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Housing for millions without new buildings? An analysis of the theoretical housing potential of under-occupied dwellings in the European building stock

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Abstract

The standard response to the shortage of housing across the political spectrum is to build new housing units. From an environmental perspective, there is a need to decarbonise the housing sector as quickly as possible and to reduce land and resource consumption. This contradiction could be resolved by making more efficient use of dwellings that are under-occupied (for example, after children have moved out). In this article, we analyse the theoretical housing potential of under-occupied living space. To this end, we use established occupancy regulations of Swiss cooperatives and municipal housing authorities, where the number of residents must always be at least equal to the number of rooms minus one or minus two. This defines an upper limit for 'needs-based living' that has been tested in practice and is comparatively broadly legitimised. Using this threshold, and based on Data from the EU Statistics on Income and Living Conditions, we identify a theoretical housing potential in the EU stock of approximately 152 million rooms. This implies a theoretical space in the building stock for 50 million additional three-room flats, which equates to housing for 100 million people or 23 % of the EU population. Significant potential exists in all types of regions: cities, towns and rural areas. The under-occupancy is lower in countries with a higher share of small and medium sized flats, which indicates a high influence of the infrastructure on the occupancy. A comparison with the occupancy in Swiss housing markets that have minimum occupancy requirements implemented suggests that a large part of the theoretical potential could be realized by shaping infrastructural and market conditions. We conclude that housing politics should focus on the development of affordable and attractive alternatives for older people and smaller households in order to free up dwellings for families and address social and ecological problems in the housing market simultaneously.

1. Introduction

'The city is built. It does not need to be built anew, but rebuilt' [1]. With these often-quoted words, Zurich city councillor Ursula Koch in 1988 formulated an almost revolutionary imperative for urban design to focus more on existing buildings and targeted infill development.

From an ecological perspective, this statement is more relevant today than ever before. With the widespread demand for new construction, Koch's insistence on rebuilding rather than building remains almost as radical as it was in 1988. Between 2000 and 2015, over 270 hectares of land were developed daily in the EU-27 [2]. The construction sector accounts for 5 %–12 % of CO_2 emissions—excluding the use

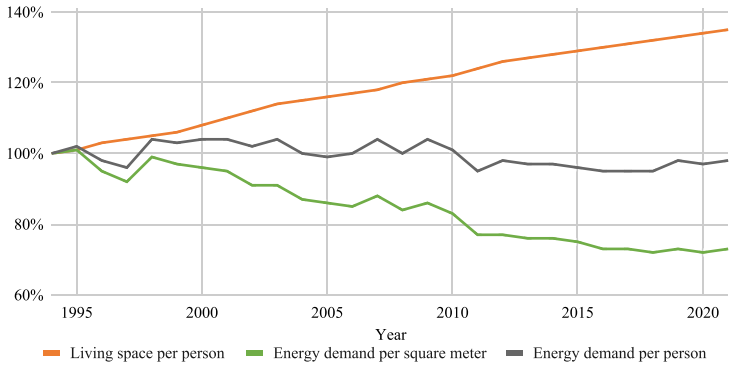

Figure 1. Energy efficiency, average living space and resulting final energy demand of residential buildings for space heating (with climate corrections) in 14 EU-member states (BG, HR, CZ, DK, FI, FR, DE, GR, HU, IT, PL, RO, ES, SE; selection due to data availability), Data [9].

phase of new buildings—and approximately 50 % of all extracted materials [3] and 37 % of waste in the EU [4], making it a major contributor to environmental damage.

Current approaches to ecological and social problems in the housing sector play out in contradictory ways. The environmental impact of new construction is often disregarded by key actors, from the EU Commissioner for Human Rights [5] to social organisations [6] to the construction industry [7], who frequently present new construction as the primary or sole solution to social problems like housing shortages, rising rents and property prices. Ecological problems are tackled primarily through technical measures aimed at improving building efficiency or circularity, for example [8]. However, the continued growth in living space offsets historical efficiency gains in space heating, limiting the ecological effects of these approaches (figure 1, [9, 10]). Technical measures also increase costs, thus exacerbating or even deliberately intensifying gentrification processes [11].

Indeed, numerous studies show that stabilising or reducing average per capita living space in the Global North is essential to achieving climate, land, and resource conservation goals, and that technical measures like improved insulation or increased use of renewable energy alone are insufficient [12–16]. Increasingly, climate neutrality scenarios and prospective analyses of the decarbonisation of the building sector stress the stabilisation or reduction of living space [2, 17–20].

Efficient use of the housing stock is crucial to stabilise the living space per capita while reducing housing shortages [15, 21, 22]. This means to address 'under-occupancy' of dwellings, particularly among older people who remain in relatively large homes after their children or partners have moved out [23]—a situation that some report as burdensome due to the work required to maintain oversized spaces or the loneliness such space can evoke [24, 25]. Thus, a reduction in under-occupancy is also partly perceived as a benefit and needs-based housing provision [26–30].

Recent research has increasingly focused on the growth of living space per capita and measures to stabilise or reduce it [21, 22, 31–36]. Yet the quantitative potential of using existing housing stock more efficiently as a solution to social and environmental problems, which is important to assess its relevance, has scarcely been addressed.

To fill this gap, the current article analyses the theoretical potential of under-occupied housing in EU member states, with 'theoretical potential' referring to the total number of under-occupied rooms, regardless of the technical, social or economic feasibility of achieving its occupation [37, 38]. Defining a needs-based and practical limit for under-occupancy, as developed in section 2, is essential to this analysis.

2. Theory: needs-based housing

2.1. Determining a legitimate limit for maximum housing consumption

The perception of what constitutes 'too much' (or, conversely, 'sufficient') housing depends heavily on historically and spatially specific social contexts. Brand *et al* describe 'societal self-limitation' [39] as a complex but necessary societal task, one ideally forged through societal debate over the need to self-limit as a 'substantial condition for a good life for all' and thus as a cultural and political model. At present, discussions about social self-limitation in relation to living space consumption face strong political resistance (see, for example [40]) accompanied by fears and conflicts about de-privileging [41]. Because privileges often are not perceived as such due to their social normalisation, efforts to de-privilege can be viewed as unfair by the people affected [42].

Consequently, for our analysis it would be best to use a threshold that is already used as an upper limit for living space consumption, that is socially

and politically as established as possible, that was co-developed together with those affected, and that is perceived by them as fair and therefore legitimate. At least in its specific social context, such a 'real-world' threshold is perceived as a rather reasonable standard to satisfy housing needs. Legitimacy theory refers to this concept as 'output legitimacy', where decisions are viewed as legitimate if they are made 'for the people' and their effects are seen as positive and just [43].

Because of its theoretical nature, statistical thresholds, such as the definition of overcrowding used by Eurostat and many national statistical offices, or other thresholds developed purely in scientific context [44, 45], are less suitable parameters for estimating housing potential within the existing housing stock. They are not implemented in any constituency in form of a collective self-limitation, and it is unclear to what extent they would be recognised as a legitimate political threshold.

As a political limit, thresholds for excessive housing consumption are set, for example, through social legislation and cooperative or public housing policies. Many European countries limit the size of dwellings for those moving into subsidised housing (object subsidy) or when the state covers housing costs (subject subsidy). However, these criteria apply only to low-income households receiving state subsidies. Their legitimacy is primarily based on preventing the wasteful use of public funds, rather than distributing housing in ways perceived as fair by those affected [46]. Consequently, it is unlikely that these thresholds would be accepted as legitimate outside of social housing contexts.

The situation differs in Switzerland, where minimum occupancy requirements for cooperative and public housing dwellings are based on the number of rooms, or in rare occasions on the living space, or a combination of both criteria [47]. Unlike the rules for state-subsidised social housing, these occupancy requirements apply to all residents regardless of income, and cooperatives house mainly people from the middle class, but also from the upper middle and upper classes [48]. In contrast to parts of the Soviet Union, where rules of 'needs-based' housing distribution also existed, Switzerland is broadly similar to other contemporary European societies with equivalent political, economic and socio-cultural conditions.

Central to their effectiveness as a threshold for 'needs-based' housing provision is that the occupancy requirements are developed in the cooperatives themselves as a collective self-limitation on members and introduced via a bottom-up process [47]. Their effects on housing distribution are seen as fair, needs-based and therefore legitimate (output legitimacy). In the actual implementation, this legitimacy is strengthened by democratic decision-making procedures ('input legitimacy' [43]; and 'throughput legitimacy' [49]).

Occupancy requirements are relatively common in Switzerland: they apply to almost 70% of all dwellings of housing cooperatives and to municipal dwellings in cities such as Zurich and Bern [47, 50, 51]. For municipal dwellings in Zurich, the regulations were introduced in 2016 by unanimous decision of the city council, with the living space limit being largely uncontroversial across all political parties, and approved by the Swiss Federal Court when two lawsuits were filed against the policy. (BGE, 4A_82/2024, BGE, 4A_105/2024) [52].

However, the transferability to other countries and markets beyond the so-called 'non-profit' housing market—consisting mainly of cooperatives and state-owned housing—is limited. In this segment, where housing is not subsidised but rented at cost and is therefore not profit-oriented, community-oriented values and issues of social justice are much more important than in the private housing market [53]. In the private sector, individual consumer freedom is more highly valued, which means that such restrictions, and state intervention in particular, are considered less legitimate [54–56].

However, while Swiss occupancy requirements do not represent a universally applicable policy in the short term, their proven effectiveness, democratic character, and relatively widespread application and effects make them suitable as a model for societal self-limitation in the sense of a 'societal boundary' [39].

2.2. Occupancy requirements in Switzerland: number of rooms minus one

Although occupancy requirements vary by cooperative and municipality, the most common rule is that the minimum number of occupants must always be equal to the number of rooms minus one (excluding bathroom and kitchen) [47]. Thus, a five-room flat must always be occupied by at least four people. If this is no longer the case (for example because the children have moved out), the remaining residents must move into a smaller flat or find new flatmates. As a rule, the housing provider is obliged to offer usually two to four suitable alternative flats, depending on the statutes. If no such flat is available, the residents of the oversized flat may remain there until a suitable flat can be offered. Additional measures are often in place to mitigate the social impact of the measure [47].

3. Methods and material

3.1. Potential analysis

Potential analyses can be categorised according to the extent of the potential being realised. This categorisation is not always consistent, but distinctions are often made between theoretical, technical, economic and practical or achievable potential [37]. Theoretical potential is the largest category, as it does not consider feasibility limits and is used to assess the relevance of a topic [37, 38]. To estimate potentials that can

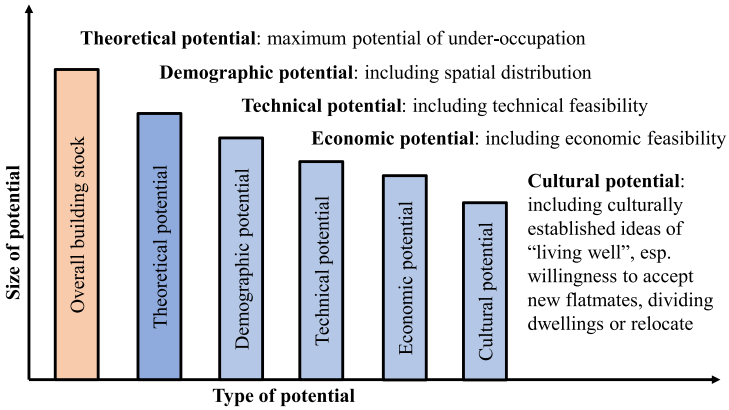

Figure 2. Own depiction, based on [38]. Adapted from [38]. © 2017 Elsevier Ltd.

be realised, restrictive framework conditions must be included in the potential analysis [57, 58]. For living space, these conditions include demographic and cultural barriers in addition to the usual technical and economic hurdles (figure 2 and section discussion).

In this article, we estimate the theoretical potential of under-occupancy in EU buildings, breaking it down by EU member state, type of ownership, degree of urbanisation, household-equivalised income quintiles and different household types [59]. This provides a first contribution to differentiating the theoretical potential.

3.2. EU-SILC data

The estimation requires data on both dwelling size and the number of household members. Published macro-data cannot provide this information. We therefore use the 'European Union Statistics on Income and Living Conditions (EU-SILC)' microdata survey on persons and households, as it contains household-specific data on the number of occupants and rooms [59]. People who usually reside together and share income or household expenses with the other household members are counted as one household (for full definition see [59, p 36]). Rooms must be at least four square meters large and intended for dwelling purposes, in order to be counted as such. Bathrooms, toilets, kitchens used only for cooking, corridors etc. are not counted as rooms ([59, p 114]).

The EU-SILC microdata contains weights that allow an upscaling of the representative sample to the total population. Because EU-SILC data is collected using a standardised procedure, it is comparable across countries. EU-SILC data are collected by National Statistical Institutes. The EU-SILC Regulation allows some degree of flexibility to countries regarding the mode of data collection. The information can be either extracted from registers or collected from interviews. The comparability in EU-SILC data is ensured by the conceptual harmonisation of target variables obtained through their detailed definition (income components etc) as provided in EU-SILC regulations and through the active role of Eurostat coordinating and supporting implementation. The sample sizes underlying the statistical analysis range between 107 786 (2004) and 278 872 (2022) observations in the EU, reflecting the increasing number of countries over time in which data is collected. A comparison of weight sums against official national and Eurostat population statistics revealed only marginal deviations. Table 1 gives an overview of some of the metadata of the population.

The EU SILC data has country-specific data limitations that affect our analysis options. Data collection started in different years: 2004 (AT, BE, DK, EE, EL, ES, FI, FR, IE, IT, LU, PT, SE), 2005 (CZ, CY, DE, HU, LT, LV, NL, PL, SI, SK), 2007 (BG, MT, RO) and 2010 (HR). For historical developments, national data for respective first available years are presented.

For 2022, the new urbanisation category of 'towns and suburbs' is (still) included in the category 'cities' for Germany, Estonia and Latvia. Additionally, the Netherlands and Slovenia do not provide any urbanisation variable. Consequently, the respective analyses and outputs were not possible for these countries.

3.3. Data analysis

We analyse the microdata in terms of under-occupancy per household. According to the above rules, a dwelling qualifies as

$$\textit{Under}-\textit{occupied: If the}$$
$$\textit{number of household members} < \textit{number of rooms} - 1$$
$$\textit{Severely under}-\textit{occupied: If the}$$
$$\textit{number of household members} < \textit{number of rooms} - 2$$

Based on the microdata, we calculate the theoretical potential as the number of under-occupied rooms using the thresholds '$n - 1$' and '$n - 2$'. The weights included in the dataset are used to estimate the total potential for each EU member state.

Table 1. Population metadata derived from EU-SILC.

	Average age	Population	Average size of household	Average number of rooms per dwelling	Average disposable household income	Share of households living in cities	Share of households living in towns	Share of households living in rural areas
AT	48	8.882.724	2,2	3,4	30.719	0,34	0,31	0,35
BE	48	11.458.627	2,3	4,5	28.554	0,31	0,54	0,14
BG	50	6.851.448	2,3	3,0	6.601	0,46	0,24	0,30
CY	46	901.042	2,6	5,0	20.630	0,63	0,20	0,18
CZ	49	10.261.354	2,3	3,5	13.086	0,33	0,33	0,34
DE	50	82.145.880	2,0	3,5	27.948	0,81		0,19
DK	48	5.828.848	2,0	3,7	34.954	0,39	0,29	0,32
EE	49	1.318.753	2,1	3,4	15.540	0,66		0,34
EL	51	10.339.444	2,6	3,2	10.812	0,41	0,30	0,29
ES	49	46.876.480	2,5	4,7	19.290	0,55	0,31	0,14
FI	50	5.468.258	1,9	3,6	27.980	0,42	0,33	0,25
FR	50	66.051.356	2,2	3,9	25.844	0,38	0,30	0,32
HR	50	3.784.997	2,7	3,3	9.053	0,34	0,31	0,34
HU	49	9.528.568	2,3	3,6	7.662	0,39	0,32	0,29
IE	46	5.060.029	2,6	5,0	32.337	0,37	0,24	0,38
IT	51	58.671.220	2,2	3,2	21.220	0,36	0,46	0,18
LT	50	2.805.978	2,0	3,2	11.892	0,43	0,15	0,43
LU	46	623.132	2,3	4,4	51.334	0,22	0,46	0,32
LV	50	1.854.357	2,2	2,7	11.271	0,68		0,32
MT		509.412	2,4	5,1	20.470	0,51	0,46	0,03
NL	48	17.328.144	2,1	4,3	29.426			
PL	48	36.856.608	2,9	3,2	9.912	0,41	0,28	0,31
PT	51	10.352.009	2,5	4,2	13.539	0,47	0,30	0,23
RO	48	18.970.604	2,5	2,9	6.151	0,33	0,27	0,40
SE	48	10.485.537	2,0	3,4	28.016	0,41	0,39	0,19
SI	49	2.079.493	2,4	3,9	16.846			
SK	48	5.376.654	3,1	3,5	9.297	0,24	0,33	0,43

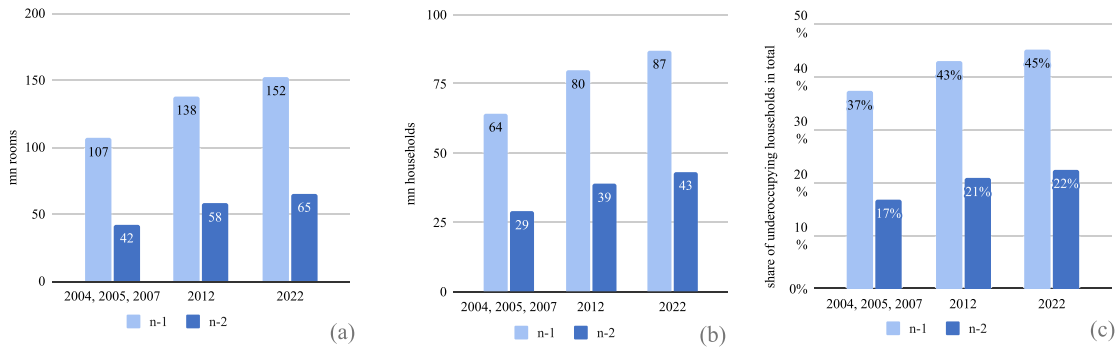

Figure 3. Number of under-occupied rooms (a) and under-occupying households (b) and share of under-occupying households of total households (c), according to definitions of n − 1 (under-occupancy) or n − 2 (severe under-occupancy).

Microdata processing and data cleaning are carried out using STATA.

Since the largest category comprises 'six or more rooms', it is simplified in the calculation as six rooms. This makes the actual theoretical potential higher than our estimation. Half rooms are rounded down according to the rule used in Switzerland; all other decimals, which occur occasionally in some countries in cases where several households share rooms [59], are rounded in the usual way.

4. Results

4.1. Under-occupancy by room and household

In the EU, approximately 152 million rooms (n − 2: 65 million) are under-occupied according to the minimum occupancy criteria of 'number of rooms minus one', and this number has increased by approximately 45 million rooms (n − 2: 23 million) in the 15–18 years since the first available data (figure 3(a)). Over the same period, the number of households with under-occupancy increased by approximately 23 million (n − 2: 14 million) (figure 3(b)), increasing the share by eight percentage points to 45% of all households in 2022 (figure 3(c)).

Most under-occupied rooms are found in one-person households (49%, n − 2: 54 %) and two-person households (38 %, n − 2: 39 %). These also represent the largest share of all under-occupied households, more than 50 % of which are under-occupied (figures 4(a), (c) and (e)). Although the number of under-occupied rooms increases with the size of the dwelling (figure 4(b)), under-occupying households are fairly evenly spread across all dwelling sizes (figure 4(d)). This means that a smaller proportion of households in larger dwellings are responsible for a larger proportion of unoccupied rooms and vice versa. Accordingly, well over half of all four-room dwellings (59 %, n − 2: 26 %), five-room dwellings (72 %, n − 2: 53 %) and ⩾six-room dwellings (86%, n − 2: 65 %) are under-occupied (figure 4(f)).

The country comparison shows that the number of unoccupied rooms and households depends on a country's population size (figure 5, columns). In a notable deviation from EU trends, 10 south-eastern European countries have more (BG, EE, EL, HR, HU, IT, LT, LV, RO) or only slightly less (CZ) under-occupied rooms in medium-sized dwellings (three and four rooms) than in larger dwellings (five, six or more rooms) (figure 6), even though the proportion of under-occupying households increases with the size of the dwelling in all EU member states. This is partly due to the existing housing stock in these 10 countries, which have the highest proportion of medium to large dwellings out of all the countries evaluated (figure 7).

The influence of the housing stock is also evident in the share of under-occupying households in all households, as the 11 countries with shares below 40 % are among the 13 countries with the highest share of medium to large dwellings (figure 5, markers, figure 7). The four countries with the lowest proportions of medium to large dwellings have particularly high proportions of under-occupying households, which exceed 70 %.

If it were possible to convert under-occupied rooms into three-room dwellings—which are in high demand due to demographic change—a minimum occupancy rate of the room number minus one would create a theoretical housing potential for at least 100 million people, equivalent to 23 % of the current EU population (figure 8). Again, the influence of the building stock is evident: Countries with a below-average housing potential relative to their population size are the ones with an above-average share of medium (compared to large) dwellings.

For the 23 EU countries with available new construction data for 2022, this potential within the existing housing stock is equivalent to 31 times the annual new construction rate (figure 9, [60–71]). Spain, in particular, has relatively low new construction figures.

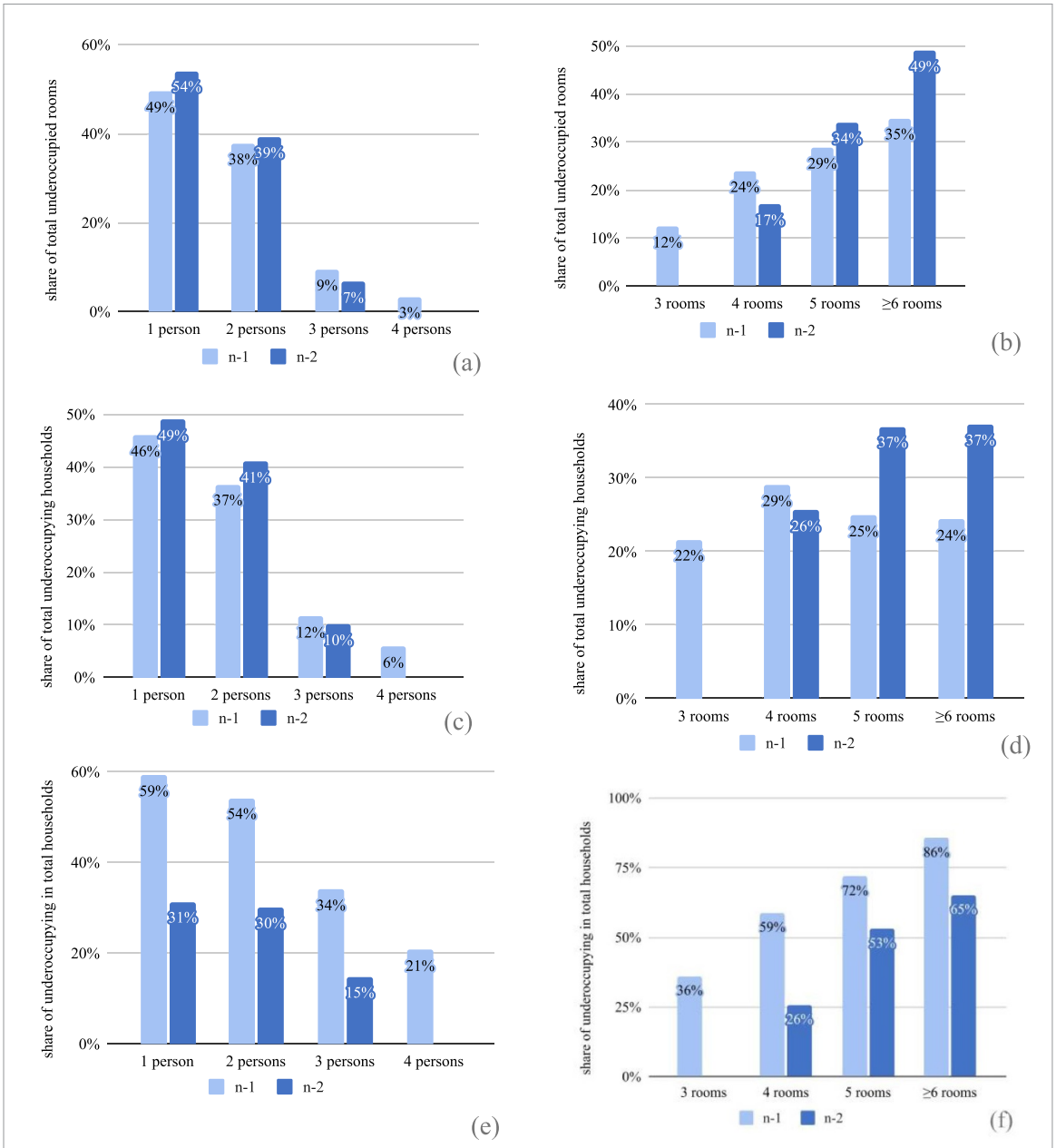

Figure 4. Distribution of under-occupied rooms (a), (b), under-occupying households (c), (d) and share of under-occupying households (e), (f) by household size (a), (c), (e) and dwelling size (b), (d), (f).

4.2. Type of ownership

Most under-occupied rooms (79 %) and under-occupying households (76 %) are found in owner-occupied dwellings. This goes hand in hand with a higher total number of households and rooms, a higher number of under-occupied rooms per under-occupied household (owned: 1.82, rented: 1.53), and a higher proportion of under-occupied households in the owner-occupied segment (52%, rented: 32 %).

In Slovakia, Sweden, Finland, Germany and France, the proportion of under-occupied rooms in the owner-occupied sector is almost or more than twice as high as in the rented segment, while in the Netherlands, Cyprus, Malta and Estonia, the proportion is higher in the rented segment than in the owner-occupied segment (figure 10).

4.3. Degree of urbanisation

Within the EU, 41 % of under-occupied dwellings are located in cities, and approximately 30 % each in rural regions and towns (figure 11). In cases of severe under-occupancy ($n-2$), the proportion shifts slightly from cities to rural regions. With a few exceptions, the proportion of under-occupied rooms as a percentage of all rooms in the respective regions increases slightly with decreasing urbanisation (EU: cities 19 %, towns 22 %, rural 24 %).

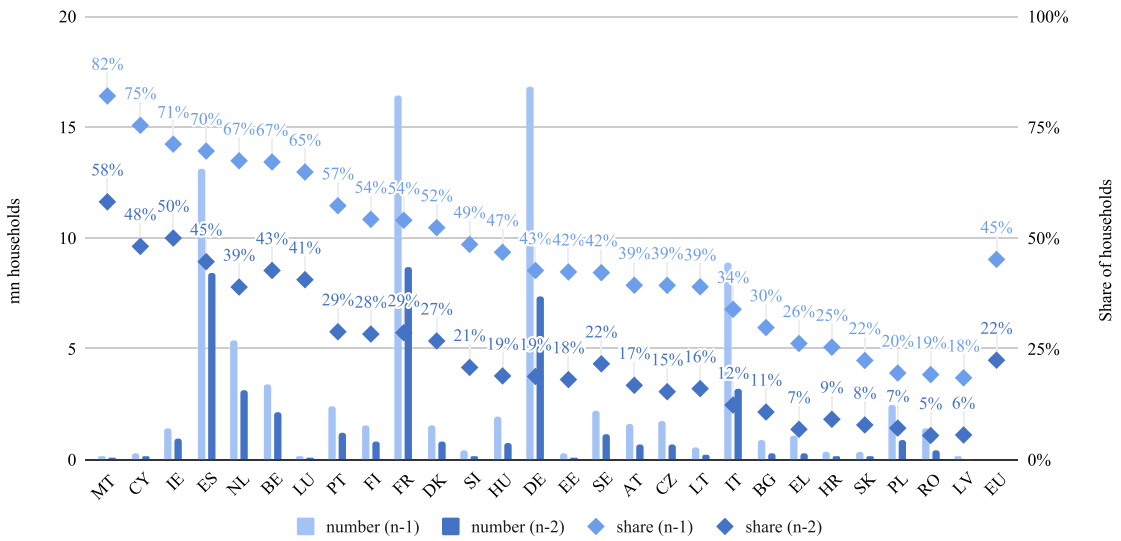

Figure 5. Under-occupying households as total number (bars in mn, left) and share in total number of households (markers in %, right axis) in 2022.

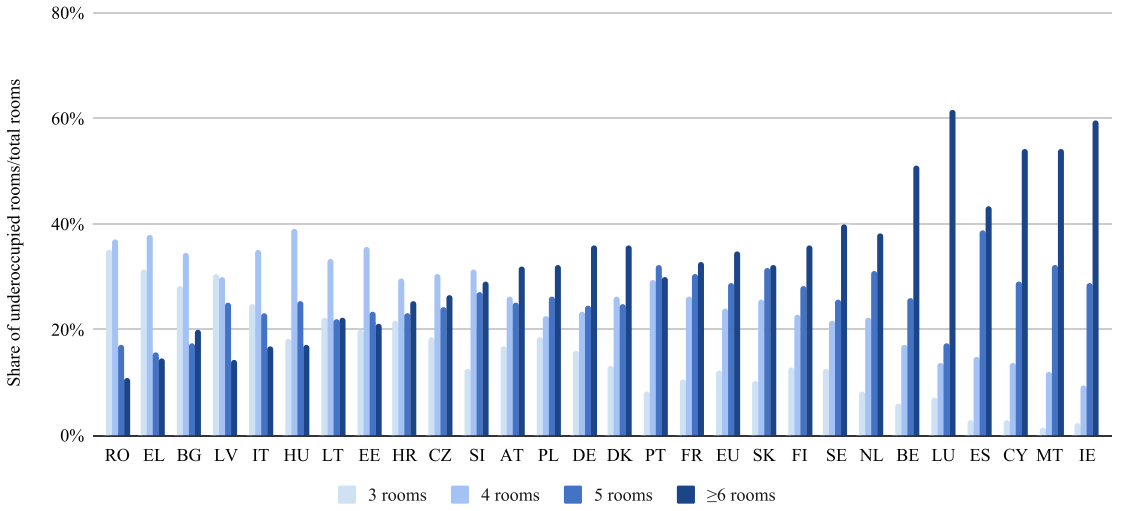

Figure 6. Distribution of under-occupied rooms by dwelling size and EU-member state in 2022 (n − 1), ordered by difference between small dwellings (3 and 4 rooms) and medium sized dwellings (5 and 6+ rooms).

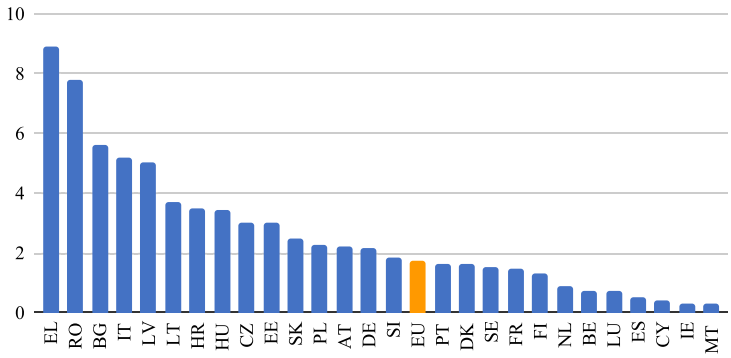

Figure 7. Theoretical minimum housing potential in three-room-apartments in the existing building stock in mn new occupants (bars, left axis) and share of population (markers, right axis), by EU member state.

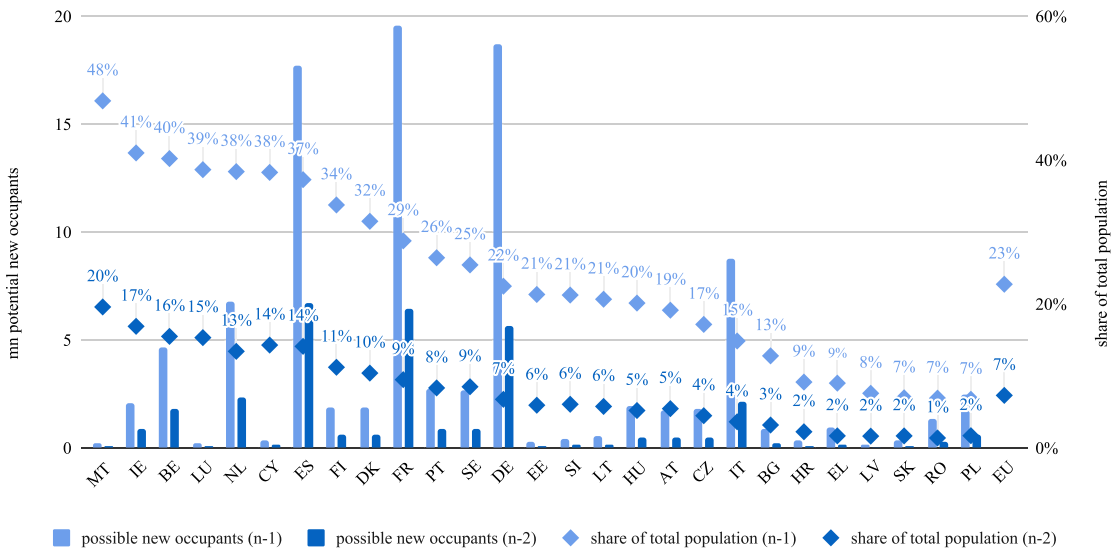

Figure 8. Theoretical potential for additional 3-room apartments in under-occupied building stock vs. mn new construction in 23 EU member states in 2022. New construction data sources [60–71].

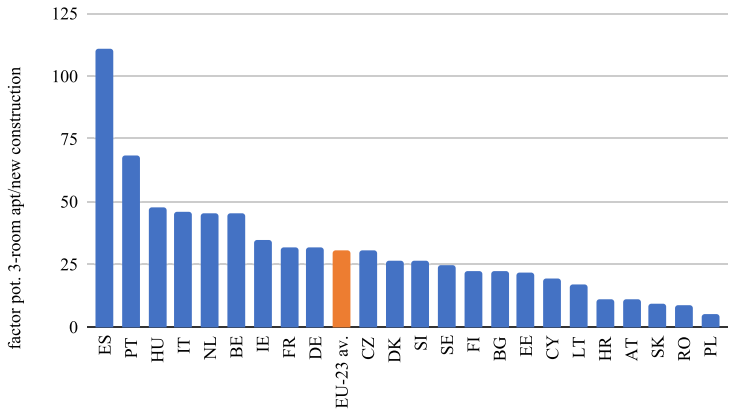

Figure 9. Factor of medium-sized apartments (three or four rooms) to large apartments (five, six or more rooms).

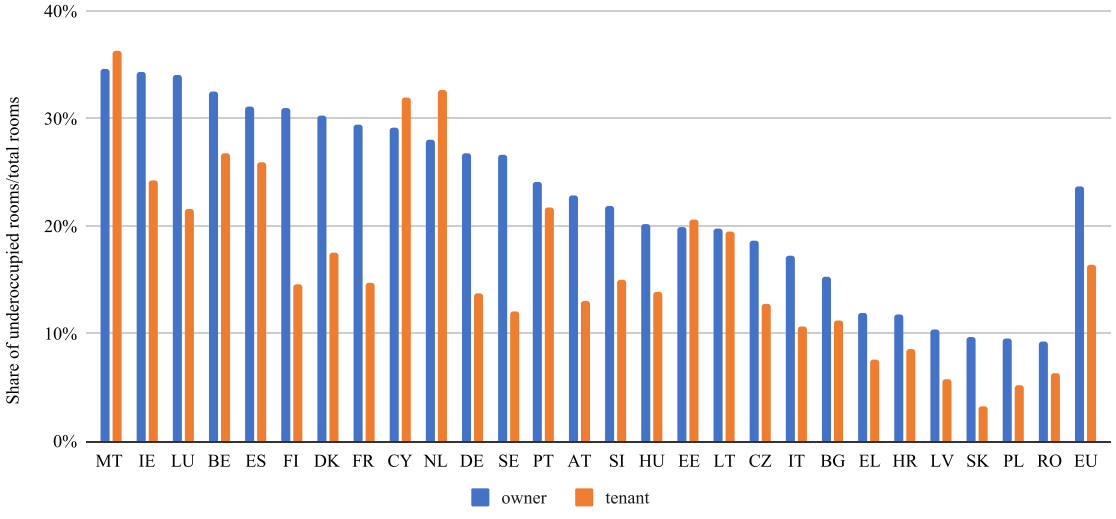

Figure 10. Share of under-occupied rooms within ownership segments (n − 1).

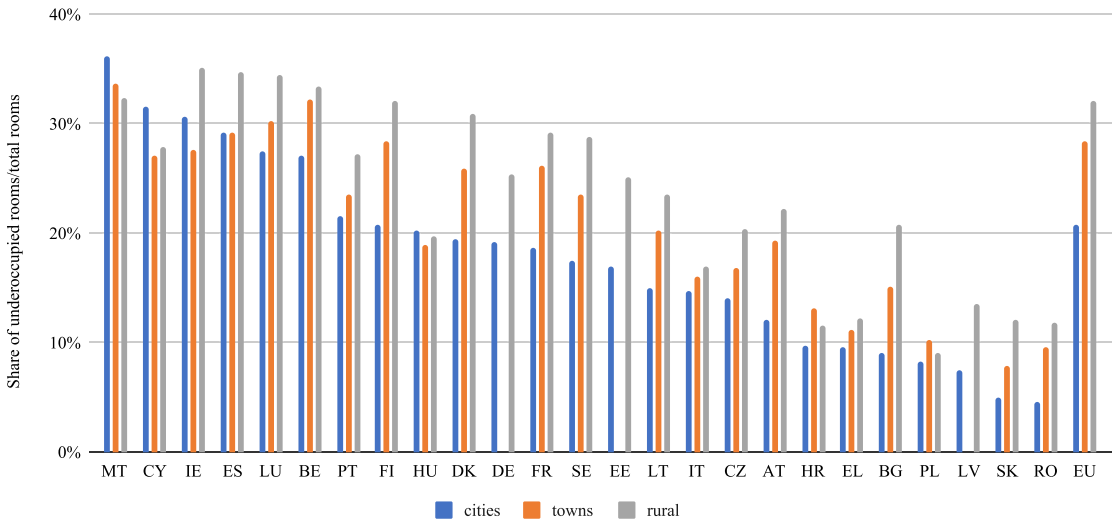

Figure 11. Share of under-occupied rooms in cities, towns and rural areas (n − 1).

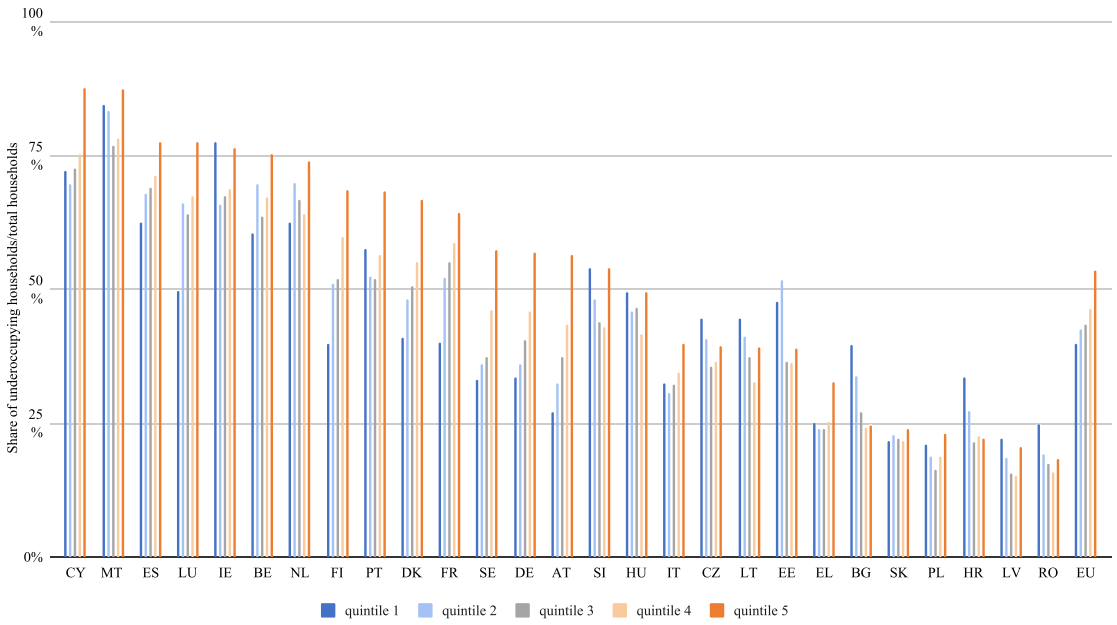

Figure 12. Share of under-occupying households within equivalised income quintiles (n − 1).

4.4. Equivalised household income

In most countries and in EU-average, households with higher equivalised household income are more likely under-occupying and are responsible for a higher share of under-occupied rooms (figure 12). However, in Bulgaria, Croatia, Estonia, Romania, Czechia, Lithuania, Latvia and Slovenia the share of under-occupying households of the two lowest income quintiles is higher than the share of the two highest income quintiles.

4.5. Household types

Differentiating the under-occupying households by different household types shows that the share of under-occupying households is generally higher for households without children (figure 13). For two-persons households, this share increases with the age of the household members. In 11 countries, more than 75 % of all one-person households and/or two-person households without children and at least one household member above 65 years are

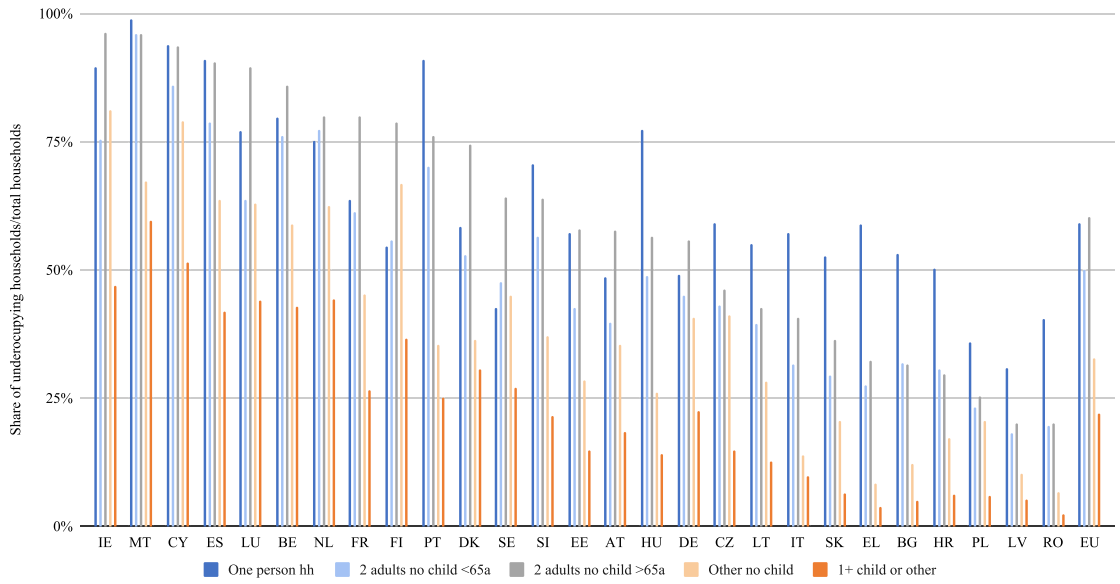

Figure 13. Share of under-occupying households within different household types (n — 1).

under-occupying, in 24 countries, at least one of these shares is above 50 %.

5. Discussion

5.1. Large potential even in urban areas

The results show a significant theoretical potential for housing from under-occupancy of existing dwellings, which is likely to be even higher due to methodological limitations. Despite the worsening housing crisis in recent years, this potential has increased during the period under review. Although it is less pronounced in some south-eastern European countries, this potential exists in all EU member states—both in rented dwellings and, to an even greater extent, in owner-occupied dwellings. Under-occupancy highly depends on the household composition; households without children and with older household members under-occupy much more often than families. The relation of under-occupancy and income differs among the countries, and seems not to be as influential as the household type and needs further in-depth analysis. The fact that under-occupied rooms can be found in rural areas, towns and cities suggest that the theoretical potential is not only found in shrinking and less populated regions, but also in growing and metropolitan areas, and thus where housing is urgently needed.

5.2. Obstacles to realising the potential of under-occupied housing

Since the under-occupied rooms are located in occupied dwellings, they could be utilized by bringing in additional flatmates, separating dwellings into smaller units, or through an exchange, i.e. by moving the occupants into smaller dwellings and moving a larger household into the vacated space. Nevertheless, the realisation of the theoretical potential is constrained by demographic, technical, economic and cultural barriers and needs significant changes in political framework conditions.

First, demographic trends limit the potential usability of under-occupied rooms, as some of the under-occupied dwellings are located in regions with shrinking populations. In these areas, there might be not enough demand for additional housing, regardless of how the space is made available. However, one third of the total built-up land expansion between 2000 and 2015 in EU27 took place in shrinking regions [2]. This land expansion could be avoided by exploiting the potential of the existing building stock.

Second, technical conditions also limit the potential, as the layout of flats may not be easily suitable for living with strangers, or for conversion or division into smaller flats [22, 72]. The supply of small flats for relocation may also be insufficient [15, 73].

Third, economical constraints mean that functional co-housing models like 'homesharing' schemes are unattractive in some countries from a tax and legal perspective [36]. The conversion of existing housing is often complicated by a plethora of building regulations, making new construction the cheaper option in some cases [74, 75]. Additionally, moving to a smaller flat is often not economically attractive or viable due to significantly higher prices per square metre, especially in comparison to those of a fully paid-off owned property [15, 27, 73].

Fourth, cultural barriers can also limit the potential usability of under-occupied housing in various ways. Moving in with new, often unfamiliar flatmates and adapting one's living space to fit with a

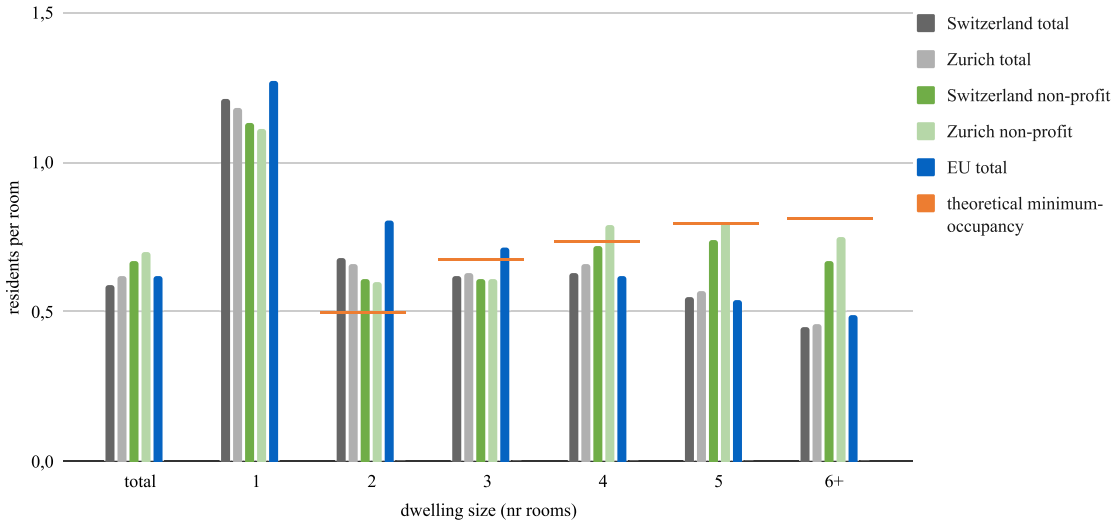

Figure 14. Residents per room in all dwellings ('total') and in non-profit housing market that have implemented occupancy requirements to a large share. Data: [73, 85] own depiction.

shrinking household size by flatsharing or downsizing are not widely established cultural practices. On the contrary, occupying one's own large flat sometimes functions as a status symbol [54, 76], although many people express the desire to downsize [25, 29, 30, 57, 77]. These studies also show that the share of people willing to downsize would foreseeably increase, if such an adjustment were culturally normalised and more strongly encouraged by structural and economic frameworks.

As the Swiss experience with occupancy requirements in cooperative and state-owned housing shows, these restrictive barriers—especially the technical, economic and cultural ones—can be shaped politically. The political shaping of the conditions needed to successfully realise the potential of privately-owned housing is more challenging; however, numerous policy proposals designed to increase and exploit this potential for different target groups exist [22, 34, 78, 79]. Some of these measures have also been recommended for policy implementation by national citizens' assemblies, indicating possible acceptance [80].

5.3. Institutional framework conditions are crucial for realising high share of theoretical potential

Further research and political experiments are needed to estimate how much of this potential can be realised. However, the comparison of the non-profit housing markets in Switzerland and the canton Zurich—which have minimum occupancy requirements in place for 70 % (Switzerland) [47] and 85 % (agglomeration Zurich) [81] of their dwellings—with the average housing markets in these regions, suggests that a high share of the potential could be realised if the right framework conditions are established (figure 14, [59, 82]). In the non-profit housing market, the average number of residents per room in small dwellings (one- and two-rooms) for which the occupancy requirement ($n-1$) does not apply, is lower than in the whole housing markets. This indicates less *over*-occupancy in the non-profit sector. The number of residents per room rises with the size of the dwelling for the non-profit sector, being close to the theoretical minimum-occupancy.

This is contrary for the entire housing sector, where the number of residents per room increase with the size of the dwelling. The occupancy-gap is much higher between the two types of housing market than between the regions, which suggests that the under-occupancy is a result of the institutional framework conditions rather than the geographical allocation. This is further supported by the trend in living space per capita in selected fast-growing metropolitan areas, such as Berlin, Hamburg, Munich, Zurich and Vienna, which has not decreased on average despite the acute housing shortage, but has actually risen in the last 30 years [83–85]. The lack of housing for some is therefore not primarily due to an overall housing shortage or geographical mismatch, but rather due to its inefficient distribution among different societal groups. If the occupancy in the whole housing sector could be developed in a similar way as the non-profit housing market in Zurich or Switzerland, a high share of the theoretical potential could be realised.

The high level of under-occupancy, especially in large dwellings, and the clear influence of the housing stock on under-occupancy that emerges from cross-country comparison, highlight the urgent need to convert the existing housing stock into smaller units in order to reconcile environmental and social challenges.

5.4. Limitations and further research

In addition to the limitations mentioned in section 5.2 regarding the realisation of the theoretical

potential of under-occupied housing stock (which also limit the interpretation of the results), there is a methodological limitation. As the EU-SILC data combines dwelling sizes with more than six rooms in the six-room category, first, it was not possible to calculate under-occupancy for households with more than four $(n-1)$ or three $(n-2)$ members, and second, under-occupancy for the smaller households is actually higher than in the calculation.

Furthermore, a more in-depth analysis of the country-specific results, and in particular the identification of concrete potentials, requires country-specific knowledge and analysis. Housing markets are structured and regulated very differently from country to country and, in some cases, from region to region. Hence, further country or region-specific studies are needed to accurately define and quantify these potentials.

6. Conclusion

Our results show that under-occupancy in existing buildings offers significant housing potential. This potential is central to addressing social and environmental problems in the housing sector and can significantly aid efforts to meet environmental targets such as the 1.5 degree target, resource targets, land use goals, and the protection of biodiversity.

Although the theoretical potential of 152 million dwellings cannot be fully exploited because it is limited by demographic, technical, economic and cultural barriers, it highlights the dimension of the issue and opportunity. A comparison with housing markets in Switzerland where minimum occupancy requirements are implemented suggest that the possibility to realise this potential highly depends on the design of the housing markets. Housing policies should focus on affordable, attractive and smaller alternatives for older people and smaller households in order to free up bigger flats for families and larger households, as the under-occupancy seems to depend highly on the infrastructure of the housing stock.

Our calculation is based on a threshold value that is already established in the political discourse and in the practice of Swiss public and cooperative housing. This minimum occupancy threshold of at least one person less than the number of rooms in the dwelling was developed by the residents themselves, legitimised by their consent, and supported across the political spectrum. Nevertheless, how the legitimacy of measures designed to exploit the housing potential of existing dwellings can be established in the face of a political discourse that largely discredits attempts to reduced new construction or convert existing dwellings, even beyond the cooperative and state-owned housing sector, remains a central question for further research.

For political practice, these results yield important insights for an open societal debate on the socially and environmentally compatible use of existing housing. This is not only about the potential to combat the housing shortage in an environmentally friendly way, which is the focus of this study, but also about the provision of needs-based housing for people who are overburdened with oversized living space but are unable to downsize due to structural barriers.

Data availability statement

All data that support the findings of this study are included within the article (and any supplementary files).

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Florin Vondung: Data curation, Formal analysis.

David Schöpf: Investigation.

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