data in Eurostat, other data sets and proxy indicators are shown when possible [134–137]. These do not have the same comprehensiveness and standardisation as the Eurostat database, and mostly report on the European continent rather than just on the EU and its MS. Thus, proxy data were not included in the side-by-side normalised cross-country assessment performed with the Eurostat-based indicators; these are nonetheless assessed in the Results and discussion section.

3.3. Assessing results for the European Union and its Member States

The selected indicator set is applied to the EU-27 and its current MS for the ten years between 2013 and 2022 to gauge the size of potential HTR groups. The analysis focuses on the EU-27, highlighting the need to recognise and target specific types of households through European energy policy. The diversity between MS is illustrated by the countries with the maximum and minimum values, as a share of the total population, for each profile in 2022. The limitations of the indicators are critically assessed, including by comparing the results with other datasets. Appendix A presents the results for all MS for the years 2013 and 2022. The Supplementary Materials to this article include additional visualisations of the results for each HTR profile and country, which can be useful to inform policymakers and practitioners.

3.4. Evaluating heterogeneity and intersectionality

To address the inherent heterogeneity within HTR profiles and intersectionality between HTR profiles [90], we return to our full indicator basket and to the Eurostat database to search for one-on-one combinations of HTR profiles (*e.g.*, low-income x elderly, rural x tenants, migrants x low education, and so on). It is not possible to extract data from Eurostat for several matchups, pointing towards data gaps in specific household types. When data were available, we followed the selection, processing, and prioritisation criteria described in Subsection 3.2. It should be noted that the indicators previously selected from the basket and those used for the combination of HTR profiles may not coincide due to a lack of data availability. The indicators used to evaluate heterogeneity and intersectionality are compiled in Appendix A. Results are shown as the share of the total EU-27 population that compounds two HTR profiles in 2013 and 2022, allowing the identification of key target groups for policy intervention. The Supplementary Materials include the analysis of intersectionality for all EU-27 countries.

4. Results and discussion

4.1. Theoretical framework for residential hard-to-reach energy users

Building on multi-disciplinary literature, we propose a theoretical framework for residential HTR energy users, visually showcased in Fig. 1. This framework aims to structure and guide our subsequent work by providing clearly defined HTR profiles while avoiding intersectionality at this stage. It includes thirteen vulnerable households' profiles, although frequent overlapping is likely on a case-by-case basis. As suggested by Sommer and Kratena [105], we subdivided the high-income group into two profiles, as considerable differences between them were found in the literature. Tenants and landlords appear as a single profile for each group with specific overarching barriers. However, the rented sector is heterogeneous and vulnerable tenants (combining the profiles of vulnerable households and tenants) deserve further attention [119].

Notably, although sex is the most basic demographic data shown in the EU-level Eurostat database and a prevalent topic across the literature (*e.g.*, [23,138,139]), we did not define gender-based HTR profiles. This merits a clear justification. On the one hand, it would be unreasonable to consider half of the population as being HTR due to gender – even if Tjørring [92] uncovered cultural norms that place energy issues in the male sphere of interest in the Danish context and Boag-Munroe and Evangelou [18] find that traditional views of masculinity are often antithetical to asking for support. On the other hand, any attempt to go beyond the binary male/female division is hindered by lack of data and would intersect with other HTR profiles (*e.g.*, by looking at income, employment, education, and age from a gendered perspective), as shown by EIGE [91] who maps gender inequalities in the EU. Poverty

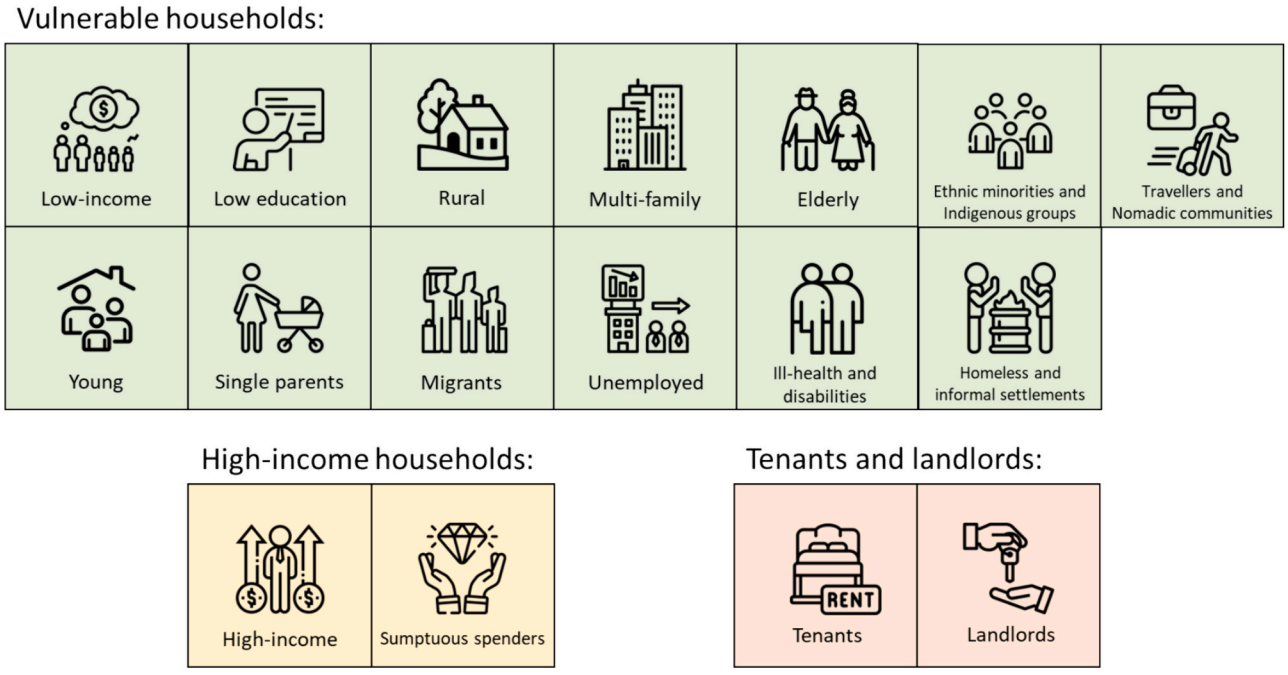

Fig. 1. Proposed theoretical framework for residential hard-to-reach energy users.

assessment by gender has met similar difficulties, and the usefulness of the term "female-headed household" has been questioned [15]. Nevertheless, a gendered analysis is relevant and can be the object of future work.

4.2. Indicator set

The proposed theoretical framework is operationalised for the EU-27 and its MS. For this purpose, a set of indicators was selected to gauge the size of potential HTR groups while exploring data availability and mapping data gaps. The proposed indicators, following the criteria established in Section 3, are shown in Table 4. In this table, we also briefly justify our choice of indicators, namely stating when it was the only strictly relevant indicator fully available for the ten years and for all MS ("single indicator"), when it represented the highest value for the HTR profile among available and relevant indicators ("highest value"), and when it was chosen as a proxy indicator from a different source than Eurostat since data in Eurostat were not found ("proxy indicator"); this process is fully fleshed out in the following subsections. The complete list of indicators for each profile and the data processing methods are detailed in Appendix A. All indicators are normalised to the total population of the EU-27 and of each MS.

Table 4
Proposed indicator set for residential HTR energy users in the European Union.

HTR profile	Proposed indicator	Justification	Reference
Low-income	Population at-risk-of-poverty after deducting housing costs (cut-off point: 60 % of median equivalised income after social transfers)	Highest value	[140]
Low education	Population aged 15 to 64 years old with less than primary, primary, and lower secondary education (levels 0–2)	Single indicator	[141,142]
Rural	Population by degree of urbanisation – Rural	Single indicator	[143]
Multi-family	Population by dwelling type - Flat	Highest value	[143]
Elderly	Population aged 65 years old or over living alone or living as a couple	Single indicator	[142,144]
Young	Population aged 18–34 years old not living with their parents	Single indicator	[142,145]
Single parents	Population living in a household composed of a single person with dependent children	Single indicator	[146]
Migrants	Population by country of birth - Foreign country	Highest value	[142,147]
Unemployed	Population aged 20 to 64 years old that is unemployed	Highest value	[142,148]
Ill-health	Population aged 16 years old or over having a long-standing illness or health problem	Highest value	[142,149]
Ethnic minorities and Indigenous groups	No data available from Eurostat; a proxy indicator was collected from other sources reporting on the Roma population in Europe	Proxy indicator	[134]
Homeless and informal settlements	No data available from Eurostat; a proxy indicator was collected from other sources reporting on people experiencing homeless in Europe	Proxy indicator	[135]
Travellers and Nomadic communities	No data available in Eurostat; no proxy indicators found	–	–
High-income	Population having income of 160 % of median income or more	Highest value	[150]
Sumptuous spenders	No data available from Eurostat; proxy indicators were collected from other sources reporting on high-net-worth individuals in Europe	Proxy indicator	[136,137]
Tenants	Population by tenure status – Tenant	Upper boundary	[151]
Landlords	No data available in Eurostat; no proxy indicators found	–	–

One of the challenges of finding indicators for HTR groups is that they lack recognition, are underrepresented in official statistics, and data neglects some of the hardest-to-reach groups [14,15]. Gouveia et al. [132,133] extensively reviewed energy poverty and HTR-related statistics, exposing data collection procedures' weaknesses and indicators' strengths and limitations. While the Eurostat database is largely harmonised, differences remain in the designs, definitions, and processes across countries and timescales; furthermore, several data points are marked as estimated, unreliable, or provisional [152]. Still, most HTR profiles presented a straightforward choice of indicators due to established criteria and limited data.

There is also a potential criticism regarding our rough quantification of HTR profiles as a percentage of the population (which is the dataset publicly available in Eurostat) instead of as a percentage of households. Intra-household dynamics could mean that one household member would fit into one of the suggested HTR profiles while others would not. This limitation does not apply to HTR profiles based on location, buildings, and household composition. The need to conduct a thorough analysis of intra-household data has also been ascertained by UNECE [15]. This analysis can be pursued using primary statistical data from EU and national statistical offices, although this will require micro-data access.

4.2.1. Vulnerable households

For the "low-income" HTR profile, numerous indicators paint a multidimensional picture of the risk-of-poverty in the EU [140,153–156]. However, it should be cautioned that relative poverty thresholds are essentially arbitrary and often a better measure of income inequality [14,132]. Another limitation is that these do not include income as informal work, begging or donations [15]. In the EU, the poverty line is usually set to 60 % of the national median equivalised income [154]; however, since price levels tend to be more similar across countries than income, this implies different cost of living values, hindering comparisons between MS [15].

Social exclusion considers dimensions beyond income, including labour market participation, educational opportunities, health and disability, access to healthcare, public services and essential infrastructure, and social, political, and civic engagement [16]. Indeed, social exclusion is a broader concept than income; thus, it would intersect with other profiles (it has also only been available since 2015) [153]. Social transfers aim to compensate for lack of income and try, but often fail, to prevent persons from falling into poverty [15,54,155]; thus, they were included in the selected indicator. Finally, UNECE [15] finds that accounting for housing costs can provide valuable insights, corroborating our final choice of indicator being the population at-risk-of-poverty after deducting housing costs [140]. An indicator reporting the persistent risk-of-poverty is also available, shedding light on this most vulnerable segment [156].

Regarding the "low education" HTR profile, only one EU-level standardised dataset was found, where the option reporting on the lowest education level was selected (less than primary, primary and lower secondary education) [141]. Still, differences may exist between countries due to different levels of mandatory education and competencies developed during enrolment. A single EU-level dataset accounted for the "rural" HTR profile, dividing the population as living in urban areas, towns or suburbs, and rural areas – the latter option being selected [143]. Its weakness is that it does not allow for asserting remoteness, which is a significant factor for a potential HTR profile. The "multi-

family" profile refers to the population living in flats, as described by the selected dataset, which also distinguishes those living in buildings with ten or more dwellings [143].

Eurostat collects demographic data by age segment [142]. However, following other research, for the "elderly" HTR profile, we focus only on households that are composed of one adult aged 65 years and over and households that are composed of two adults aged 65 years and over, therefore excluding those living in institutional homes or living with their kin [75,144]. A similar procedure was used for the "young" HTR profile, following the age brackets suggested by Petrova [82] and considering only young adults not living with their parents [145].

For the "single parents" HTR profile – defined as a parent not living with a partner and bearing responsibilities for raising a child [15] – only one EU-level dataset was found, which reports on household composition [146]. Although data is available on households consisting of a single person, the vulnerability comes from the additional factor of parenthood [58]. This indicator does not inform on the number of children, which could also be interesting [15].

The proposed "migrants" HTR profile is particularly complex. First, migratory status is usually defined by distinguishing between native-born and foreign-born persons [15]. This indicator is selected considering the broader barriers to migrants' participation [147]. For a more refined analysis, the data can be disaggregated by country of birth. However, the option to separate migrants born in EU and non-EU countries has only been available since 2017. Alternatively, building on the assertion that migrants from low- and medium-income countries potentially present a harder-to-reach profile [73,81], it is also possible to disaggregate according to the level of human development of the country of birth [157]. This provides only a statistical likelihood since immigrants from a given country may have different characteristics and may develop their own economic, educational, and social status.

Relevant data also reports on the length of the stay in the host country by quantifying recent migrants [158], with these deemed as potentially more vulnerable [46]. On the other hand, the prevalence of second-generation migrants, defined as native-born persons with at least one foreign-born parent, and where cultural factors, trust, discrimination, and language may still pose a barrier [93,99], is not systematically collected and was only the target of an *ad-hoc* module in 2014 [159]. Data on the permits for subsidiary protection or refugee status is available [93,160]. Finally, data on illegal migration is reported as third-country nationals found to be illegally present each year (only available since 2021), which is naturally an underestimate [161].

The "unemployed" HTR profile reflects the classification by employment status as a vulnerability factor that emerged in the literature review [46]. EU-level data allows the quantification of persons from 20 to 64 years old in several employment situations, namely unemployment, long-term unemployment, underemployment, working part-time, and outside the labour force [148,162,163]. Following the criteria established, the general unemployment indicator was selected. The other options present additional layers of the problem, and outside the labour force can encompass an extensive range of situations.

Data on the health conditions of the EU population is extensively collected, providing several options of indicators to represent the "ill-health and disabilities" HTR profile. Following the criteria of gauging the highest value, the indicator showcasing people aged 16 or over having a long-standing illness or health problem was chosen [149]. Other relevant indicators collected annually include the self-perceived health status and the self-perceived long-standing limitations in usual activities due to health problems [164,165]. It should be noted that the concept of disability is broad and does not fully overlap with ill-health [96]. Thorough EU-level data collection on specific signs of illness (depressive symptoms and bodily pain) was performed in 2014 and 2019, while data collection on disability status, longstanding health problems, and longstanding difficulties in basic activities was conducted as an *ad-hoc* module in 2012 [166–170]. Although health is relevant for the conceptualisation of HTR households, in practice, its relevance will vary because ill-health can be a transitory condition and, if chronic, may be associated with disability or advanced age.

Notably, no indicators in Eurostat were found to match the profiles "ethnic minorities and indigenous groups", "homeless and informal settlements", and "travellers and nomadic communities", pointing towards data gaps in these often-marginalised HTR groups. Data on ethnicity and indigenous groups is not commonly collected in the EU. Furthermore, ethnic identity is multidimensional, including ancestry, cultural origins, nationality, race, colour, minority status, tribe, language, and religion; thus, international comparability is low [15]. Country of birth is often used as a proxy, including in energy research, but it may be a weak indicator for ethnicity and is unsuitable for indigenous groups [15,89]. The Fundamental Rights Agency carries out research on vulnerable groups, such as ethnic minorities, descendants of immigrants, LGBTI, and Roma, among others; however, these are not systematic or quantitative. The European Commission's Roma strategic framework reports on the Roma population in Europe [134]. FEANTSA and The Abbé Pierre Foundation [135] report on people experiencing homelessness. These may be used as proxy indicators but do not fully encompass the HTR profiles defined and lack comparability with the standardised Eurostat database.

4.2.2. High-income households

Besides the general disaggregation of income by quintiles or deciles, there is surprisingly little data available on the high-income population, as also reported by Baltruszewicz *et al.* [97]. For the "high-income" HTR profile, only one EU-level standardised dataset was found, reporting the share of people with income above a certain threshold [150]. The highest threshold available (160 % of median or mean income) was chosen, and, like the procedure for the "low-income" profile, the median was selected. As with relative poverty metrics, this threshold is essentially arbitrary, reporting more on income inequality than on high income or wealth *per se*.

Notably, no indicators in Eurostat were found to match the profile "sumptuous spenders", pointing towards data gaps in this elusive group. Seeking potential proxy indicators, data were collected from international sources that report on the high-net-worth population in Europe [136,137]. Still, these do not have the same level of standardisation and comparability of the Eurostat database.

4.2.3. Tenants and landlords

The "tenants" HTR profile attempts to capture the overarching effects of housing tenure on households' agency to implement energy interventions. Thus, the selected indicator showcases the share of the population living in rented houses, regardless of their income, rent level, or being public housing or privately rented [151]. Tenants can also be divided into those paying rent at market prices and those having rent at reduced price or free, with the latter potentially having more income to pay for other necessities than the former [15]. Finally, no data is available in Eurostat regarding "landlords", and no proxy indicator was found to report on this profile.

4.3. Results for the European Union and its Member States

This subsection shows the results of applying the selected indicators to the EU-27 and its MS. Data were collected from Eurostat for the ten years between 2013 and 2022 to assess macro trends (Fig. 2). The results for the complete basket of indicators are shown in Appendix A. To illustrate the variability between MS, Fig. 3 showcases the range of values for each profile considering the highest and lowest data points among Member States in the year 2022. Results for all 27 current MS are shown in Appendix A and in the Supplementary Materials, enabling an in-depth national-scale analysis of HTR profiles, which can be useful for future research and policymaking. As explained in Section 3, HTR profiles for which there is no available data in Eurostat are not shown in the figures due to their lack of comparability, being nonetheless presented

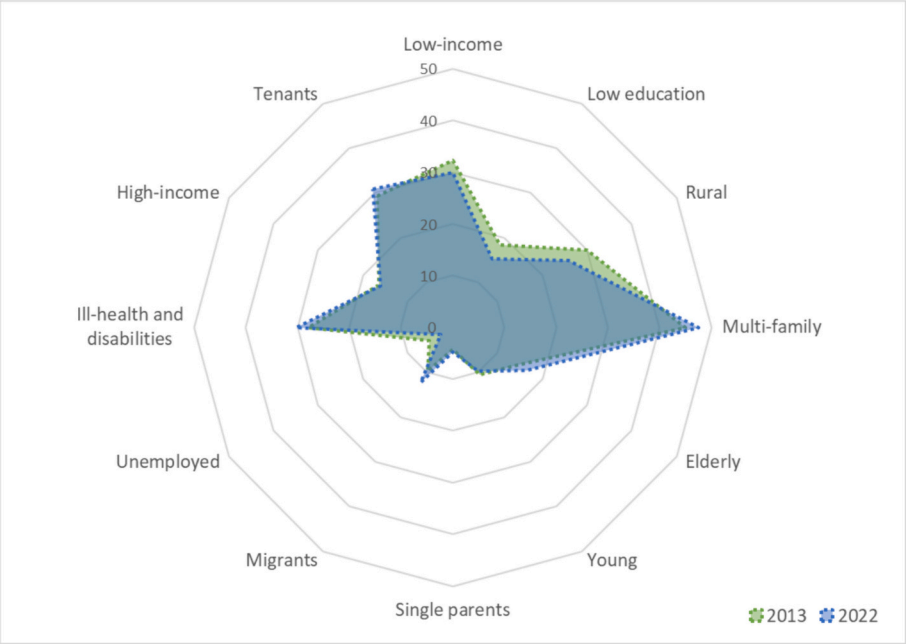

Fig. 2. Share of the systematised HTR profiles in the total EU-27 population.

and discussed in this section.

4.3.1. *Vulnerable households*

The largest group identified is the "multi-family" profile, accounting for 48 % of the EU population and highlighting the role of fragmented ownership and organizational barriers where the need for multiple homeowners, tenants, and landlords to agree on investment decisions hinders the uptake of whole-building interventions [12,25]. Of these, slightly more than half live in buildings with more than ten flats, where these barriers may be more severe. The size of this group is significant in most MS. Still, variations are noted, as illustrated by Ireland and Spain, with 11 % and 66 % of their population living in flats, respectively.

The "low-income" profile suggests that up to 30 % of the EU population may be at greater risk of energy poverty while experiencing a lack of financial capacity and other barriers to adopting energy interventions [46,58]. However, if other indicators were to be selected, for instance, not including housing costs, this value would be reduced to about half at EU-scale. Since both these indicators are a better metric for income inequality than for absolute low income, the results should be critically assessed as significative differences are to be expected between countries, even if the data may look similar [14,132]. For example, according to this indicator, Romania and the Netherlands present similar levels of low-income population (32 % of the total population); however, in 2022, the monthly minimum wage was 2–3 times lower in absolute values and in purchasing power standards, respectively, in the former compared to the latter [171].

Following, the "ill-health and disabilities" HTR profile also represents up to 30 % of the EU population with higher vulnerability to energy poverty, dependence on healthcare services, and cognitive, sensory, or communication impairments [81,96,98]. Data on disabilities is only available for 2012 when around 14 % of the EU population had disability status (only accounting for those aged 15 years old and over). More specific health issues, such as self-perceived bad health, severe bodily pain, and depressive symptoms, are reported for less than 10 % of the EU population. For the selected indicator, data varies among MS, as illustrated by Italy and Finland, with only 15 % and more than 40 % of their population suffering from a long-standing illness or health problem, respectively.

At the EU level, ill-health shows a growing trend that may be linked to an aging population with potential impacts on energy use [79]. The "elderly" HTR profile accounts for 17 % of the population (up from 14 % in 2013); according to the literature, these households may be less prone to invest in improving energy performance [76]. Data is relatively homogenous, with the elderly living alone or as a couple representing 9 % to 22 % of the MS's population in 2022.

Around one-quarter of the population lives in a rural settlement, where barriers such as lack of available services and use of unregulated energy carriers may impact the adoption of energy interventions [43,67]. Nevertheless, it should be noted that results may lack comparability across countries due to different definitions of rural areas [64]. For the last 10-year period, the rural population appears to have slightly decreased at the EU level, with significant differences in trends and values among MS.

While EU education levels have risen in the past 10-year period, the suggested "low education" HTR profile still accounts for 15 % of the population in 2022, potentially with lower literacy levels and a lack of knowledge on energy issues [61]. Significant differences exist across countries, with the share of the population in the lowest education bracket ranging from 7 % to 24 % in 2022 for Lithuania and Portugal, respectively.

Over the past decade, migration fluxes led to an increase in the "migrants" profile, which accounts for 12 % of the EU population. Of these, at least half were born in non-EU countries, and a quarter were born in countries with low or medium levels of human development; these can be more susceptible to language barriers and concerns about legal status [46,73,81]. Particularly vulnerable groups, such as refugees, illegal immigrants, and recent immigrants, represented a small share of the EU population – around 0.4 %, 0.1 %, and 1.5 %, respectively – but these are not negligible, being among the hardest-to-reach groups [93]. The share of migrants in the national population varies considerably, with Western European and Nordic countries presenting higher values and Eastern European countries presenting lower values.

The dynamics of an aging population also mean that the share of the suggested "young" profile has reduced in the past decade. Young adults living without their parents account for around 10 % of the EU population; these can be vulnerable due to unstable and transient housing and employment patterns [82]. Nordic countries seem to have a higher share of young adults living independently, while Southern Europe and

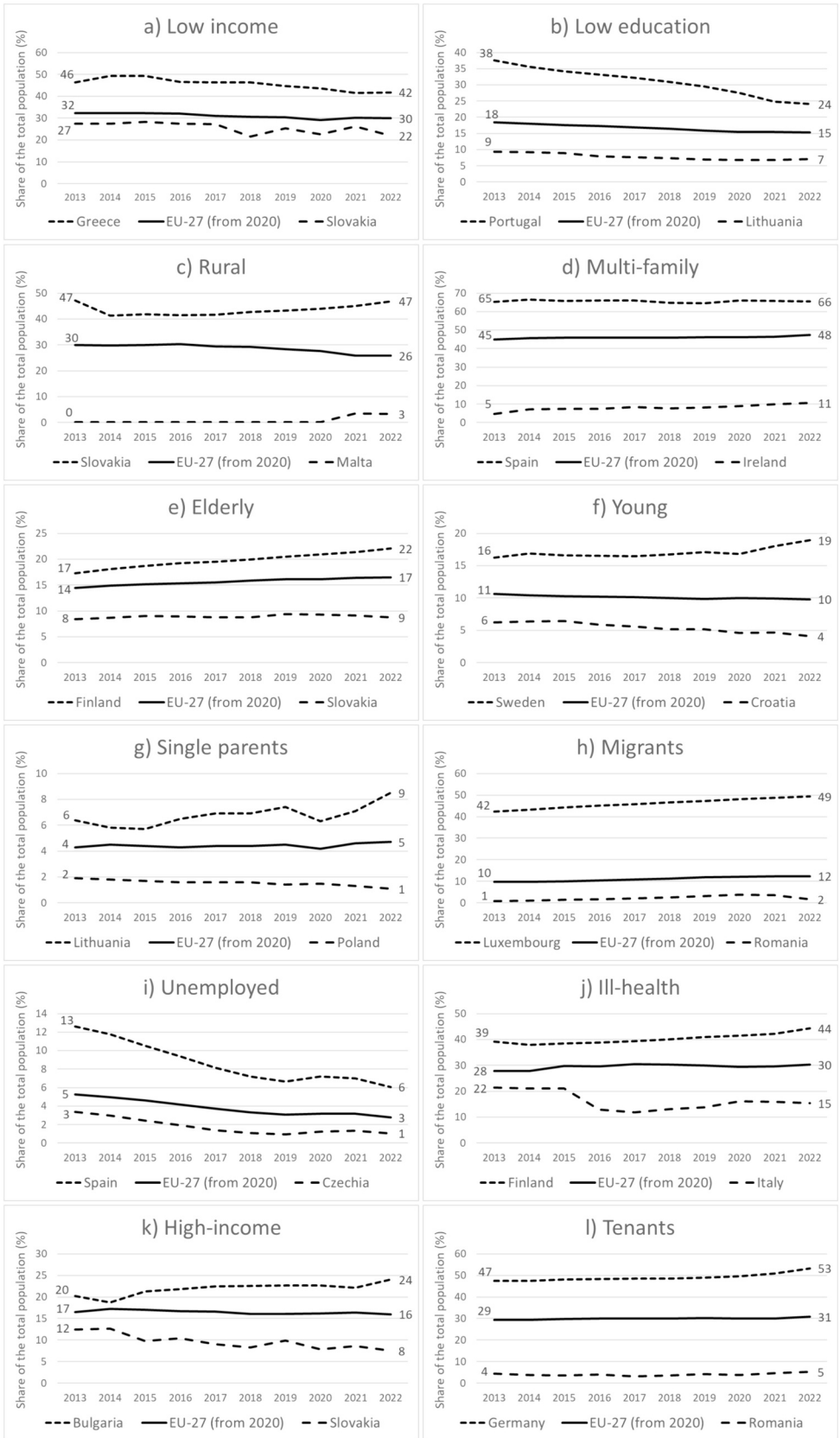

Fig. 3. Evolution of proposed HTR profiles in the EU-27 and range between Member States: a) low-income, b) low education, c) rural, d) multi-family, e) elderly, f) young, g) single parents, h) migrants, i) unemployed, j) ill-health and disabilities, k) high-income, and l) tenants.

Eastern Europe countries have lower values. The HTR profiles "single parents" and "unemployed" each represent less than 5 % of the EU population. Simultaneously, around 12 % of the EU population is outside the labour force; this employment status might be associated with the additional risk of energy poverty [9].

Finally, no data can be ascertained from Eurostat regarding the profiles "ethnic minorities and indigenous groups", "homeless and informal settlements", and "travellers and nomadic communities". However, other sources attempt to shed light on these groups. For instance, the European Commission [134] estimates that between 10 and 12 million Roma live in Europe – equivalent to up to 2.7 % of the EU's population (the source reports on Europe, not only in the EU) – facing discrimination and exclusion. Still, this represents only a portion of a much broader population profile. While focusing only on the most visible forms of homelessness and not considering informal or illegal settlements, FEANTSA and The Abbé Pierre Foundation [135] estimate that a minimum of 895 thousand people is homeless in Europe – equivalent to at least 0.2 % of the EU's population (the source reports on Europe, not only on the EU). For the "travellers and nomadic communities", no data could be ascertained from Eurostat or from other proxies.

4.3.2. High-income households

Like the "low-income" profile, the "high-income" results can be seen as a measure of income inequality and not as absolute high income, and any comparisons should be critically assessed. For instance, Ivanova and Wood [107] report that as much as 36 % of Luxembourg's households can be classified as being in the top 10 % of high emitters within the EU, while in Croatia, only 1 % would be classified as such; however, our indicator does not show this situation presenting similar values for both countries. At the EU level, this profile may account for up to 16 % of the total population (alternatively, using the mean would suggest 13 %), where price signals and cost savings may be ineffective drivers [34,110,112].

For the elusive "sumptuous spenders" HTR group, Capgemini [137] estimates that 5.6 million people in Europe can be classified as high net worth individuals with over one million dollars in wealth in 2022 – this would be equivalent to around 1.3 % of the EU's population (the source reports on Europe, not only on the EU). In addition, Altrata [136] estimates that around 100 thousand individuals in Europe can be classified as ultra-high net worth individuals with over 30 million dollars in wealth – this would be equivalent to about 0.02 % of the EU's population (the source reports on Europe, not only on the EU).

4.3.3. Tenants and landlords

At the EU level, tenants represent 31 % of the population, pointing towards the need to address the split incentives problem [119]. Of these, around one-third pay rent at market price while the remaining have reduced or free rent. The general trend for the EU shows an increase in the population living in rented houses, which Galvin and Sunikka-Blank [58] pin on increasing economic inequality and neoliberal policies. Variation is considerable among MS, with Eastern European countries having larger shares of homeownership (*e.g.*, less than 5 % of the population in Romania rents their home) compared with Western and Northern European countries (*e.g.*, half of the population in Germany rents their home). As mentioned, we did not find Eurostat statistical data or any proxy indicators referring to landlords in the European context.

4.4. Heterogeneity and intersectionality

Up to this point, we have purposely omitted the heterogeneity within HTR profiles and the intersectionality of multiple vulnerabilities, characteristics, and circumstances in the individuals and households belonging to HTR profiles. Considerable heterogeneity between nations, regions, and households will exist, particularly since the HTR concept is context-specific [10,45]. Furthermore, there is an emerging literature on intersectionality, which avoids focusing on one characteristic and instead explores several intersecting features [90]. Energy poverty research has moved in this direction, seeking to cross-examine and combine various dimensions to assess vulnerabilities across countries and regions [45,57,122,133].

Following, Tables 5 and 6 present the results from the one-on-one combinations of HTR profiles for the years 2013 and 2022, respectively. These are shown as a share of the total EU-27 population. This process allows the identification of key groups that compound multiple HTR characteristics, and that may require targeted energy policies and interventions.

A significant share of the EU population intersects low incomes with living in rural settlements, in multi-family buildings, and/or being a tenant; all these aspects can compound to further hinder the uptake of interventions. Furthermore, where low incomes are prevalent, a range of other stressors often aggravate, including physical and mental health problems, social isolation, discrimination, crime, substance abuse, and poor housing [31,56,60]. Rural households can become even harder-to-reach when geographical isolation intersects with low education levels and ill-health [62,65]; our analysis shows that a significant share of the population compounds these vulnerabilities. Nonetheless, national-scale assessments can miss regional differences, as Simcock et al. [46] argue that vulnerability varies widely across rural areas.

Chard and Walker [74] report enormous heterogeneity across the elderly regarding income, health, mobility, aspirations, and outlook, which may influence their capability and willingness to engage. Regarding the level of income, in 2022, 6 % of the EU population combined "elderly" with "low income", and 2 % combined "elderly" with "high income", illustrating the inherent diversity in this group. There is a significant overlap between advanced age and aggravating health problems, which merits particular attention. Disabilities include a vast range of impairments which can change over time, may or may not demand specific energy needs, and may intersect with other vulnerabilities, such as struggling to secure stable employment [45,94].

An undifferentiated view of immigrants' neglects to account for trends in specific communities while not considering relevant intersections with low education levels and tenure status [93]. The former is illustrated by Jacques-Avinó *et al.*, [81] who noted different responses to energy-saving interventions from immigrants according to their country of origin; suggesting how intersections between migratory status and ethnicity can make households HTR. A relevant share of the EU population lives as a tenant while intersecting migratory status and/or ill-health and disabilities; research has shown that the barriers in the private rented sector can be exacerbated for vulnerable tenants who are in a weaker bargaining position [82,93,120].

Heterogeneity and intersectionality are also present for smaller HTR groups, for instance, a single-parent household may compound vulnerabilities related to gender, low incomes, tenure status, and ethnicity, which may accentuate the HTR profile [90]. However, data gaps hinder a more comprehensive analysis across HTR profiles, prominently regarding the population living in multi-family buildings, single-parents, and tenants. As previously mentioned, very scarce data is collected on higher-income population segments. Heterogeneity may also be present in this group, with a few authors stating that some of the wealthiest persons actively engage in energy-related causes while still using excessive amounts of energy [32,106].

5. Implications for just energy policies

5.1. Targeting vulnerable households

Our research has shown that different profiles of HTR households account for a significant share of the EU population and that a relevant subset compounds at least two vulnerabilities; these can be at increased risk of being left behind in energy transitions. Currently, most approaches have proven largely inadequate in identifying and supporting

Table 5
One-on-one combinations of HTR profiles as a share of the total EU-27 population (2013).

EU-27, 2013	Low-income	Low education	Rural	Multi-family	Elderly	Young	Single parents	Migrants	Unemployed	Ill-health (…)	High-income	Tenants
Low income		5 %	11 %	8 %	5 %	2 %	2 %	3 %	2 %	4 %	–	8 %
Low education			10 %	–	6 %	2 %	0 %	4 %	2 %	–	1 %	–
Rural				6 %	4 %	3 %	–	1 %	1 %	10 %	3 %	–
Multi-family					–	–	–	–	–	–	–	–
Elderly						–	–	1 %	0 %	9 %	2 %	3 %
Young							–	1 %	1 %	2 %	–	–
Single parents								–	0 %	–	–	2 %
Migrants									1 %	3 %	–	5 %
Unemployed										1 %	–	–
Ill-health (…)											–	7 %
High-income												–
Tenants												

Table 6
One-on-one combinations of HTR profiles as a share of the total EU-27 population (2022).

EU-27, 2022	Low-income	Low education	Rural	Multi-family	Elderly	Young	Single parents	Migrants	Unemployed	Ill-health (…)	High-income	Tenants
Low income		4 %	8 %	9 %	6 %	2 %	2 %	4 %	1 %	5 %	–	8 %
Low education			7 %	–	5 %	2 %	0 %	5 %	1 %	8 %	1 %	–
Rural				4 %	4 %	2 %	–	1 %	1 %	10 %	3 %	–
Multi-family					–	–	–	–	–	–	–	–
Elderly						–	–	2 %	0 %	10 %	2 %	4 %
Young							–	2 %	1 %	2 %	–	–
Single parents								–	0 %	–	–	3 %
Migrants									1 %	3 %	–	8 %
Unemployed										1 %	–	–
Ill-health (…)											–	7 %
High-income												–
Tenants												

these households, lacking the cultural sensitivity and accessibility needed, for instance, on formal requirements (*e.g.*, excluding migrant populations and those living in informal housing), upfront investment (*e.g.*, excluding those on low incomes or in unstable housing or employment situations), and engagement methods (*e.g.*, often requiring digital and other taken-for-granted skills thereby excluding groups with advanced aged or low education levels) [56,60,93]. Even programmes providing full financial support, can meet barriers such as distrust, information gaps, and split incentives between tenants and landlords [29,59].

Several authors argue for policies and interventions targeted and tailored to specific groups that acknowledge their needs [31,62,81]. These imply proactive action, as opposed to relying on individuals taking the initiative, and there needs to be a better understanding of how different types of households become aware of schemes, why they get involved, and what barriers they must overcome [23,74,80,100].

In this context, the importance of local scale action has been highlighted [13,37,79]. A few lessons can be learned from the experience of conducting poverty surveys with HTR groups, where traditional methods had to be adapted, and from the extensive work of health and social services professionals [15,16,18]. These find that enhancing trust and accessibility is key, for instance, by providing culturally appropriate materials in several languages that can meet the needs of migrants, ethnic minorities, persons with ill-health and disabilities, among others. Tailoring policies and interventions to specific vulnerable groups requires consultation with the populations or their representatives at all stages [46]. Several authors argue for a community-based approach (*e.g.*, [29,172,173]), which can make use of trusted middle actors, enhancing targeting, awareness, and uptake of interventions by vulnerable groups.

Energy-related support to vulnerable households must often be delivered face-to-face and in-home, as studies show that the provision of advice by phone or online is insufficient for groups with low literacy levels or advanced age, among others [63,95,103]. Butler *et al.* [101] underline the need for training, support, and supervision of organisations that interact with HTR groups, addressing both energy and cultural awareness and reducing biases. UNECE [15] argues for the recruitment of peers from the community or from the target group to conduct fieldwork. This approach has been employed in energy support; for instance, in the United States, Reames [29] reports on the hiring of all African American staff to foster trust among residents.

Nevertheless, even targeted policies can involve trade-offs. For instance, associated with the decision to support one group of households over others or with the provision of support to all people from a potentially vulnerable profile (*e.g.*, for being elderly, disabled, or migrant) while neglecting to consider the diversity of cases and the intersection with other vulnerabilities and amending factors [61,74]. Addressing vulnerable households often requires working case-by-case, and a poorly targeted policy or intervention can be ineffective and waste limited funds; more research is needed to inform on effective designs [100,174].

5.2. *Targeting high-income households*

While reaching vulnerable households is key for just energy transitions, Otto *et al.* [32] and Oswald *et al.* [114] argue that policies are also needed to target the opposite end of the social ladder. Reducing excess consumption in high-income families may be the most efficient and equitable approach to curb energy demand [34,110,175]. Furthermore, behaviour change in this group has downstream benefits, inspiring the consumption patterns of the population [32]. The common feature of high-income households is that costs are not a constraint to energy use. The degree of disproportionate energy use is, therefore, not only a function of income but also of mentality. Measures to deal with this need

a different focus, and current energy policies have mostly neglected high-income households [34,107].

Nevertheless, there are ways in which policymakers might be able to target excessive consumption while mitigating unintended consequences for vulnerable households [104,110]. To achieve this goal, we first alert to the persisting lack of data on high-income households, as we were only able to gauge the share of the EU population having income above a certain level which may or may not translate into excessive energy use.

Oxfam [116] calls for increasing taxation on the top 1 % and proposes major taxes on highly energy-intensive luxury consumption, such as SUVs, mega-yachts, private jets, and space tourism. Other authors also argue for progressive taxation and redistribution policies, simultaneously targeting overconsumption and poverty [90,108,175]. For instance, Oswald *et al.* [114] argue for luxury-focused taxation as an effective method to reduce emissions, which can recycle revenues for retrofitting homes. Complementary to taxation, François *et al.* [176] draw on historical cases to suggest caps on wealth and income as a tool to decrease inequality.

Decision makers can guide, constrain, or outright ban potentially unsustainable energy-intensive innovations through precautionary policies, as exemplified with space tourism by Markard *et al.* [115]. Furthermore, interventions explicitly targeting the wealthiest could include obligatory installation of renewable energy, taking advantage of their capability to meet requirements [32]. Perhaps more unconventional, Barros and Wilk [106] suggest public shaming to pressure sumptuous spenders by creating socially acceptable limits and punishing violators.

While multiple sources call for energy policies to effectively target HTR high-income households, these are hampered by several barriers. First, is the very realisation among policy makers that the wealthy must be limited in their energy use, which can be seen as an affront to personal freedom; second, increasingly polarised political environments in which these policies cannot be proposed; third, ineffective policy designs that fail to meet their goals [33,108,175]. Finally, policies targeted at high-income households are bound to meet resistance because there are strong ties between the wealthy and the political elites [32,109,114].

5.3. Targeting tenants and landlords

Energy policies have so far neglected to provide a definitive response to the challenges of the rented sector [119], which accounts for around 30 % of the EU population. In a review of policies in Global North countries, Bouzarovski and Burbidge [177] found scarce examples of specialised support for tenants and landlords. The same authors report that most policies focus on technical and financial measures, with a limited number involving behaviour change and energy conservation. Ambrose [119] argues for policies that consider landlords' perspectives and that raise awareness among landlords and tenants.

Cauvain and Bouzarovski [83] list a few examples of interventions aimed at the improvement of energy performance in rented houses, for instance, including the energy performance certificate as a condition, promoting systematic programmes of inspection, grants, support, and voluntary accreditation, and adopting minimum energy performance standards. In the United States, Reames [29] reports on the use of a discount incentive for landlords to renovate their houses, which also provides tenants with a reasonable bargain for intervention.

Nevertheless, most authors admit that no single policy can overcome split incentives and that neither regulatory mechanisms, information instruments, nor incentive schemes are sufficient on their own [118,120]. Thus, these authors propose a package approach tailored to specific segments of the private rented market, including legislative changes, institutional support, financial incentives, and dissemination of information. Finally, tenants and landlords should be involved in formulating, designing, and implementing EU and national policies through a mediated discussion to address their respective needs [177].

5.4. Using the hard-to-reach framework for policy design

Clear, informative, and measurable EU and national-scale knowledge on HTR groups can be highly relevant for designing policies, as well as for *ex-ante* and *ex-post* evaluations of their outcomes towards just transitions. If effective multi-scalar policies and interventions are to be deployed, policymakers and practitioners must first know their audiences well and recognise the specific challenges hindering engagement in energy transitions. Furthermore, acknowledging intra-group diversity and inter-group overlap is important to pinpoint key groups and efficiently allocate funds while avoiding falling into stereotypes and stigma [101,103,119].

For instance, when launching a national-scale funding scheme for building renovation, policymakers can leverage on our framework, indicators, and results to be aware of the specificities of their target population and ask fundamental questions such as "Does this funding meet the upfront cash needs of low-income households which represent a significant share of our population? Is it inclusive towards people with advanced age and/or low educational levels? Is it available in several languages and with culturally appropriate materials so that our immigrant communities and/or ethnic minorities can apply? Does it tackle head-on the split incentives challenges in the private rental sector? Are service providers and installers ready to implement these interventions in rural and remote areas?", among others. When piloting energy efficiency or renewable energy actions to increase citizen engagement in energy transitions, practitioners should raise similar questions according to their regional and local contexts, for example "Are there trusted intermediaries in place to ensure that our actions reach people with ill-health and disabilities? Is our message applicable to people in homeless situations or inhabiting informal housing? Do we have the necessary buy-in to engage with Indigenous communities?", among others. Key questions that should also be raised by policymakers include "Do our policies call upon high-income households to take responsibility and reduce sumptuous energy use? Is the allocation of public funding having regressive effects and further increasing inequalities in the uptake of energy interventions?"

Still, more important than systematising and quantifying HTR profiles *per se*, it is to emphasise that dealing with these households requires targeted and tailored approaches, often deployed on a case-by-case basis. More important than assessing intersectionality in deterministic terms, it is to create the local capacity to take this into account for each household through flexible, responsive, and dynamic interventions [29,127]. Engaging the HTR requires more holistic and people-centred policies that break silos spanning areas such as energy, family, social security, health, housing, labour, and migration [54,81]. While much more needs to be done to ensure that HTR energy users are not left out of the energy transition, existing research already sheds light on effective mechanisms to target different types of households.

6. Limitations and future work

Our work has delved into largely uncharted territory, and there are inherently some associated limitations. First, although we strived to include different streams-of-though in the literature review, other sources could have provided different evidence. Second, limitations exist in the statistics publicly available from the Eurostat database, as described by Gouveia *et al.* [132], including the data collection methods themselves, missing or unreliable data, and lack of comparability. Third, statistics do not cover the whole population due to sampling methods that exclude the most vulnerable and wealthiest groups [14,15,32]. Fourth, the selection of indicators to gauge HTR groups in the EU and its MS is exploratory, and the results should be seen in each national context considering heterogeneity and intersectionality. Fifth, the discussion of approaches to target HTR groups does not intend to be comprehensive, merely paving the way for future research.

Our work on HTR energy users opens a wide space for further

interdisciplinary and multi-scalar research. First, we join other authors in arguing for the need to collect and analyse data at the national, regional, and local scales to inform tailored solutions [27,57,78]. The collection procedures should be established in statistical offices, and data gaps should be closed [14,36]. Second, heterogeneity and intersectionality merit further research by disaggregating and exploring the variables that may lead to an increase or decrease in the vulnerabilities, characteristics and conditions that suggest an HTR profile [45,97]. Third, more research is still needed to understand the drivers and barriers that impact the participation of HTR groups. These can include empirical case studies, adopting human-centred approaches and working alongside members from the target groups [23,98,178].

7. Conclusions

Throughout this work, we have contributed to the advancement of the concept of HTR energy users – building on the seminal review by Rotmann *et al.* [12] – with a focus on the EU and its MS. Our review synthesises the challenges to identifying, communicating, and engaging with three major groups, namely vulnerable households, high-income households, and tenants and landlords. We critically assess the usefulness of the HTR concept while framing the participation of these groups in energy transitions as a necessity for its completeness and a matter of justice.

Following, we propose a theoretical framework and select an indicator set, including thirteen HTR profiles for vulnerable households (low-income, low education, rural, multi-family, elderly, young, single parents, migrants, unemployed, ill-health and disabilities, ethnic minorities and indigenous groups, homeless and informal settlements, and travellers and nomadic communities), two profiles for high-income households (high-income and sumptuous spenders), and two profiles for tenants and landlords (tenants and landlords). This framework does not intend to 'write in stone' a rigid list of HTR profiles nor to define a fixed set of indicators; these are context-specific and should reflect national, regional, and local dynamics. The results are discussed for the EU and its MS, identifying key target groups for energy policies and mapping persistent data gaps. Furthermore, we take our indicator set a step further to evaluate the heterogeneity and intersectionality in HTR profiles, highlighting groups which compound at least two HTR characteristics. Finally, our research provides insights for improved targeting and tailoring of policies and interventions that meet the needs of the HTR.

Considering the criticism and limitations of this work, the following insights can be summarised:

i) There are multiple and distinct barriers to HTR groups participation in energy transitions, and these are often specific to the characteristics of each HTR profile.
ii) At EU-level the systematised profiles individually account for significant shares of the population – *e.g.*, "low-income", "ill-health and disabilities", and "tenants" profiles individually represent around 30 % of the EU population – which are likely not being properly included in energy transitions, with wide-ranging variations among MS.
iii) There is a lack of standardised data on the most vulnerable and marginalised groups and on the most wealthy and powerful groups, while more detailed and open-access datasets could allow a refined analysis of other HTR profiles.
iv) Reality is more complex than theory, and the heterogeneity within HTR profiles and the intersectionality between HTR profiles will likely aggravate the challenges of deploying just energy policies.
v) The HTR nature of the mapped household profiles demands targeted and tailored energy policies and interventions to address their often very specific needs.
vi) Existing research points towards the important role of local-scale community-based social, technical, and financial support for vulnerable households, stringent taxation, caps, mandates, and bans for high-income households, and a package of regulations, information, and incentives for tenants and landlords.

Increasingly, energy transitions are being seen as more than average energy users adopting reasonable and cost-effective technologies and behaviours. This leads to a necessary reflection on the ones left behind, comfortably or harmed, by one-size-fits-all approaches – the hard-to-reach. In this work, we suggest that involving HTR households is key for just energy transitions, ensuring that the vulnerable and often marginalised also benefit from existing solutions and that the wealthy and often powerful contribute their fair share.

Our proposed theoretical framework and indicator set can serve as a decision-making tool to guide the development of multi-scalar, targeted, and tailored energy policies and interventions that foster just energy transitions while also being useful for *ex-post* analysis of their effects. Policy is about choices, and science is most useful to policy when it helps to set priorities. We hope this work offers useful insights to recognise and address the needs of HTR groups. Successfully reaching and engaging the hard-to-reach is urgent and vital to materialise the multiple benefits of energy transitions.

CRediT authorship contribution statement

Miguel Macias Sequeira: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **João Pedro Gouveia:** Writing – review & editing, Validation, Supervision, Conceptualization. **João Joanaz de Melo:** Writing – review & editing, Validation, Supervision, Conceptualization.

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.

Data availability

Data will be made available on request.

Acknowledgements

CENSE NOVA-FCT is supported by the Portuguese Foundation for Science and Technology (FCT) through project UIDB/04085/2020. Miguel Macias Sequeira's PhD scholarship is funded by FCT (doi:10.54499/2020.04774.BD). The authors thank the colleagues from the International Energy Agency UsersTCP Task on Hard-To-Reach Energy Users for their collaboration over the years.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.erss.2024.103612.

References

[1] IPCC, Summary for policymakers, in: Core Writing Team, H. Lee, J. Romero (Eds.), Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Intergovernmental Panel on Climate Change, Geneva, Switzerland, 2023, pp. 1–34, https://doi.org/10.59327/IPCC/AR6-9789291691647.001.
[2] IEA, Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach (2023 Update), International Energy Agency, 2023. Retrieved from, https://www.iea.org/reports/net-zero-roadmap-a-global-pathway-to-keep-the-15-0c-goal-in-reach.

[3] S. Okushima, Energy poor need more energy, but do they need more carbon? Evaluation of people's basic carbon needs, Ecol. Econ. 187 (2021) 107081, https://doi.org/10.1016/j.ecolecon.2021.107081.
[4] B. Soergel, E. Kriegler, B.L. Bodirsky, N. Bauer, M. Leimbach, A. Popp, Combining ambitious climate policies with efforts to eradicate poverty, Nat. Commun. 12 (2021) 2342, https://doi.org/10.1038/s41467-021-22315-9.
[5] T.M. Skjølsvold, L. Coenen, Are rapid and inclusive energy and climate transitions oxymorons? Towards principles of responsible acceleration, Energy Res. Soc. Sci. 79 (2021) 102164, https://doi.org/10.1016/j.erss.2021.102164.
[6] K. Mahoney, R. Lopes, S. Sareen, J.P. Gouveia, Perceptions of competing agendas in carbon neutrality policies in Portugal: adverse impacts on vulnerable population groups, Energy Res. Soc. Sci. 112 (2024) 103509, https://doi.org/10.1016/j.erss.2024.103509.
[7] Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (recast). Off. J. Eur. Union, L231, 1–111. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ%3AJOL_2023_231_R_0001&qid=1695186598766.
[8] L. Oliveras, A. Peralta, L. Palència, M. Gotsens, M. José López, L. Artazcoz, C. Borrell, M. Marí-Dell'Olmo, Energy poverty and health: trends in the European Union before and during the economic crisis, 2007-2016, Health Place 67 (2021) 102294, https://doi.org/10.1016/j.healthplace.2020.102294.
[9] A. Clair, E. Baker, Cold homes and mental health harm: evidence from the UK Household Longitudinal Study, Soc. Sci. Med. 314 (2022) 115461, https://doi.org/10.1016/j.socscimed.2022.115461.
[10] A. Ambrose, W. Baker, E. Batty, A. Hawkins, Reaching the "Hardest to Reach" With Energy Advice: Final Report, Sheffield Hallam University, Centre for Regional Economic and Social Research, 2019, https://doi.org/10.7190/cresr.2019.8286642862.
[11] A. Ambrose, W. Baker, E. Batty, A. MacNair Hawkins, Focus article: "I have a panic attack when I pick up the phone": experiences of energy advice amongst 'hard to reach' energy users, People Place Policy 14 (1) (2019), https://doi.org/10.3351/ppp.2019.3479427335.
[12] S. Rotmann, L. Mundaca, R. Castaño-Rosa, K. O'Sullivan, A. Ambrose, R. Marchand, M. Chester, B. Karlin, K. Ashby, D. Butler, J. Chambers, Hard-to-reach energy users: a literature review, in: User-Centred Energy Systems TCP - HTR Task, 2020. ISBN: 978-0-473-64983-8. Retrieved from, https://userstcp.org/hard-to-reach-energy-users-task/.
[13] L. Mundaca, S. Rotmann, K. Ashby, B. Karlin, D. Butler, M.M. Sequeira, J. P. Gouveia, P. Palma, A. Realini, S. Maggiore, M. Feenstra, Hard-to-reach energy users: an ex-post cross-country assessment of behavioural-oriented interventions, Energy Res. Soc. Sci. 104 (2023) 103205, https://doi.org/10.1016/j.erss.2023.103205.
[14] UNECE, Guide on Poverty Measurement, United Nations Economic Commission for Europe, 2017. Retrieved from, https://unece.org/statistics/publications/guide-poverty-measurement.
[15] UNECE, Poverty Measurement: Guide to Data Disaggregation, United Nations Economic Commission for Europe, 2020. ISBN 978-92-1-117260-7. Retrieved from, https://unece.org/statistics/publications/poverty-measurement-guide-data-disaggregation.
[16] UNECE, Approaches to Measuring Social Exclusion. Prepared by the UNECE Task Force on the Measurement of Social Exclusion, United Nations Economic Commission for Europe, 2022. ISBN 978-92-1-117283-6. Retrieved from, https://unece.org/statistics/publications/approaches-measuring-social-exclusion.
[17] W. Roberts, Engaging Hard to Reach Young People Through Sport, Published by the Berkeley Foundation, 2016, https://doi.org/10.13140/RG.2.2.20582.52804.
[18] G. Boag-Munroe, M. Evangelou, From hard to reach to how to reach: a systematic review of the literature on hard-to-reach families, Res. Pap. Educ. 27 (2) (2010) 209–239, https://doi.org/10.1080/02671522.2010.509515.
[19] A. Shaghaghi, R.S. Bhopal, A. Sheikh, Approaches to recruiting 'hard-to-reach' populations into research: a review of the literature, Health Promot. Perspect. 20; 1(2) (2011) 86–94, https://doi.org/10.5681/hpp.2011.009.
[20] B. Bonevski, M. Randell, C. Paul, K. Chapman, L. Twyman, J. Bryant, I. Brozek, C. Hughes, Reaching the hard-to-reach: a systematic review of strategies for improving health and medical research with socially disadvantaged groups, BMC Med. Res. Methodol. 14 (2014) 42, https://doi.org/10.1186/1471-2288-14-42.
[21] A.E.M. Liljas, K. Walters, A. Jovicic, S. Iliffe, J. Manthorpe, C. Goodman, K. Kharicha, Strategies to improve engagement of 'hard to reach' older people in research on health promotion: a systematic review, BMC Public Health 17 (2017) 349, https://doi.org/10.1186/s12889-017-4241-8.
[22] Users TCP - IEA Technology Collaboration Programme, UsersTCP Hard-to-Reach Energy Users, Accessed in March 2024: https://userstcp.org/hard-to-reach-energy-users-task/, 2024.
[23] B.K. Sovacool, What are we doing here? Analyzing fifteen years of energy scholarship and proposing a social science research agenda, Energy Res. Soc. Sci. 1 (2014) 1–29, https://doi.org/10.1016/j.erss.2014.02.003.
[24] B.K. Sovacool, S.E. Ryan, P.C. Stern, K. Janda, G. Rochlin, D. Spreng, M. J. Pasqualetti, H. Wilhite, L. Lutzenhiser, Integrating social science in energy research, Energy Res. Soc. Sci. 6 (2015) 95–99, https://doi.org/10.1016/j.erss.2014.12.005.
[25] K.J. Baker, R. Mould, F. Stewart, S. Restrick, H. Melone, B. Atterson, Never try and face the journey alone: exploring the face-to-face advocacy needs of fuel poor householders in the United Kingdom, Energy Res. Soc. Sci. 51 (2019) 210–219, https://doi.org/10.1016/j.erss.2019.01.009.
[26] R. Raslan, A. Ambrose, Solving the difficult problem of hard to decarbonize homes, Nat. Energy 7 (2022) 675–677, https://doi.org/10.1038/s41560-022-01075-w.
[27] E. Houghton, L. Kelly, R. Raslan, C. Cui, Defining and Identifying Complex-to-decarbonise Homes and Retrofit Solutions - Research Report, Department for Energy Security and Net Zero, Government of the United Kingdom, 2023. Retrieved from: https://www.gov.uk/government/publications/defining-and-identifying-complex-to-decarbonise-homes.
[28] N. Labanca, F. Suerkemper, P. Bertoldi, W. Irrek, B. Duplessis, Energy efficiency services for residential buildings: market situation and existing potentials in the European Union, J. Clean. Prod. 109 (2015) 284–295, https://doi.org/10.1016/j.jclepro.2015.02.077.
[29] T.G. Reames, A community-based approach to low-income residential energy efficiency participation barriers, Local Environ. 21 (12) (2016) 1449–1466, https://doi.org/10.1080/135498 39.2016.1166567.
[30] J. Koch, O. Christ, Household participation in an urban photovoltaic project in Switzerland: exploration of triggers and barriers, Sustain. Cities Soc. 37 (2018) 420–426, https://doi.org/10.1016/j.scs.2017.10.028.
[31] B.R. Lukanov, E.M. Krieger, Distributed solar and environmental justice: exploring the demographic and socio-economic trends of residential PV adoption in California, Energy Policy 134 (2019) 110935, https://doi.org/10.1016/j.enpol.2019.110935.
[32] I.M. Otto, K.M. Kim, N. Dubrovsky, W. Lucht, Shift the focus from the super-poor to the super-rich, Nat. Clim. Chang. 9 (2019) 82–87, https://doi.org/10.1038/s41558-019-0402-3.
[33] K.S. Nielsen, K.A. Nicholas, F. Creutzig, T. Dietz, P.C. Stern, The role of high-socioeconomic-status people in locking in or rapidly reducing energy-driven greenhouse gas emissions, Nat. Energy Perspect. (2021), https://doi.org/10.1038/s41560-021-00900-y.
[34] A.C. Garcia, A. Ambrose, A. Hawkins, S. Parkes, High consumption, an unsustainable habit that needs more attention, Energy Res. Soc. Sci. 80 (2021) 102241, https://doi.org/10.1016/j.erss.2021.102241.
[35] K. Chadwick, R. Russell-Bennett, N. Biddle, The role of human influences on adoption and rejection of energy technology: a systematised critical review of the literature on household energy transitions, Energy Res. Soc. Sci. 89 (2022) 102528, https://doi.org/10.1016/j.erss.2022.102528.
[36] M. Ring, E. Wilson, K.N. Ruwanpura, M. Gay-Antaki, Just energy transitions? Energy policy and the adoption of clean energy technology by households in Sweden, Energy Res. Soc. Sci. 91 (2022) 102727, https://doi.org/10.1016/j.erss.2022.102727.
[37] 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. Soc. Sci. 29 (2017) 53–61, https://doi.org/10.1016/j.erss.2017.05.012.
[38] F. Hanke, R. Guyet, M. Feenstra, Do renewable energy communities deliver energy justice? Exploring insights from 71 European cases, Energy Res. Soc. Sci. 80 (2021) 102244, https://doi.org/10.1016/j.erss.2021.102244.
[39] S. Hall, J. Anable, J. Hardy, M. Workman, C. Mazur, Y. Matthews, Matching consumer segments to innovative utility business models, Nat. Energy 6 (2021) 349–361, https://doi.org/10.1038/s41560-021-00781-1.
[40] B.K. Sovacool, M.H. Dworkin, Energy justice: conceptual insights and practical applications, Appl. Energy 142 (2015) 435–444, https://doi.org/10.1016/j.apenergy.2015.01.002.
[41] B. Karlin, S. Rotmann, K. Ashby, L. Mundaca, D. Butler, M.M. Sequeira, J. P. Gouveia, P. Palma, A. Realini, S. Maggiore, Process Matters: Assessing the Use of Behavioural Science Methods in Applied Behavioural Programmes, European Council for an Energy Efficient Economy 2022 Summer Study on Energy Efficiency (ECEEE 2022), 2022. Retrieved from, https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2022/4-monitoring-and-evaluation-for-a-wise-just-and-inclusive-transition/process-matters-assessing-the-use-of-behavioural-science-methods-in-applied-behavioural-programmes/.
[42] M.M. Sequeira, J.P. Gouveia, Non-residential hard-to-reach energy users: a vast audience forgotten by the energy transition?, in: 8th Meeting on Energy and Environmental Economics Aveiro University, Portugal, 2023 https://doi.org/10.48528/v3b3-fk78.
[43] K. Ashby, J. Smith, S. Rotmann, L. Mundaca, A. Ambrose, HTR Characteristics, HTR Annex by Users TCP by IEA, Wellington, 2020, https://doi.org/10.47568/3XR102.
[44] R. Pawson, T. Greenhalgh, G. Harvey, K. Walshe, Realist synthesis: an introduction, in: ESRC Research Methods Programme, University of Manchester, 2004 (RMP Methods Paper 2/2004).
[45] L. Middlemiss, Who is vulnerable to energy poverty in the global north, and what is their experience? WIREs Energy Environ. 11 (2022) e455 https://doi.org/10.1002/wene.455.
[46] N. Simcock, K.E.H. Jenkins, M. Lacey-Barnacle, M. Martiskainen, G. Mattioli, D. Hopkins, Identifying double energy vulnerability: a systematic and narrative review of groups at-risk of energy and transport poverty in the global north, Energy Res. Soc. Sci. 82 (2021) 102351, https://doi.org/10.1016/j.erss.2021.102351.
[47] S.M. Flanagan, B. Hancock, 'Reaching the hard to reach' - lessons learned from the VCS (voluntary and community sector). A qualitative study, BMC Health Serv. Res. 10 (2010) 92, https://doi.org/10.1186/1472-6963-10-92.
[48] P. Griffiths, M. Gossop, B. Powis, J. Strang, Reaching hidden populations of drug users by privileged access interviewers: methodological and practical issues, Addiction 88 (1993) 1617–1626, https://doi.org/10.1111/j.1360-0443.1993.tb02036.x.

[49] I. Shaw, M. Bloor, R. Cormack, H. Williamson, Estimating the prevalence of hard-to-reach populations: the illustration of mark-recapture methods in the study of homelessness, Soc. Policy Adm. 3 (1) (1996) 69–85, https://doi.org/10.1111/J.1467-9515.1996.TB00482.X.
[50] R. Atkinson, J. Flint, Accessing hidden and hard-to-reach populations: snowball research strategies, in: Social Research Update 33, University of Surrey, 2003. Retrieved from: https://sru.soc.surrey.ac.uk/SRU33.html.
[51] F. Alexandrescu, I.-M. Anghel, J. Adorjáni, L. Ştefanescu, A. Pop, A. Mihai, On the path of evictions and invisibilization: poor Roma facing climate vulnerability, Cities 114 (2021) 103201, https://doi.org/10.1016/j.cities.2021.103201.
[52] European Commission, Consumer vulnerability across key markets in the European Union, in: Final Report, 2016. January 2016. Retrieved from, https://ec.europa.eu/info/files/consumer-vulnerability-report_en.
[53] B.K. Sovacool, M.L. Barnacle, A. Smith, M.C. Brisbois, Towards improved solar energy justice: exploring the complex inequities of household adoption of photovoltaic panels, Energy Policy 164 (2022) 112868, https://doi.org/10.1016/j.enpol.2022.112868.
[54] L. Middlemiss, R. Gillard, Fuel poverty from the bottom-up: Characterising household energy vulnerability through the lived experience of the fuel poor, Energy Res. Soc. Sci. 6 (2015) 146–154, https://doi.org/10.1016/j.erss.2015.02.001.
[55] A. Drehobl, L. Ross, R. Ayala, How High Are Household Energy Burdens? An Assessment of National and Metropolitan Energy Burden Across the United States, ACEEE - American Council for an Energy-Efficient Economy, 2020. Retrieved from, https://www.aceee.org/research-report/u2006.
[56] 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.
[57] C. Chen, J. Greig, H. Nelson, F. Li, When disadvantage collides: the concentrated effects of energy insecurity and internet burdens in the United States, Energy Res. Soc. Sci. 91 (2022) 102713, https://doi.org/10.1016/j.erss.2022.102713.
[58] R. Galvin, M. Sunikka-Blank, Economic inequality and household energy consumption in high-income countries: a challenge for social science based energy research, Ecol. Econ. 153 (2018) 78–88, https://doi.org/10.1016/j.ecolecon.2018.07.003.
[59] F. Stewart, Friends with benefits: how income and peer diffusion combine to create an inequality "trap" in the uptake of low-carbon technologies, Energy Policy 163 (2022) 112832, https://doi.org/10.1016/j.enpol.2022.112832.
[60] R. Mould, K.J. Baker, Documenting fuel poverty from the householders' perspective, Energy Res. Soc. Sci. 31 (2017) 21–31, https://doi.org/10.1016/j.erss.2017.06.004.
[61] 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.
[62] J.P. Gouveia, P. Palma, S.G. Simões, 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.
[63] M.M. Sequeira, J.P. Gouveia, A sequential multi-staged approach for developing digital one-stop shops to support energy renovations of residential buildings, Energies 2022 (15) (2022) 5389, https://doi.org/10.3390/en15155389.
[64] D. Roberts, E. Vera-Toscano, E. Phimister, Fuel poverty in the UK: is there a difference between rural and urban areas? Energy Policy 87 (2015) 216–223, https://doi.org/10.1016/j.enpol.2015.08.034.
[65] L. Ross, A. Drehobl, B. Stickles, The High Cost of Energy in Rural America: Household Energy Burdens and Opportunities for Energy Efficiency, ACEEE – American Council for an Energy-Efficient Economy, 2018. Retrieved from, https://www.aceee.org/research-report/u1806.
[66] S. MacDonald, B. Winner, L. Smith, J. Juillerat, S. Belknap, Bridging the rural efficiency gap: expanding access to energy efficiency upgrades in remote and high energy cost communities, Energ. Effic. 13 (2019) 503–552, https://doi.org/10.1007/s12053-019-09798-8.
[67] A. Stojilovska, D. Dokupilová, J.P. Gouveia, A.Z. Bajomi, S. Tirado-Herrero, N. Feldmár, I. Kyprianou, M. Feenstra, As essential as bread: fuelwood use as a cultural practice to cope with energy poverty in Europe, Energy Res. Soc. Sci. 97 (2023) 102987, https://doi.org/10.1016/j.erss.2023.102987.
[68] J. Palm, K. Reindl, Understanding barriers to energy-efficiency renovations of multifamily dwellings, Energ. Effic. 11 (2018) 53–65, https://doi.org/10.1007/s12053-017-9549-9.
[69] M. Eisermann, C. Maurer, I. Turner, Boosting energy retrofits in condominiums: approaches for local authorities to facilitate change, in: Interreg North-West Europe ACE-Retrofitting and Energy Cities, 2019. ISBN 978-2-490384-11-2. Retrieved from, https://energy-cities.eu/publication/boosting-energy-retrofits-in-condominiums/.
[70] D. Streimikiene, T. Balezentis, Willingness to pay for renovation of multi-flat buildings and to share the costs of renovation, Energies 13 (2020) 2721, https://doi.org/10.3390/en13112721.
[71] R. Moura, M.C. Brito, Prosumer aggregation policies, country experience and business models, Energy Policy 132 (2019) 820–830, https://doi.org/10.1016/j.enpol.2019.06.053.
[72] C.W. Kraaijvanger, T. Verm, N. Doorn, J.E. Goncalves, Does the sun shine for all? Revealing socio-spatial inequalities in the transition to solar energy in The Hague, The Netherlands, Energy Res. Soc. Sci. 104 (2023) 103245, https://doi.org/10.1016/j.erss.2023.103245.
[73] L. Oliveras, L. Artazcoz, C. Borrell, L. Palència, M. José López, M. Gotsens, A. Peralta, M. Marí-Dell'Olmo, The association of energy poverty with health, health care utilisation and medication use in southern Europe, SSM – Popul. Health 12 (2020) 100665, https://doi.org/10.1016/j.ssmph.2020.100665.
[74] R. Chard, G. Walker, Living with fuel poverty in older age: coping strategies and their problematic implications, Energy Res. Soc. Sci. 18 (2016) 62–70, https://doi.org/10.1016/j.erss.2016.03.004.
[75] V. Pais-Magalhães, V. Moutinho, M. Robaina, Is an ageing population impacting energy use in the European Union? Drivers, lifestyles, and consumption patterns of elderly households, Energy Res. Soc. Sci. 85 (2022) 102443, https://doi.org/10.1016/j.erss.2021.102443.
[76] M.A. Abreu, R.A.F. Oliveira, J. Lopes, Younger vs. older homeowners in building energy-related renovations: learning from the Portuguese case, in: 6th International Conference on Energy and Environment Research, ICEER 2019, 22–25 July, Energy Reports, 6, University of Aveiro, Portugal, 2020, pp. 159–164, https://doi.org/10.1016/j.egyr.2019.08.036.
[77] J. Sommerfeld, L. Buys, K. Mengersen, D. Vine, Influence of demographic variables on uptake of domestic solar photovoltaic technology, Renew. Sustain. Energy Rev. 67 (2017) 315–323, https://doi.org/10.1016/j.rser.2016.09.009.
[78] E. Bîrsănuc, Mapping gendered vulnerability to energy poverty in Romania, Appl. Spat. Anal. Policy (2022), https://doi.org/10.1007/s12061-022-09442-6.
[79] H. Zhen, Y. Long, R. Wood, D. Moran, Z. Zhang, J. Meng, K. Feng, E. Hertwich, D. Guan, Ageing society in developed countries challenges carbon mitigation, Nat. Clim. Chang. 12 (2022) 241–248, https://doi.org/10.1038/s41558-022-01302-y.
[80] 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.
[81] C. Jacques-Avinó, A. Peralta, J. Carrere, M. Marí-Dell'Olmo, J. Benach, M. López, Qualitative evaluation of an intervention to reduce energy poverty: effects perceived by participants according to typologies of social vulnerability, Energy Policy 167 (2022) 113006, https://doi.org/10.1016/j.enpol.2022.113006.
[82] S. Petrova, Encountering energy precarity: geographies of fuel poverty among young adults in the UK, Trans. Inst. Br. Geogr. 43 (2017) 17–30, https://doi.org/10.1111/tran.12196.
[83] J. Cauvain, S. Bouzarovski, Energy vulnerability in multiple occupancy housing: a problem that policy forgot, People Place Policy 10 (1) (2016) 88–106, https://doi.org/10.3351/ppp.0010.0001.0007.
[84] I. Kousis, M. Laskari, V. Ntouros, M. Assimakopoulos, J. Romanowicz, An analysis of the determining factors of fuel poverty among students living in the private-rented sector in Europe and its impact on their well-being, Energy Sources B: Econ. Plan. Policy 15 (2) (2020) 113–135, https://doi.org/10.1080/15567249.2020.1773579.
[85] A. Nazarahari, N. Ghotbi, K. Tokimatsu, Energy poverty among college students in Japan in a survey of students' knowledge, attitude and practices towards energy use, Sustainability 13 (2021) 8484, https://doi.org/10.3390/su13158484.
[86] C.C. Castro, J.P. Gouveia, Students' perception of energy poverty—a comparative analysis between local and exchange university students from Montevideo, Lisbon, and Padua, Front. Sustain. Cities, Sec. Urban Energy End-Use 5 (2023), https://doi.org/10.3389/frsc.2023.1114540.
[87] A.M. Tod, P. Nelson, A. Cronin de Chavez, C. Homer, V. Powell-Hoyland, A. Stocks, Understanding influences and decisions of households with children with asthma regarding temperature and humidity in the home in winter: a qualitative study, BMJ Open 6 (2016) 009636, https://doi.org/10.1136/bmjopen-2015-009636.
[88] K. Mahapatra, B. Mainali, G. Pardalis, Homeowners' attitude towards one-stop-shop business concept for energy renovation of detached houses in Kronoberg, Sweden, in: 10th International Conference on Applied Energy (ICAE2018), 22–25 August 2018, Hong Kong, China, Energy Procedia, 158, 2019, pp. 3702–3708, https://doi.org/10.1016/j.egypro.2019.01.888.
[89] O.D. Groote, G. Pepermans, F. Verboven, Heterogeneity in the adoption of photovoltaic systems in Flanders, Energy Econ. 59 (2016) 45–57, https://doi.org/10.1016/j.eneco.2016.07.008.
[90] M. Sunikka-Blank, R. Galvin, Single parents in cold homes in Europe: how intersecting personal and national characteristics drive up the numbers of these vulnerable households, Energy Policy 150 (2021) 112134, https://doi.org/10.1016/j.enpol.2021.112134.
[91] EIGE, Gender equality index 2023: towards a green transition in transport and energy, in: European Institute for Gender Equality, Publications Office of the European Union, Luxembourg, 2023, https://doi.org/10.2839/64810.
[92] L. Tjørring, We forgot half of the population! The significance of gender in Danish energy renovation projects, Energy Res. Soc. Sci. 22 (2016) 115–124, https://doi.org/10.1016/j.erss.2016.08.008.
[93] S. Bouzarovski, M. Burbidge, A. Sarpotdar, M. Martiskainen, The diversity penalty: domestic energy injustice and ethnic minorities in the United Kingdom, Energy Res. Soc. Sci. 91 (2022) 102716, https://doi.org/10.1016/j.erss.2022.102716.
[94] C. Snell, M. Bevan, H. Thomson, Justice, fuel poverty and disabled people in England, Energy Res. Soc. Sci. 10 (2015) 123–132, https://doi.org/10.1016/j.erss.2015.07.012.
[95] D. Butler, L. Steadman, M. Jackson, H. Stockton, P. Smith, Taking the Temperature of NG6: A Review of How NG6 is Delivering Warm and Safe Homes, and What More Can Be Done for Vulnerable and Terminally Ill People, National Energy Action, 2023. Retrieved from, https://www.nea.org.uk/publications/taking-the-temperature-of-ng6/.
[96] D. Ivanova, L. Middlemiss, Characterizing the energy use of disabled people in the European Union towards inclusion in the energy transition, Nat. Energy 6 (2021) 1188–1197, https://doi.org/10.1038/s41560-021-00932-4.

[97] M. Baltruszewicz, J.K. Steinberger, J. Paavola, D. Ivanova, L. Brand-Correa, A. Owen, Ecol. Econ. 205 (2023) 107686, https://doi.org/10.1016/j.ecolecon.2022.107686.
[98] M. Chapman, J. Gilbertson, J. Bradley, C. Damm, V. Farnsworth, A. Ferguson, A. Owen, B. Stafford, B. Taylor, A. Tod, D. Wolstenholme, Being warm being happy: understanding factors influencing adults with learning disabilities being warm and well at home with inclusive research, People Place Policy 16 (2) (2022) 193–215, https://doi.org/10.3351/ppp.2022.2942847959.
[99] S.A. Churchill, R. Smyth, Ethnic diversity, energy poverty and the mediating role of trust: evidence from household panel data for Australia, Energy Econ. 86 (2020) 104663, https://doi.org/10.1016/j.eneco.2020.104663.
[100] A. Owen, L. Middlemiss, D. Brown, D. Davis, S. Hall, R. Bookbinder, M.C. Brisbois, I. Cairns, M. Hannon, G. Mininni, Who applies for energy grants? Energy Res. Soc. Sci. 101 (2023) 103123 https://doi.org/10.1016/j.erss.2023.103123.
[101] D. Butler, E. Nuttall, H. Stockton, N. Storey, Plugged, in: Strengthening Energy Advice and Support for Gypsies, Travellers, Roma and Nomadic Communities – Final Report, National Energy Action, 2023. Retrieved from, https://www.nea.org.uk/researchpolicy/gypsies-travellers-roma-nomadic-communities/.
[102] U. Ruiz-Rivas, S. Tirado-Herrer, R. Castano-Rosa, J. Martínez-Crespo, Disconnected, yet in the spotlight: emergency research on extreme energy poverty in the Canada Real informal settlement, Spain, Energy Res. Soc. Sci. 102 (2023) 103182, https://doi.org/10.1016/j.erss.2023.103182.
[103] N. Forster, P. Hodgson, C. Bailey, Energy advice for Traveller Communities in the context of ethnic and spatial premiums: 'paying the price' for other people's choices, J. Poverty Soc. Justice 27 (1) (2019) 61–78, https://doi.org/10.1332/175982718x15451316707778.
[104] Y. Oswald, A. Owen, J.K. Steinberger, Large inequality in international and intranational energy footprints between income groups and across consumption categories, Nat. Energy 5 (2020) 231–239, https://doi.org/10.1038/s41560-020-0579-8.
[105] M. Sommer, K. Kratena, The carbon footprint of European households and income distribution, Ecol. Econ. 136 (2017) 62–72, https://doi.org/10.1016/j.ecolecon.2016.12.008.
[106] B. Barros, R. Wilk, The outsized carbon footprints of the super-rich, Sustain. Sci. Practice Policy 17 (1) (2021) 316–322, https://doi.org/10.1080/15487733.2021.1949847.
[107] D. Ivanova, R. Wood, The unequal distribution of household carbon footprints in Europe and its link to sustainability, Glob. Sustain. 3 (e18) (2020) 1–12, https://doi.org/10.1017/sus.2020.12.
[108] S. Gossling, A. Humpe, Millionaire spending incompatible with 1.5 °C ambitions, Clean. Prod. Lett. 4 (2023) 100027, https://doi.org/10.1016/j.clpl.2022.100027.
[109] T. Wiedmann, M. Lenzen, L.T. Keyßer, J.K. Steinberger, Scientists' warning on affluence, Nat. Commun. 11 (2020) 3107, https://doi.org/10.1038/s41467-020-16941-y.
[110] N. Cass, K. Lucas, M. Adeel, J. Anable, M. Buchs, R. Lovelace, M. Morgan, C. Mullen, Curbing Excess: High Energy Consumption and the Fair Energy Transition, Centre for Research into Energy Demand Solutions, Oxford, UK, 2022. ISBN: 978-1-913299-14-9. Retrieved from, https://www.creds.ac.uk/publications/curbing-excess-high-energy-consumption-and-the-fair-energy-transition/.
[111] Oxfam International and the Institute for European Environmental Policy, Carbon Inequality in 2030, 2021, https://doi.org/10.21201/2021.8274.
[112] D. Kenner, Inequality of overconsumption: The ecological footprint of the richest, in: GSI Working Paper 2015/2, Global Sustainability Institute, Anglia Ruskin University, Cambridge, 2015. Retrieved from, https://whygreeneconomy.org/wp-content/uploads/2015/11/Inequality-of-overconsumption.-The-ecological-footprint-of-the-richest-Dario-Kenner.pdf.
[113] J. Starr, C. Nicolson, M. Ash, E.M. Markowitz, D. Moran, Assessing U.S. consumers' carbon footprints reveals outsized impact of the top 1%, Ecol. Econ. 205 (2023) 107698 https://doi.org/10.1016/j.ecolecon.2022.107698.
[114] Y. Oswald, J. Millward-Hopkins, J.K. Steinberger, A. Owen, D. Ivanova, Luxury-focused carbon taxation improves fairness of climate policy, One Earth 6 (2023) 884–898, https://doi.org/10.1016/j.oneear.2023.05.027.
[115] J. Markard, P. Wells, X. Yap, H. van Lente, Unsustainabilities: a study on SUVs and space tourism and a research agenda for transition studies, Energy Res. Soc. Sci. 106 (2023) 103302, https://doi.org/10.1016/j.erss.2023.103302.
[116] Oxfam, Survival of the richest: how we must tax the super-rich now to fight inequality, in: Oxfam Briefing Paper: January 2023, 2023. Retrieved from, https://www.oxfam.org/en/research/survival-richest.
[117] European Commission, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A Renovation Wave for Europe – Greening Our Buildings, Creating Jobs, Improving Lives, Brussels, 14.10.2020, COM(2020) 662 final. Retrieved from, https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1603122220757&uri=CELEX:52020DC0662, 2020.
[118] B. Ástmarsson, P.A. Jensen, E. Maslesa, Sustainable renovation of residential buildings and the landlord/tenant dilemma, Energy Policy 63 (2013) 355–362, https://doi.org/10.1016/j.enpol.2013.08.046.
[119] A. Ambrose, Improving energy efficiency in private rented housing: what makes landlords act? Indoor Built Environ. 24 (7) (2015) 913–924. Retrieved from, https://shura.shu.ac.uk/9866/7/Ambrose_-_IBE_paper_v4_-_final.pdf.
[120] A. Ambrose, L. McCarthy, Taming the 'masculine pioneers'? Changing attitudes towards energy efficiency amongst private landlords and tenants in New Zealand: a case study of Dunedin, Energy Policy 126 (2019) 165–176, https://doi.org/10.1016/j.enpol.2018.11.018.
[121] S. Bird, D. Hernández, Policy options for the split incentive: increasing energy efficiency for low-income renters, Energy Policy 48 (2012) 506–514, https://doi.org/10.1016/j.enpol.2012.05.053.
[122] N. Longhurst, T. Hargreaves, Emotions and fuel poverty: the lived experience of social housing tenants in the United Kingdom, Energy Res. Soc. Sci. 56 (2019) 101207, https://doi.org/10.1016/j.erss.2019.05.017.
[123] K. Jenkins, D. McCauley, R. Heffron, H. Stephan, R. Rehnera, Energy justice: a conceptual review, Energy Res. Soc. Sci. 11 (2016) 174–182, https://doi.org/10.1016/j.erss.2015.10.004.
[124] X. Wang, K. Lo, Just transition: a conceptual review, Energy Res. Soc. Sci. 82 (2021) 102291, https://doi.org/10.1016/j.erss.2021.102291.
[125] B.K. Sovacool, M. Burke, L. Baker, C.K. Kotikalapudi, H. Wlokas, New frontiers and conceptual frameworks for energy justice, Energy Policy 105 (2017) 677–691, https://doi.org/10.1016/j.enpol.2017.03.005.
[126] B.K. Sovacool, S.E. Bell, C. Daggett, C. Labuski, M. Lennon, L. Naylor, J. Klinger, K. Leonard, J. Firestone, Pluralizing energy justice: incorporating feminist, anti-racist, indigenous, and postcolonial perspectives, Energy Res. Soc. Sci. 97 (2023) 102996, https://doi.org/10.1016/j.erss.2023.102996.
[127] J. Millward-Hopkins, E. Johnson, Distributing less, redistributing more: safe and just low-energy futures in the United Kingdom, Energy Res. Soc. Sci. 95 (2023) 102915, https://doi.org/10.1016/j.erss.2022.102915.
[128] K. Grossmann, E. Trubina, How the concept of dignity is relevant to the study of energy poverty and energy justice, Front. Sustain. Cities 3 (2021) 644231, https://doi.org/10.3389/frsc.2021.644231.
[129] G. Walker, R. Day, Fuel poverty as injustice: integrating distribution, recognition and procedure in the struggle for affordable warmth, Energy Policy 49 (2012) 69–75, https://doi.org/10.1016/j.enpol.2012.01.044.
[130] C. Kivunja, Distinguishing between theory, theoretical framework, and conceptual framework: a systematic review of lessons from the field, Int. J. Higher Educ. 7 (2018) 6, https://doi.org/10.5430/ijhe.v7n6p44.
[131] 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.
[132] J.P. Gouveia, P. Palma, S. Bessa, K. Mahoney, M. Sequeira, Energy poverty national indicators: insights for a more effective measuring, in: Energy Poverty Advisory Hub. Directorate General for Energy, European Commission, 2022. Retrieved from, https://energy-poverty.ec.europa.eu/discover/publications/publications/energy-poverty-national-indicators-insights-more-effective-measuring_en.
[133] J.P. Gouveia, P. Palma, S. Bessa, K. Mahoney, M. Sequeira, Energy poverty national indicators: uncovering new possibilities expanded knowledge, in: Energy Poverty Advisory Hub. Directorate General for Energy, European Commission, 2023. Retrieved from, https://energy-poverty.ec.europa.eu/discover/publications/publications/epah-report-energy-poverty-advisory-hub-national-indicators-uncovering-new-possibilities-expanded_en.
[134] European Commission, Communication from the Commission to the European Parliament and the Council. A Union of Equality: EU Roma Strategic Framework for Equality, Inclusion and Participation, Brussels, 7.10.2020, COM(2020) 620. Retrieved from, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0620, 2020.
[135] FEANTSA and The Abbé Pierre Foundation, Eight Overview of Housing Exclusion in Europe – 2023, Retrieved from, https://www.feantsa.org/en/report/2023/09/05/report-8th-overview-of-housing-exclusion-in-europe-2023, 2023.
[136] Altrata, World Ultra Wealth Report 2023, Retrieved from, https://altrata.com/reports/world-ultra-wealth-report-2023, 2023.
[137] Capgemini, World Wealth Report 2023 – Wealth Management, Retrieved from, https://www.capgemini.com/insights/research-library/world-wealth-report/, 2023.
[138] C. Fraune, Gender matters: women, renewable energy, and citizen participation in Germany, Energy Res. Soc. Sci. 7 (2015) 55–65, https://doi.org/10.1016/j.erss.2015.02.005.
[139] M. Feenstra, J. Clancy, A view from the north: gender and energy poverty in the European Union, in: J. Clancy, G. Özerol, N. Mohlakoana, M. Feenstra, L. Sol Cueva (Eds.), Engendering the Energy Transition, 2020, https://doi.org/10.1007/978-3-030-43513-4_8.
[140] Eurostat, At-risk-of-Poverty Rate After Deducting Housing Costs by Age and Sex, ILC_LI45. Last update: 15/12/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/ILC_LI45.
[141] Eurostat, Population by Educational Attainment Level, Sex and Age (%) - Main Indicators, EDAT_LFSE_03. Last update: 14/09/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/EDAT_LFSE_03.
[142] Eurostat, Population on 1 January by Age and Sex, DEMO_PJAN, 2023, https://doi.org/10.2908/DEMO_PJAN. Last update: 28/09/2023. Accessed: 21/12/2023.
[143] Eurostat, Distribution of Population by Degree of Urbanisation, Dwelling Type and Income Group - EU-SILC Survey, ILC_LVHO01. Last update: 15/12/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/ILC_LVHO01.
[144] Eurostat, Distribution of Population Aged 65 and Over by Type of Household - EU-SILC Survey, ILC_LVPS30. Last update: 15/12/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/ILC_LVPS30.
[145] Eurostat, Share of Young Adults Aged 18–34 Living With Their Parents by Age and Sex - EU-SILC Survey, ILC_LVPS08. Last update: 15/12/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/ILC_LVPS08.
[146] Eurostat, Distribution of Population by Household Type and Income Group - EU-SILC Survey, ILC_LVPS02. Last update: 15/12/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/ILC_LVPS02.

[147] Eurostat, Population on 1 January by Age Group, Sex and Country of Birth, MIGR_POP3CTB. Last update: 28/11/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/MIGR_POP3CTB.
[148] Eurostat, Unemployment by Sex and Age – Annual Data, UNE_RT_A. Last update: 14/12/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/UNE_RT_A.
[149] Eurostat, People Having a Long-standing Illness or Health Problem, by Sex, Age and Labour Status, HLTH_SILC_04. Last update: 15/12/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/HLTH_SILC_04.
[150] Eurostat, Share of People Having Income Greater or Equal to Specific National Thresholds by Age and Sex, ILC_DI20. Last update: 15/12/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/ILC_DI20.
[151] Eurostat, Distribution of Population by Tenure Status, Type of Household and Income Group - EU-SILC Survey, ILC_LVHO02. Last update: 15/12/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/ILC_LVHO02.
[152] S. Sareen, H. Thomson, S. Tirado Herrero, J.P. Gouveia, I. Lippert, A. Lis, European energy poverty metrics: scales, prospects and limits, Glob. Transit. 2 (2020) 26–36, https://doi.org/10.1016/j.glt.2020.01.003.
[153] Eurostat, Persons at Risk of Poverty or Social Exclusion by Age and Sex, ILC_PEPS01N. Last update: 15/12/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/ILC_PEPS01N.
[154] Eurostat, At-risk-of-poverty Rate by Poverty Threshold, Age and Sex - EU-SILC and ECHP Surveys, ILC_LI02. Last update: 15/12/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/ILC_LI02.
[155] Eurostat, At-risk-of-poverty rate before social transfers (pensions excluded from social transfers) by poverty threshold, age and sex - EU-SILC and ECHP surveys, ILC_LI10. Last update: 19/12/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/ILC_LI10.
[156] Eurostat, Persistent at-risk-of-poverty rate by sex and age - EU-SILC and ECHP surveys, ILC_LI21. Last update: 15/12/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/ILC_LI21.
[157] Eurostat, Population on 1 January by age group, sex and level of human development of the country of birth, MIGR_POP8CTB. Last update: 05/10/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/MIGR_POP8CTB.
[158] Eurostat, Recent immigrants by sex, age and country of birth, LFST_RIMGPCGA. Last update: 14/12/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/LFST_RIMGPCGA.
[159] Eurostat, Population by sex, age, migration status, country of birth and country of birth of parents, LFSO_14PCOBP. Last update: 28/03/2019. Accessed: 21/12/2023, 2019, https://doi.org/10.2908/LFSO_14PCOBP.
[160] Eurostat, All valid permits by reason, length of validity and citizenship on 31 December of each year, MIGR_RESVALID. Last update: 19/12/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/MIGR_RESVALID.
[161] Eurostat, Third country nationals found to be illegally present - annual data (rounded), MIGR_EIPRE. Last update: 06/11/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/MIGR_EIPRE.
[162] Eurostat, Long-term unemployment by sex - annual data, UNE_LTU_A. Last update: 14/12/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/UNE_LTU_A.
[163] Eurostat, Supplementary indicators to unemployment - annual data. LFSI_SUP_A, Last update: 14/12/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/LFSI_SUP_A.
[164] Eurostat, Self-perceived health by sex, age and degree of urbanisation, HLTH_SILC_18. Last update: 15/12/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/HLTH_SILC_18.
[165] Eurostat, Self-perceived long-standing limitations in usual activities due to health problem by sex, age and labour status, HLTH_SILC_06. Last update: 15/12/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/HLTH_SILC_06.
[166] Eurostat, Current depressive symptoms by sex, age and income quintile, HLTH_EHIS_MH1I. Last update: 16/06/2023. Accessed: 21/12/2023, 2023, https://doi.org/10.2908/HLTH_EHIS_MH1I.
[167] Eurostat, Severity of bodily pain by sex, age and educational attainment level, HLTH_EHIS_PN1E. Last update: 22/03/2022. Accessed: 21/12/2023, 2022, https://doi.org/10.2908/HLTH_EHIS_PN1E.
[168] Eurostat, Population by sex, age and disability status, HLTH_DPEH005. Last update: 18/05/2015. Accessed: 21/12/2023, 2015, https://doi.org/10.2908/HLTH_DPEH005.
[169] Eurostat, Population by sex, age, disability status and having a longstanding health problem, HLTH_DPEH050. Last update: 18/05/2015. Accessed: 21/12/2023, 2015, https://doi.org/10.2908/HLTH_DPEH050.
[170] Eurostat, Population by sex, age, disability status and having a longstanding difficulty in basic activities, HLTH_DPEH060. Last update: 18/05/2015. Accessed: 21/12/2023, 2015, https://doi.org/10.2908/HLTH_DPEH060.
[171] Eurostat, Monthly minimum wages - bi-annual data, EARN_MW_CUR. Last update: 31/01/2024. Accessed: 08/03/2024, 2024, https://doi.org/10.2908/EARN_MW_CUR.
[172] A. Horta, J.P. Gouveia, L. Schmidt, J.C. Sousa, P. Palma, S. Simões, Energy poverty in Portugal: combining vulnerability mapping with household interviews, Energy Build. 203 (2019) 109423, https://doi.org/10.1016/j.enbuild.2019.109423.
[173] M. Sequeira, J.J. Melo, Energy saving potential in the small business service sector: case study Telheiras neighborhood, Portugal, Energ. Effic. 13 (2020) 551–569, https://doi.org/10.1007/s12053-020-09842-y.
[174] A. Pillai, M.T. Reaños, J. Curtis, An examination of energy efficiency retrofit scheme applications by low-income households in Ireland, Heliyon 7 (2021) e08205, https://doi.org/10.1016/j.heliyon.2021.e08205.
[175] M. Büchs, N. Cass, C. Mullen, K. Lucas, D. Ivanova, Emissions savings from equitable energy demand reduction, Nat. Energy 8 (2023) 758–769, https://doi.org/10.1038/s41560-023-01283-y.
[176] M. François, S.M. Wilmars, K. Maréchal, Unlocking the potential of income and wealth caps in post-growth transformation: a framework for improving policy design, Ecol. Econ. 208 (2023) 107788, https://doi.org/10.1016/j.ecolecon.2023.107788.
[177] S. Bouzarovski, M. Burbidge, A. Stojilovska, Deliverable 2.6 Report on Energy Poverty in the PRS – Overview & Framework, University of Manchester, United Kingdom: ENPOR Project, 2023. Retrieved from, www.enpor.org.
[178] P. Budworth, Care, comfort, and capacity: the importance of being flexible in research with disabled and chronically ill people, SSM - Qualitative Res. Health 4 (2023) 100352, https://doi.org/10.1016/j.ssmqr.2023.100352.