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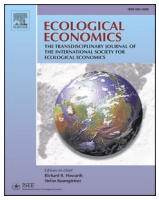

Meeting housing needs within planetary boundaries: A UK case study

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ABSTRACT

This paper addresses a neglected aspect of the UK housing crisis: how to rapidly but fairly decarbonise the housing stock to meet tough net zero targets while meeting housing needs of the entire population. To do so the authors adopt a radical approach based on sufficiency. The sufficiency approach is based on determining both a housing floor – a decent minimum standard for all – and a housing ceiling - above which lies unsustainable excess. The authors define these thresholds in terms of bedrooms and floorspace and analyse the distribution of housing in England. They find that excess housing is widespread, concentrated in home ownership, particularly outright ownership, and characterised by above average emissions per square metre. They conclude that current policies based solely on energy efficiency and increasing housing supply cannot achieve agreed decarbonisation goals while securing decent accommodation for those who are housing deprived. To do this will require policies that distinguish between sufficient and excess housing to make more effective use of the housing stock to meet housing needs within planetary boundaries.

1. Introduction

Housing is a unique consumption good in many ways. It is a capital stock that yields a supply of services over a long period of time. The land on which it sits is inherently limited in supply. Housing is immobile, heterogenous and 'lumpy' with high construction and transaction costs. Housing capital constitutes the most dominant form of personal capital, and the dominant form of personal savings, certainly in the UK. Yet 36 % of households have no home equity and decent housing is increasingly unaffordable for millions of people. Government responses to the housing crisis since the 1980s, especially in the UK, can be broadly characterised as a 'market-fixing' approach. Treating the housing market as broadly competitive, this seeks to increase the supply of new housing by removing planning and regulatory restrictions, and providing subsidies, allowances and benefits to support demand for purchase and renting (Mazzucato and Farha, 2023).

The fundamental premise of our analysis is that not all housing demands and uses are equal. There is a fundamental difference between housing being demanded and used to meet a fundamental human need for shelter, privacy or health, and housing demanded for other uses, which in the extreme amounts to an open-ended pursuit for positional goods (Hirsch, 1977; Frank, 2000). Demand, for housing or any other marketised good, is broadly determined by preferences or wants backed by income. Need, for housing or any other good, introduces a distinct value concept, discussed further below.

Housing *needs* and *wants* compete for the same resources. This is problematic because housing is a major source of carbon emissions and thus a significant contributor to climate change, through construction, use, maintenance and eventual demolition. The UK CCC reported that 15 % of all greenhouse gas emissions in the UK can be attributed to domestic heating, while a further 4 % is generated from the use of electricity in the home for appliances and lighting (CCC, 2019, 27). Bringing down home emissions in line with the UK's target for 2050 will require a rapid upscaling of home energy retrofits. Progress towards this goal is inadequate and sporadic and operates in the shadow of a Labour Party, now government, policy to build up to 300,000 new homes a year (Labour Party Manifesto, 2024). Here we argue that if the goal of housing policy is to meet housing needs within planetary boundaries (Rockström et al., 2009, 2024; Steffen et al., 2015), then we have to prioritise meeting housing needs over expanding housing independent from use.

Human needs for shelter, privacy and health can be identified and met, as discussed below. Conflating housing needs with open-ended wants threatens ecological sustainability while needs remain unaddressed (Gough, 2017). If solving the housing crisis involved just building more homes (Giles, 2024) then we would not be having a

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housing crisis to begin with. UK housing stock since the 1980s has largely accrued in second and third spare bedrooms, rather than addressing persistent problems of overcrowding, homelessness and affordability (Dorling, 2014; Tunstall, 2015).

This paper adopts a quite distinct approach, one based on the concept of *sufficiency* that recognises meeting housing needs within ecological limits to production and consumption. It pursues this argument in the following sequence:

- Part 2 sets out the sufficiency framework in general: how to meet needs in an affluent country within planetary limits.
- Part 3 establishes 'floors' and 'ceilings': *thresholds* of *necessary* housing and *excess* housing, and proposes measures of each.
- Part 4 uses these thresholds to calculate the distribution of the housing stock in England, arriving at the shares of deprivation, sufficiency and excess, and their carbon footprints.
- Part 5 sketches a series of policy proposals that would facilitate a transition or 'corridor' to fair decarbonisation of housing in the UK.
- Part 6 concludes.

In the UK housing policy is devolved. This means that the constituent countries of the UK have the power to legislate housing policies (Gibb, 2021). In this paper, we look at the case of England.

2. The sufficiency framework

The concept of sufficiency combines the social and ecological dimensions of housing policy. Analogous to the framework of Raworth (2017), sufficiency involves meeting human needs within planetary boundaries. There is a burgeoning literature on sufficiency (Jungell-Michelsson and Heikkurinen, 2022), including in housing (e.g. Bohnenberger, 2021). Using a metaphor from housing itself, Gough defines sufficiency as a conceptual *space* between a *floor*, to ensure a decent minimum standard for all, and a *ceiling* above which lies unsustainable excess (Gough, 2020, 2023). These categories can in theory be applied to the different domains of wellbeing, wealth/income, consumption and production - see Fig. 1.

Both floors and ceilings entail *objective* and *universal* limits of some kind: human needs and planetary boundaries. Human needs, commonly including health, autonomy and social participation, are prerequisites for avoiding harm (Doyal and Gough, 1991). Planetary boundaries ultimately rest on biophysical tipping points—thresholds where environmental systems undergo a non-linear transformation which is likely to be irremediable (Green, 2021).

2.1. Floors

The concept of a *floor* depends ultimately on some notion of human need. 'Shelter' or decent housing is one of these. There are links between the idea of universal needs and the 1948 UN Declaration of Human Rights, and the 2015 Sustainable Development Goals (SDGs). All theories of need incorporate a distinction between needs and need *satisfiers*, which are contextual and socially constructed. Satisfiers are the goods, services, activities, and relationships that contribute to need satisfaction in any particular ecological and social context. The needs for shelter apply to all peoples, but there exist widely different forms of dwelling that can meet any given specification of protection from the elements.

Since Townsend's (1979) work on poverty, necessities in any particular social context can be defined as those goods, services and facilities that enable people to *participate* in accepted social activities and to avoid poverty or social exclusion. Ideally, to define such *contextual necessities* requires a distinct methodology: *deliberative* procedures that draw on two forms of knowledge: the codified knowledge of experts and the experientially grounded knowledge of ordinary people in everyday lives. It requires a 'dual strategy of policy formation' which values compromise, provided that it does not extend to the general character of basic human needs and rights (Doyal and Gough, 1991, Chap.14; Nussbaum, 2000). The UK Minimum Income Standard (MIS) studies provide a reasonable operationalisation of this participation criterion. The criterion used to decide what goods, services and activities to include in the minimum standard is the ability of a person or household to *participate in accepted social activities* in society (Davis et al., 2015; Gough, 2020).

2.2. Ceilings

A sufficiency approach also entails defining and implementing maxima or *ceilings* on many components of high carbon consumption, including housing. Daly (1977) distinguishes two broad arguments for *limits* to inequality: ethico-social and biophysical. Ethico-social arguments for limits to inequality in the Western canon can be traced back to Plato and Aristotle and have more recently emerged from different disciplines. These discourses have been augmented and arguably overtaken in recent years by the emergence of the Anthropocene, ecological crisis and biophysical limits. A wealth of recent research has now demonstrated the responsibility for emissions of the top 10 % of households, the top 1 % and the top 0.1 % in the UK and the global North as a whole (Baltruszewicz et al., 2023; Chancel, 2020; Oxfam, 2023).

The commitment of the UK and other nations to achieve a 'net zero' economy by 2050, rests on rapid 'supply-side' decarbonisation. But it is now established that absolute 'decoupling' of production or consumption from emissions is not possible in the scale and time required (Vogel and Hickel, 2023). Therefore, 'demand-side' policies are also needed: total and average per capita consumption levels will need to be recomposed and reduced, particularly in the global North. This is now recognised in parts of the IPCC (Creutzig et al., 2022) and by the UK Committee on Climate Change (CCC) in its Progress Report to Parliament (CCC, 2023, 25).

Once the necessity for demand-side mitigation is recognised, issues of justice and fairness are raised. Whose consumption should be cut? The existence of human needs as an essential requirement for equal participation in society suggests that there is a fundamental difference between consumption to meet human needs and other consumption (Gough, 2017). Guaranteeing decent living standards within limits

	Wellbeing	Wealth/Income	Consumption	Production
	Excess	Riches	Luxuries	Waste, excess
Ceiling				
Sufficiency	Flourishing	Moderate incomes	Conventional comfort	'In-between' production
	Needs met	Decent minimum	Necessities	Foundational production
Floor				
	Deprivation	Poverty	Lack of necessities	Weak/absent foundational economy

Fig. 1. The Sufficiency Framework.

entails prioritising human needs over other consumer preferences in some circumstances (Shue, 1993; Schramme, 2024; Gough, 2023). In addition, increasing consumption at the higher 'wants' end of the spectrum, leads to positioning pressure and an escalation of 'need satisfiers' (Brand-Correa et al., 2020; Bärnthaler and Gough, 2023).

Sufficiency does not imply a sharp distinction between necessities and luxuries. The view of sufficiency illustrated in Fig. 1 moves beyond this to distinguish three categories: necessities, luxuries and – between these – 'comfort goods'. The space of *'sufficiency' is not restricted to meeting 'minimal' needs* but extends beyond this minimum to embrace concepts of flourishing, moderate incomes and conventional comfort – up to a ceiling.

2.3. Transition to a sustainable housing corridor

A standard floor required for participation, as outlined above, immediately raises a dilemma. The standards of housing, food, mobility, leisure pursuits and so on that are required for participation in UK society have expanded hugely over the past century (Davis et al., 2015). The contemporary lifestyles these standards engender are ecologically unsustainable. But even if the entire UK population were living on the MIS budget, average per capita emissions would still amount to 7.3 t per person (Druckman and Jackson, 2010; Akenji et al., 2019).

At the same time, a wide range of research has now demonstrated that basic *needs* could be met for a global population of 10 billion within very tight climate constraints if a sufficiency strategy is implemented. In the Millward-Hopkins et al. (2020) model, final global energy requirements for such sufficiency levels in 2050 could be more than 60 % lower than consumption today, benefitting several billions of people in the world. However, this would require drastic energy cuts of up to 95 % by today's highest per capita energy consumers, entailing significantly different wants and preferences in the global North and among the affluent of the global South.

Changes on this scale cannot happen instantaneously but require a path that brings consumption patterns into planetary boundaries. This is expressed in the concept of "consumption corridors", defining consumption minima (allowing every individual to live a good life) and maxima (ensuring a limit on the use of natural and social resources) (Fuchs et al., 2021). In this paper we attempt to define clear minimum and maximum space thresholds for housing in England, compute the extent of excess housing and its emissions, and address the policy implications.

3. Applying the sufficiency approach: Defining necessary and excessive housing

3.1. Floorspace as a core metric

The most commonly identified dimensions of housing adequacy in the UK are size (in bedrooms or sqm), quality, affordability, security, and location. Housing quality typically refers to the physical condition of a property, its state of repair, and the amenities it offers. The affordability threshold is generally conceived to be met when financial costs associated with housing are at, "such a level that the attainment and satisfaction of other basic needs are not threatened or compromised" (Boyle and Flegg, 2022). Housing security refers to the security of tenure, or the guarantee that housing occupants can reside in their homes without fear or experience of forced eviction, harassment, and other intimidations (Mansour et al., 2022). Finally, even when these four conditions are met, housing has to be in the right place. If housing need did not have to be met in a specific place, displacement would not be a problem.

To achieve housing sufficiency, a household requires sufficient housing space of adequate quality, affordable and secure, and in the right place. However, the remainder of this paper focuses on housing space.

Housing space is a major contributor both to human wellbeing and to carbon emissions. Home size per capita is by far the strongest predictor of residential energy consumption per capita (Huebner and Shipworth, 2017), at least over the short- or medium-term. Holden (2004, 102-103) similarly asserts that the physical dimensions of a property and its site are central to the household's ecological footprint. Lorek & Spangenberg (2019, 288) find that: "Without [policy] instruments limiting average dwelling floor area per person it is hardly imaginable how an absolute reduction in household energy demand could be achieved". Hertwich et al. (2020) and Pauliuk et al. (2021) argue that more intensive use of housing is an important element of a comprehensive strategy to reduce emissions, and that reducing average housing floorspace per person is one of the most promising approaches.

In this light, if the goal of housing policy is to meet the housing needs of the population, the first logical step would arguably be to confirm if the required housing (in bedrooms or sqm), already exist. However, such an analysis is rarely done, leading to widespread claims that there is a "severe lack" of physical housing space in the UK (e.g. Watling and Breach, 2023). Earlier analysis has already demonstrated inequality in the distribution of housing in the UK (Dorling, 2014; Tunstall, 2015). But what has not been attempted thus far is to specify and measure the extent of necessary, sufficient and excess housing in the UK. This we do for England, using data from the English Housing Survey.

3.2. Defining a sufficient housing floor

Adequate minimum housing is a multi-dimensional concept, a need satisfier dependent on particular cultural, social and environmental contexts. The necessity standard, the 'floor' for the UK will, in global terms, be very generous compared with a middle-income country such as South Africa, let alone low-income countries (Rao et al., 2019). The United Nations definition of sufficient housing space is one third of a room per person (UN-Habitat, 2022). This 'sufficiency' threshold would be considered extreme deprivation and overcrowding in the UK today.

To determine a minimum threshold of floorspace ideally requires a dialogic approach, as argued above. In the absence of such research, government-set minimum standards would provide a helpful starting point for the analysis. These have some indirect legitimacy as the outcome of representative democratically elected governments. Padley et al. (2021) have undertaken a focus group exercise for a wide variety of household types, distinguishing standards for London and the rest of the UK. Interestingly, in most (though not all) cases the members of the public chose to use the existing standards as their acceptable minimum. The UK government has specified two such space standards:

- The bedroom standard
- The floorspace standard

The bedroom standard has been used in UK housing statistics since 1960. It requires that a separate bedroom should be provided to the following persons: 1) couples of adults, 2) a person aged 21 years or over; 3) pairs of same-sex persons aged between 10 and 20 years; 4) people aged 10 to 20 years who are paired with a person aged under 10 years of the same sex; 5) pairs of children aged under 10 years, regardless of their sex; and 6) people aged under 21 years who cannot be paired with someone in 3), 4) or 5). We use this as our first sufficiency threshold.[1]

The floorspace standard. In 2015, the UK government for the first time launched a national space standard for new dwellings in all tenures

[1] In practice, most dissent with the bedroom standard revolves around the space needs of (especially older) children, which are deemed too restrictive (e.g. Davis et al., 2015). We disregard this here but note that the bedroom standard likely sets too low a threshold for housing space needs to be met in the UK today.

in England.[2] It sets out requirements for the Gross Internal (floor) Area (GIA) of new dwellings at a defined level of occupancy as well as floor areas and dimensions for key parts of the home, notably bedrooms, storage and floor to ceiling height (DLUHC, 2015, 3). The standard begins at 37m^2 of floor space for a one bed flat with a shower room. Fig. 2 below provides an excerpt.

This standard, like the bedroom standard, is highly 'equivalised'. That means that it takes account of economies of scale in sharing a dwelling as people share a kitchen and other common spaces, and some people share bedrooms. Consequently, the housing need of each additional person can be satisfied with less floorspace than the first person. This is more realistic than 'square metres per head' indicators, as households are often larger than one person. However, it disregards involuntary sharing, where single households really need the square metres of a first person.[3] Unlike the bedroom standard, the floorspace standard also does not distinguish by household composition. For example, young children count the same as an adult.[4] For simplicity, we extrapolate from the table above a simple standard as follows: 40m^2 for one person +10m^2 for each extra person.

We thus identify two distinct standards for housing sufficiency thresholds in England. To the analysis of the space needs of housed households, we add the homeless, the most blatant form of inadequate housing space. In the UK, this includes both rough sleepers and people in hostels and shelters and other temporary accommodation.

3.3. Defining a sufficient housing ceiling

Can we identify a similar threshold of excess housing? There is an academic and research literature on maxima or ceilings to the consumption of housing (see Naess and Xue, 2016; Bierwirth and Thomas, 2019; Lorek and Spangenberg, 2019; Cohen, 2021). Cohen, for example, estimates biophysical ceilings for housing space as "an initial point of departure for assessing the prospect of sustainable consumption transition" (2021, 180). His resulting sufficient home size is extremely minimal: between 14m^2 and 20m^2 for a single individual - half or less than the minimum floorspace standard in England (above). Bierwirth and Thomas (2019) set the European benchmark for "adequate" space per person much higher, between 30m^2 and 35m^2, regardless of household type. However, in most cases sufficient floorspace is neither minimum nor a maximum. In other words, there is no band between the minimum required to participate in modern society and the maximum extend of 'conventional comfort'.

Number of bedrooms (b)	Number of bed spaces (persons)	1 storey dwellings
1b	1p	39(37)*
	2p	50
2b	3p	61
	4p	70
3b	4p	74
	5p	86
	6p	95
4b	5p	90
	6p	99
	7p	108
	8p	117

Fig. 2. Minimum gross internal floor areas and storage (m^2) as defined by the Nationally Described Space Standards (extract from larger table).
Note: Homes with more than one storey have additional circulation space.
(Source: DLUHC, 2015)

An alternative perspective is provided by the study of richness in London (Davis et al., 2020; Hecht et al., 2022). Focus groups distinguished five housing levels:

E. Super-rich: multiple homes, global
D. Wealthy: larger home owned outright; a second home.
C. (Securely) comfortable: Home owned with mortgage.
B. (Surviving) comfortably: Wider choice of rental housing.
A. Minimum income standard: Social housing (renting).

The distinction between the wealthy (D) and the comfortable (C) is of particular interest to a sufficiency analysis. However, it does not provide a clear enough threshold for our research.

Based on this context, we define ceilings as follows:

- The bedroom standard regards *one spare bedroom* per household as conventional comfort, while any additional spare bedrooms mean that a dwelling is *under-occupied*. We follow this existing standard, feeling confident in defining *two or more* bedrooms above the standard as 'excess'.
- For the floorspace standard we define a generous threshold of excess floorspace as *double* the official UK government minimum space standards. This amounts to 80m^2 for a single person, 100m^2 for a household of two people, 120m^2 for three and so on.

To this we add the bedrooms/floorspace in long-term vacant and second homes, numbering approximately 500,000 in England (see annex).

Fig. 3 below summarises the lower and upper thresholds we use to calculate housing deprivation, sufficiency, and excess in England.

4. The distribution of housing space and housing emissions in England: Deprivation and excess

We now turn to analyse the distribution of existing housing space in England between these sufficiency categories. The basic data source is the English Housing Survey 2019–20, so our findings relate to England only. All data below refer just to the one year, 2019–20; it gives no indication of trends over time. Nor do we consider here the potential contributions of new housing. Detailed tables, methods and assumptions are provided in the annex.

There are two distinct ways of analysing the distribution of housing:

- The housing stock perspective: categorising all housing space available in England into three categories: space used to meet the housing needs of its occupants, for comfort, and excess, as well as the housing space that is lacking to house overcrowded and homeless households.
- The household perspective: categorising households in England according to whether they have sufficient space, excess space, or are lacking space.

[2] In other jurisdictions in Europe, the quantitative adequacy of housing has long been defined in terms of floorspace (measured in m^2) (Bärnthaler, 2024).

[3] Equivalisation also implies that single households are more resource intensive. We discuss this in the policy implication (section 5.3.2).

[4] Space requirements will also depend on other personal and social factors such as disability. Our macro-analysis cannot delve further into such variation. This relates to the 'conversion' problem discussed in the capability approach literature (Robeyns, 2017).

		Bedroom standard	Floorspace standard
	Excess	At or above ceiling threshold + second/empty homes	Above ceiling threshold + second/empty homes
Ceiling threshold		Two bedrooms above the bedroom standard	Double the space standard: 80m^2 for the first person, 20m^2 for each additional person
Sufficiency	**Comfort**	Having one more bedroom than required by the standard	Above the floor threshold and below the ceiling threshold
	Needs met	Having the number of bedrooms required by the standard	
Floor threshold		Bedroom standard	Floorspace standard: 40m^2 for the first person, 10m^2 for each additional person
	Deprivation	Below bedroom standard + homeless	Below the floorspace standard + homeless

Fig. 3. Upper and lower thresholds for a sufficiency model of housing.

A household[5] is categorised as "excess" household if it has more housing space than it requires to meet needs and for comfort. But only the housing space not used to meet its housing needs and for comfort is categorised as "excess" space. As a consequence, the share of excess households will be higher than the share of excess housing space. In what follows we take the two perspectives in turn.

4.1. The housing stock perspective

4.1.1. Distribution of the housing stock

The total floorspace available in England in 2019–20 was 2.34 billion square metres. This is then allocated to our three categories – 'meeting needs', 'comfort' and 'excess' – using data on the households occupying each property. For example, in a 120 m^2 house that is occupied by two residents, some of the floorspace is used to meet the housing needs of its residents, another portion is regarded as 'comfort' and another part as 'excess'. Based on the criteria developed in part 3 above, 50 m^2 (40 m^2 + 10 m^2) are used to meet the housing needs of its residents. The excess boundary starts at 100 m^2 (80 m^2 + 20 m^2). Thus, another 50 m^2 are regarded as 'comfort' and the remaining 20 m^2 as 'excess'. In this way, the use of the entire housing stock can be allocated between these three categories. Correspondingly, the distribution of housing can also be calculated using the bedroom standard. Fig. 4 below provides an overview. Refer to the annex for full data.

Based on the floorspace standard, 53 % of the housing stock can be regarded as meeting needs, 31 % as providing comfort space, and 16 % is excess space, either within occupied or second homes. This broadly corresponds to the bedroom standard, according to which 56 % of bedrooms in England are used to meet housing needs and another 25 % are first spare bedrooms, or conventional comfort based on the terminology defined earlier. 19 % are second and further spare bedrooms and bedrooms in second and long-term empty homes.

[5] In England, there are around 1.6 million 'concealed' households (MHCLG, 2020). These are adults who would prefer to live in their own accommodation but cannot afford to and hence share an accommodation with one or more other households. In the EHS these adults are counted as part of the same household. This means that our analysis understates the floorspace (m^2) need of concealed households, which would be higher if they lived in their own accommodation (40m^2 instead of 10m^2 for the first person).

Using either measure the conclusion is clear: the English housing stock is, at an aggregate level, more than adequate for meeting needs and comfort. Excess floorspace and excess bedrooms far exceeds the amount required to meet the housing needs of overcrowded households and the homeless.

The regional distribution of excess bedrooms and floorspace is also important. It might be expected that under-occupied bedrooms will be located in places which lack jobs or other attractions, such as small towns in peripheral regions. However, this is only the case to a limited degree. With the exception of London, all English regions have comparable under-occupied bedrooms per capita. Fig. 5 below shows that under-occupied bedrooms largely follow the population. In London alone, there are nearly enough under-occupied bedrooms (1.05 million) to meet the housing needs of all overcrowded and homeless households in England (1.2 million lacking bedrooms).

4.1.2. Emissions from the UK housing stock

Two sources of carbon emissions from housing can be distinguished:

- Emissions from adding to the housing stock: new construction and improvements
- Emissions from operating the housing stock, including space heating, domestic activities, and maintenance and repairs

The following analysis focuses only on the latter, by far the most important source of total carbon emissions in housing. The UKGBC estimates that embodied carbon from the construction and refurbishment of buildings currently makes up 20 % of UK built environment emissions (Benstead and Wilde, 2023). Serrenho et al. (2019, 272), who have comprehensively modelled potential decarbonisation pathways of the UK housing stock, conclude that "operational emissions are one order of magnitude greater than embodied emissions of new construction". The implication of this is that even if all new construction had net-zero emissions, it would neither resolve the ecological overshoot of the housing sector nor necessarily the meeting of housing needs (Mulheirn, 2019). This suggests that better understanding of the use of and emissions from the existing housing stock should play a more central role.

Our analysis of the operational emissions from the English housing stock is based on the 2019–20 EHS. We calculate emissions using the UK government standard model, which derives a dwelling's operational

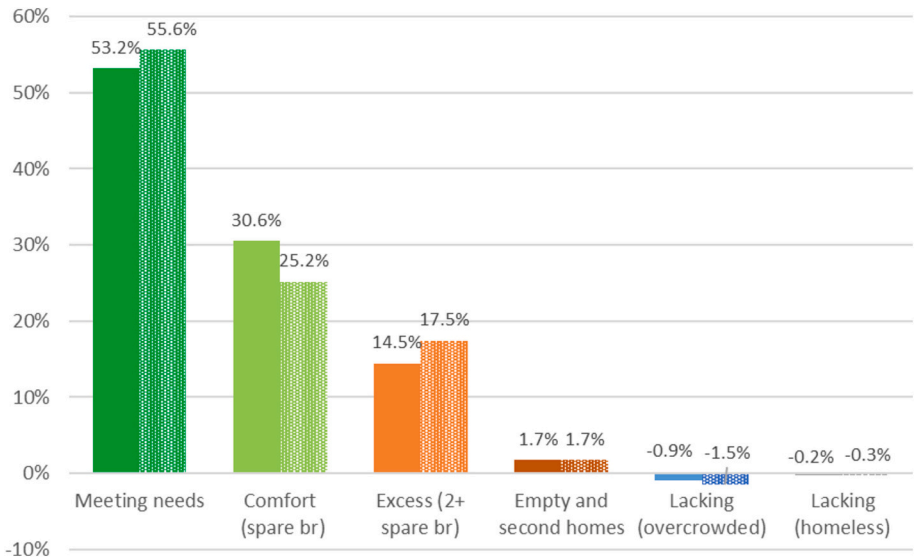

Fig. 4. Distribution of housing stock by use based on floorspace (m^2) standard (solid bars) and bedroom standard (patterned bars).
Source: Own calculations based on EHS 2019–20.

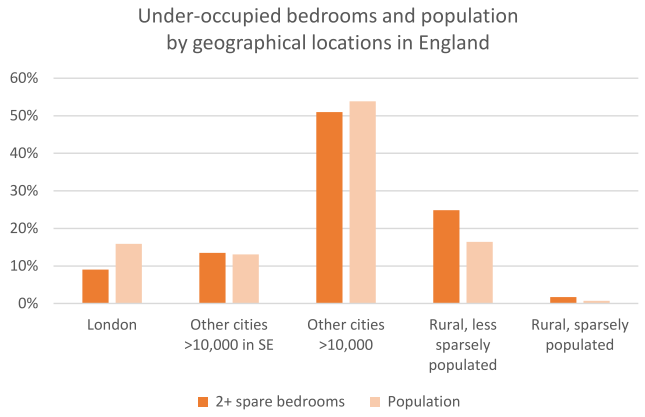

Fig. 5. Under-occupied bedrooms and population by geographical locations in England.
Source: EHS 2019–20. Geographical location as defined by 2011 Census Output Area (COA) rurality classification.

emissions as the product of its EIR (Environmental Impact Rating) and its floorspace (DECC, 2014). This methodology is used by both Serrenho et al., 2019 and zu Ermgassen et al., 2022. The results indicate total carbon emissions from operating the housing stock in *England* in 2019–20 of 61.4 $MtCO_2$. Using a different methodology, but still based on the EHS, the National Housing Federation arrives at a similar figure of 58.5 $MtCO_2$ (NHF, 2021). This estimate is broadly consistent with *UK* residential carbon emissions of 67.7 $MtCO_2$ in 2020 (66.3*0.83 = 55.0 $MtCO_2$) (DBEIS, 2022).[6]

In what follows, we present evidence on the distribution of current housing emissions, using the housing stock perspective above. This means we are showing the excess emissions of households with excess floorspace consumption. Emissions from their floorspace below that level are included in the other categories. We are analysing the average modelled emissions arising from this excess floorspace, not the total domestic emissions of households with excess floorspace. Analogous to this, we calculate the share of emissions stemming from the sufficiency space (below the ceiling and above the floor) and the share of emissions stemming from the space devoted to meeting needs. This will include the emissions of housing that contributes to but does *not* completely meet the space needs of its members. For example, a household that needs 40m^2 to meet needs but only has 39m^2 has all its 39m^2 classed as 'meeting needs'. In this analysis, there is no 'deprivation' category. We cannot say that we 'lack emissions' whereas we can say that we 'lack floorspace'. We are not incurring emissions for floorspace that does not exist, but we could provide this floorspace with emissions.

Fig. 6 shows that 54 % of total housing in-use emissions are incurred to provide necessary levels of housing, and half that again (29 %) to provide 'comfort' levels of housing. But one sixth of the total – 11.7 million tonnes of CO_2 – is emitted from excess housing space including second homes.

The distribution of emissions largely tracks the distribution of floorspace, but not entirely. Fig. 7 below shows the CO_2 emissions per square metre of floorspace in standardised form, with 100 corresponding to the average CO_2 emissions per square metre of the English housing stock (27.1 $kgCO_2/m^2$/year).

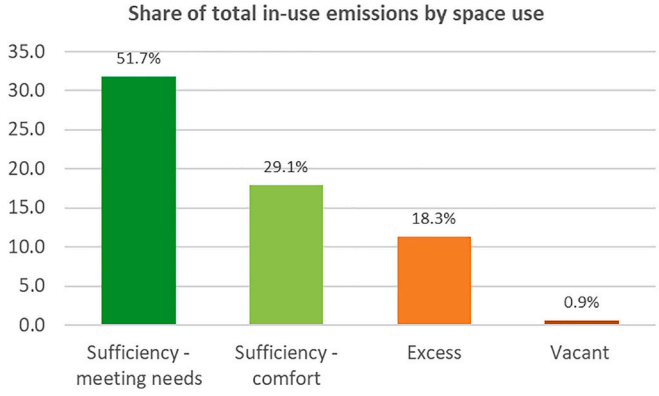

Fig. 6. Summary distribution of total in-use housing emissions by housing sufficiency category.
Note: This assumes that vacant and second homes have the same characteristics of the occupied housing stock, but that emissions are 50 % of the average occupied housing stock, due to only partial use.
Source: Own calculations based on EHS 2019-20 and DECC (2014).

[6] This assumes that carbon emissions per dwelling are similar in all parts of the UK. In 2020, 83 % of all UK dwellings were in England (ONS, 2024).

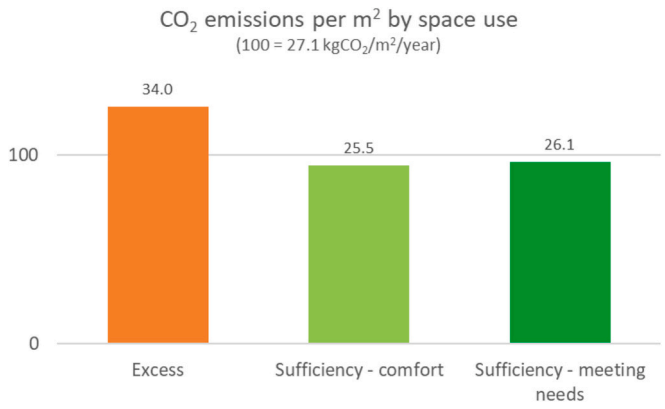

Fig. 7. CO2 emissions per m2 by space use.
Source: Own calculations based on EHS 2019-20 and (DECC, 2014).

The surprising finding here is that excess floorspace has an average emissions intensity 25 % greater than the average. The emissions intensity of needs-based and comfort housing is remarkably similar. This supports the validity of separating off excess from comfort housing. This is surprising and questions arguments that richer households are more able and more likely to invest in energy and emissions saving improvements.

4.2. The household perspective

We now turn to the household perspective. In total there were 24.0 million households in England in 2019–20. Fig. 8 below categorises them into how much space they have their disposal.

In this perspective, housing *deprivation* is lower using the official bedroom standard but quite extensive using the floorspace standard (the official standard for new builds). Deprivation is higher among individuals than households: 8.8 m people, 16 % of the English population, are deprived according to the floorspace standard, compared to 10 % of households (see annex tables). The reason is that space deprived households tend to be larger. This includes the homeless: 95,000 households containing 265,000 persons. While homelessness should not be underestimated, it forms a small proportion of the English population that is bedroom-deprived and floorspace-deprived.

The floorspace standard is more generous than the bedroom standard in defining an *excess* line. Hence, fewer households (30 %) enjoy excess floorspace, compared to more than one third enjoying two or more spare bedrooms (37 %). In addition, 3 % of English households own one or more second homes in England. We assume that these second homes are owned by households that already have excess space in their main home. Thus, the inclusion of vacant homes does not affect the total number of households with excess housing, but it does augment the amount of excess space they enjoy.

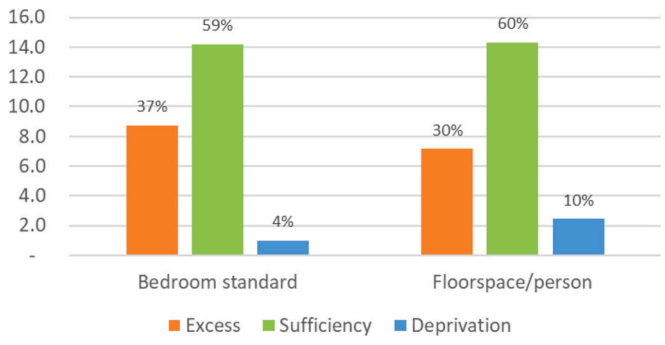

Fig. 8. Households by housing sufficiency category.
Source: Own calculations based on EHS 2019-20.

Housing space distribution diverges notably between households. Fig. 9 below reveals a dramatic contrast between tenure groups. 90 % of households with excess space (both bedrooms and floorspace) are in the owner-occupied sector. Within this tenure, the numbers of excess space in the 'owned outright' tenure group are double those in households with a mortgage. As regards deprivation, the two standards lead to different results. 21 % of private renters are overcrowded based on the floorspace standard, though only 10 % are lacking on the bedroom standard. One fifth of households in the social sector (0.9 m) are space deprived (see annex tables). The data suggests there is little scope for reducing deprivation by reallocating space within the tenure. Any reduction in deprivation through reallocation would need to involve transfer between tenures.

Another factor is the *size and composition* of households, as illustrated in Fig. 10 below. The proportion of households with two or more spare bedrooms is highest among elderly couples, followed by elderly singles and couples under 60 without dependents. Excess floorspace, a higher bar, is equally concentrated in elderly households – singles and couples (see annex tables).

Putting these two variables together, of the 7.2 m households with excess floorspace, the vast majority comprise *older owner-occupiers without mortgage* (3.3 m). The next group are mortgaged couples under 60 with or without dependents (1.3 m), and then mortgaged singles under 60 (0.4 m) – Fig. 11.

4.3. Summary

We have constructed two measures of housing adequacy in England, based on the number of bedrooms and floorspace. Between deprivation and excess, they measure the extent of 'sufficient' housing – a measure based on, but going well beyond, 'meeting needs'. This enables us to define a (generous) limit to bedrooms and floorspace above which housing can be regarded as 'excess'. The two measures result in different proportions of both the housing stock and households defined as deprived, sufficient and in excess. However, they show similar patterns in terms of the tenure and type of households that would likely be affected by any policies to address excess housing and deprivation.

At the most aggregate level, our analysis supports those who argue that there is no gross shortage of housing in England: on both measures, far more households enjoy excess space than those who lack sufficient space. The dominant assumption in much debate that the housing crisis requires a substantial programme of housebuilding to meet needs is not supported at this macro-level of analysis. This conclusion holds at a regional level as well, with the exception of London. As expected, emissions largely track floorspace, though we find that the emissions per square metre of floorspace are *higher* among properties with excess floorspace.

The major contributors to excess emissions and floorspace are elderly owner occupiers, and especially outright elderly owners. At the same time, excess emissions are entirely absent in the social housing sector, both local authority and housing associations. There is a clear contrast here between wants - backed by income - and needs as criteria of housing allocation. These findings pose interesting and difficult issues for policy makers supporting a redistribution strategy. It also influences policymaking in the two other domains central to the fair decarbonisation of housing: retrofitting and newbuild. We turn to these broad policy issues in the next section.

5. Towards a fair decarbonisation of housing

5.1. Distinguishing efficiency and sufficiency

What strategies and policies does a sufficiency framework suggest? It certainly requires a stupendous decarbonisation of the economy – a decoupling of economic output from ecological harms – in this case, greenhouse gas emissions. But it also entails devising and pursuing a

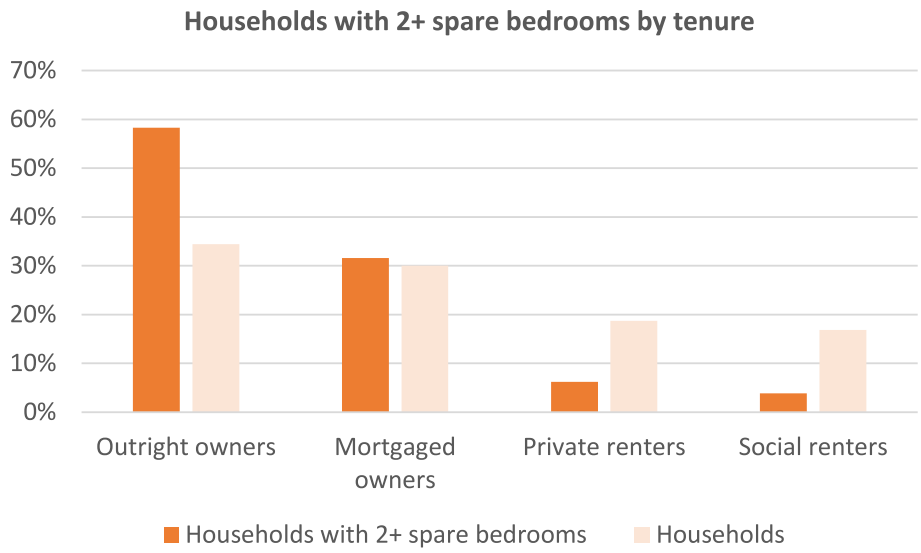

Fig. 9. Households with 2+ spare bedrooms by tenure.
Source: EHS 2019-20.

Fig. 10. Households with 2+ spare bedrooms by household type.
Source: EHS 2019-20.

'corridor' towards a net zero economy, where the floor is an acceptable standard of need satisfaction, and the ceiling ensures a fair restraint on consumption and production. This broader perspective involves questioning and 'recomposing' *what* is produced and consumed (Gough, 2017).

Efficiency and sufficiency are utterly different: efficiency is a means, sufficiency a value goal. The dictionary defines efficiency as "the quality of achieving the largest amount of useful work using as little energy, fuel, effort, etc. as possible" (Cambridge Dictionary, 2024). It says nothing about the end goal: useful for what?[7] Both efficiency and sufficiency are required to fairly decarbonise housing, but sufficiency should take precedence over techno-economic efficiency (Bärnthaler, 2024). However carbon *efficient* the housing stock is made, it will not become more *effective* at delivering sufficient housing to households who need it. The question 'To what end are resources used?' precedes the question of means, i.e. how these resources are utilised to achieve these ends.

Efficiency plays a central, but subordinated role in the sufficiency framework. In the following section, we describe the need for efficiency in a sufficiency framework. Then we discuss how the efficient housing stock might be directed to the goal of housing sufficiency.

5.2. *Efficiency: Retrofitting the existing housing stock*

Decarbonising the UK housing stock is an urgent task. The potential for emissions reduction through such retrofits is very substantial. Yet current policies are woefully inadequate, as argued by Lord Deben, former head of the CCC (Deben and CCC, 2022): "*Reducing energy*

[7] The distinction parallels that between 'formal rationality' and 'substantive rationality', discussed in Wiedenbrüg et al. (2022).

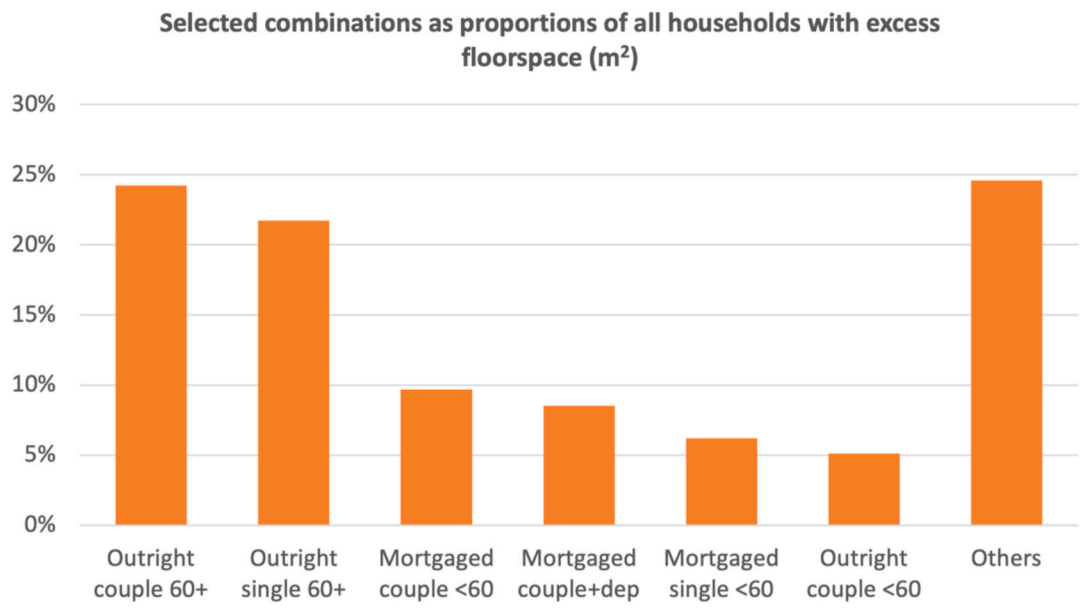

Fig. 11. Selected combinations as proportions of all households with excess floorspace (m^2).
Source: EHS 2019-20.

demand in UK buildings is now the biggest gap in current Government energy policy".

One of the most comprehensive studies of this type to date, zu Ermgassen et al., 2022 find that retrofitting all existing homes to the emissions standards of today's newbuilds by 2035 could avoid 0.8 $GtCO_2e$, equivalent to 32 % of the UK's cumulative carbon budget for 1.5 °C. They model three pathways of which only the third delivers a net zero housing system by 2050. This pathway combines ambitious efficiency – full retrofitting and decarbonisation of the existing stock - with one element of sufficiency - the elimination of vacant and second homes. However, they do not go further to question or model the allocation of the existing housing stock.

Importantly, they do not consider whether or not housing needs are met. This depends on how the decarbonised housing stock is used. If housing needs are not met despite full decarbonisation, there will be political pressure to build more housing to achieve that goal. In practice, energy efficiency improvements are partially, sometimes wholly, offset by higher energy demand resulting from more floorspace (Kopatz 2016; Røpke and Jensen, 2018; Tunstall, 2022).

It is becoming clear that a more interventionist, 'mission-guided', place-based retrofitting strategy is needed, with new forms of targeting, regulation and substantial subsidies (Mazzucato and Farha, 2023). This approach would require upfront public capital spending and a proactive industrial policy. The entire provisioning system needs to be built almost from scratch: a huge collective effort, combining information, training, bulk purchase, new industries, standards, regulation, an overall planning agency, and much more.

The scale of this effort suggests that not all efficiency measures could be done at the same time given real physical constraints in the economy, including skilled labour, reticence to tax other parts of the economy to fund the effort, etc. (Serrenho et al., 2019). Sufficiency principles can guide the prioritisation of efficiency measures. Such a sufficiency focus would provide targeted funding and guidance for housing needs (such as in the 2008 *Warm Front* and *Decent Homes* programmes), while using taxation and regulation to increase the efficiency of excess space. There are efforts in this direction at the local authority level, e.g. in Islington (see Evans et al., 2023). The Labour Party plans an extensive 'home insulation scheme' but planned funding has been sharply reduced (Stacey and Harvey, 2024).

5.3. Specific sufficiency policies

To operationalise the sufficiency strategy in the UK we discuss a series of policy options to ensure that efficient housing stock is used for sufficiency goals, in the following order:

1. Pricing and regulation
2. Policies to better match housing stock and households
3. Shift to more effective tenures

5.3.1. Pricing and regulation

First, alongside the now escalating calls for a fundamental reform of UK property taxation (e.g. Fairer Share, 2024), policies should also discriminate between sufficient and excess housing and target the latter (Cohen, 2019). This could begin with taxing second homes as in Germany's *Zweitwohnungssteuer* (second home tax) (Köpf, 2022) and council tax surcharges for empty homes in Wales (Welsh Government, 2023). In their 2024 manifestos, such measures have been proposed by the Lib Dem party (higher taxes for second homes and holiday lets) and the Green Party (a new second home planning use class) (Green Party, 2024; Liberal Democrats, 2024).

To be effective, taxation would need to extend to under-occupied homes in general. Property taxation guided by sufficiency would give discounts on meeting housing need but levy significant charges on excess space. At the moment, large homes occupied by a single person are taxed at a lower council tax rate. Under-occupation is encouraged by preferential tax treatment of owner-occupied primary residences generally. The exemption of primary residences, independent from size, from capital gains taxes and partially from inheritance tax, incentivises owners to treat spare bedrooms as an investment, rather than investing in productive activities (Ryan-Collins, 2024). This has deeper roots as a lack of adequate public pensions and attractive alternative investments compels households to invest in housing space as 'asset-based welfare' (Doling and Ronald, 2010; Ronald et al., 2017).

This is the same principle as needs-based pricing of domestic energy, where a *rising block tariff* provides a first tranche of energy free or at a low cost, with escalating prices for subsequent tranches of energy. This type of pricing engages with both aspects of sufficiency: depressing overall energy use while ensuring the affordability of necessary energy

(Chapman and Kumar, 2023; Lausberg and Croon, 2023). Applied to housing, this would benefit households with sufficient floorspace, while households with excess housing would experience high cost for operating excess floorspace.

However, the scope to apply taxation and pricing is inherently limited given widening inequality and a high-income elasticity of demand for extra housing space. The higher the level of inequality, the less effective the price mechanism as an allocation mechanism (Weitzman, 1974; Gough, 2017). This was evident for example in German cities, where affluent households have simply paid taxes levied on second homes. Local authorities therefore moved to control second homes through regulation and licensing (Köpf, 2022).

There is growing experience in imposing licensing requirements or outright bans on second homes and holiday rentals in Cornwall, Wales and other locales in Europe. However, it is politically more difficult to apply this approach to excess space within primary residences for various reasons, including the value and longevity of the asset and the intimacy of domestic space (Lage et al., 2023). Another question is how the direct regulation of excess floorspace in existing homes could actually be enforced. Much like pricing, effective enforcement risks regulating people out of their homes. This would undermine other dimensions of housing wellbeing.

5.3.2. *Policies to better match housing stock and households*

The problem of displacement is particularly salient in the case of 'empty-nesters', the older, smaller households who occupy the majority of under-occupied floorspace. Over 65 s are currently far less likely to move home than any other age group (Hudson, 2022). But more than a quarter have expressed a wish to downsize (Cavendish, 2023). To enable this, a joined-up suite of local interventions are needed, embracing information, incentives and, where necessary, provision of alternative housing (e.g. the *OptiWohn* project in four German cities (OptiWohn, 2020)). Immediate relief could be provided by supporting those looking to divide an existing (large) property into two or more separate homes (Kingman, 2016). This would allow older occupants to downsize without the hassle and distress which may result from leaving their neighbourhood and community.

At the other end of the age scale, another element of housing sufficiency would be to halt and perhaps reverse the relentless shift to single-person households. Economies of scale in housing are universally recognised and are incorporated in our space standards. Household members share appliances and equipment, cook together, heat and cool common living spaces, and require less individual living space, saving energy and emissions (Williams, 2007; Ivanova and Büchs, 2020, 2022).

There are many examples and experiments where co-housing projects reduce space consumption while fostering cooperation, care and responsibility and, indeed, wellbeing. In the Hunziker Areal in Zurich, Switzerland, each separate building provides washing rooms and other communal facilities for residents including a library, party room and repair shop. As a result,"the number of rooms per person are limited which leads to a floor space demand of less than 35m^2 on average" (Bierwirth and Thomas, 2019, 36). In the UK, there are currently 19 fully established co-housing communities, mostly self-started by groups of people looking to live sustainably together. Less idealistically, there is also an increasing stock of build to rent blocks with smallish flats and some shared facilities. It is important to ensure that incentives to share do not encourage the involuntary household sharing that is common in the current housing system.

5.3.3. *Shift to more effective housing tenures*

Our analysis in section 4 confirms there are significant differences between housing tenures in how floorspace is used, in particular that social housing allocates floor space according to need rather than market demand.

While household type affects floorspace use (older households account for the majority of excess floorspace), the effect is overruled by tenure: older households who are not owner-occupiers do not account for a disproportionate share of excess floorspace. This suggests that ownership of an appreciating asset incentivises excess space. Given the deficiencies of the UK private rental sector in terms of affordability and security, it is local authorities and housing associations that most effectively deliver housing sufficiency outcomes. Although not separately shown in our high-level data, this sector includes other non-profit tenures such as cooperatives and community land trusts (CLTs).

A key element would be the public acquisition of housing assets that notably conflict with sufficiency objectives, such as vacant and non-decent private rental homes (Diner, 2023). This can involve acquisitions on the open market, rights of first refusal, and, ultimately, compulsory purchase. Once acquired, these housing assets could be retrofitted both physically and institutionally, i.e., energy efficiency and ownership and tenure forms that are less prone to be used for excess housing. An example of public housing acquisition is the extensive use of pre-emptive rights by the city of Paris (Fuller, 2024).

A tenure shift does not exclusively have to lead to council owned and operated housing stock. The city of Barcelona regularly leases land to third parties with specific mandates to deliver, not houses, but housing policy goals (Ajuntament de Barcelona, 2021). From a sufficiency perspective, any *new* construction would be primarily designed to address net population growth, geographical shifts and stock replacement - not to side-step the misallocation of the existing housing stock. For this reason, there is a strong case that *all* new built housing in the UK should be of tenures that more effectively deliver sufficiency outcomes.

6. Discussion and conclusion

We argue that solving the UK housing crisis requires taking a step back and asking what the goal of housing policy is. We propose that the primary goal of UK housing policy should be to meet the housing needs of the population within planetary boundaries. The means that not all housing demand is equal. The distinction between housing need and wants sheds a very different light on the housing sector. While around 55 % of the English housing stock contributes to meeting housing needs and a further 30 % contributes to 'comfort' needs, 15 % is excess space devoted to other preferences. While second homes and homelessness are qualitatively extreme problems at each end of the spectrum, the vast majority of both excess and deprivation occurs within the existing housing stock.

We find that households and individuals enjoying *excess* housing are far more numerous than the numbers in housing deprivation. This inequality incurs an ecological cost alongside the social cost: the extra space at the top of the housing distribution adds to emissions *and* has higher emissions per square metre of floorspace. Today's climate and broader ecological crises are, at their core, distributional crises, where excess and deprivation, overshoot and shortfall, are interconnected (see also Gough, 2017; Büchs et al., 2023).

To achieve the fair decarbonisation of housing in the UK we therefore envisage a 'housing corridor' from where we are now to where we need to be by 2050: an aggregate stock of housing with zero net emissions that provides sufficient housing for all. To do this, we recognise the need for a crash carbon *efficiency* strategy as discussed elsewhere. But we contend that this must be situated within a housing *sufficiency* strategy. The principal reason is that providing efficient housing stock does not alone guarantee that housing needs are met. Efficient housing has to actually be used to meet housing needs. In fact, the continual upsizing of housing at the top would accelerate rising expectations of housing quantity throughout the population. It would be interesting to integrate the efficiency modelling as done by zu Ermgassen et al., 2022 with sufficiency considerations.

We propose a suite of housing sufficiency policies, including taxation and regulation, integrated strategies to encourage and help 'empty nesters' to downsize, and a shift to more effective tenure forms. This would be in addition to a massive improvement of the housing stock via

retrofitting. And finally, a reduced rate of newbuild to what is necessary to meet population growth. These are radical proposals but without them, however carbon *efficient* the housing stock is made, it will not become more *effective* at delivering decent accommodation to households who need it.

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CRediT authorship contribution statement

Stefan Horn: Writing – review & editing, Writing – original draft, Methodology, Investigation, Data curation. **Ian Gough:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Conceptualization. **Charlotte Rogers:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Conceptualization. **Rebecca Tunstall:** Writing – review & editing, Writing – original draft, Investigation.

Declaration of competing interest

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

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ecolecon.2024.108510.

Data availability

Model outputs are provided in annex file.

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