Building sufficiency – five measures for an unerring and just transition of the building sector

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Abstract

The building sector phases transformational challenges not only due to its huge negative environmental impacts but also because of injustices and difficulties to provide affordable and liveable housing for the majority. Until now, the focus in planning processes and political discussions to overcome these challenges has clearly been on technical measures like efficiency (thermal insulation) and consistency (renewable energies and materials) as well as classic real estate and housing policy approaches (focus on new construction and social housing subsidies). In contrast, the sufficiency strategy has only played a minor role.

This article aims to define the sufficiency strategy more specifically for the building sector by suggesting five specific building sufficiency measures. First, the prioritization of the use of existing buildings over new construction will be described from an ecological and an economical point of view, with an analysis of the housing potential in existing buildings in Germany. Second, the paper elaborates why per capita living space is a relevant parameter in this context, which should be given more attention in policy instruments as well as urban and building planning. Using Germany as an example, its social and regional distribution is explained. Based on the considerations of the donut economy, a socio-ecological target corridor for the living space per capita in Germany is derived by literature research and statistical or data evaluation. The three other sufficiency measures – mindful user energy behaviour, low tech or robust buildings strategies and adaptability – are briefly explained at the end.

Finally, the article lists possible policy interventions to leverage the potential of sufficiency for a climate-neutral and affordable building stock.

Introduction

Construction, operation and demolition of buildings have massive impact on compliance with planetary boundaries. In Germany, the life cycle of buildings is responsible for around 40 % of greenhouse gas (GHG) emissions (BBSR, 2020). While the German target is to achieve climate neutrality by 2045, the buildings sector is likely to have failed to meet its sector targets in 2023 for the fourth time in a row (Agora Energiewende, 2024). At the same time, the building sector is responsible for 90 % of domestic mineral raw material extraction (VDI ZRE, 2019). And while the goal is to achieve net zero land take by 2050, around 39 hectares are still being used additionally every day for housing, industry and commerce (Destatis, 2023a). To achieve the mentioned sustainability goals, science distinguishes between three complementary strategies (IZT, 2018). Efficiency aims at quantitatively improving the input-output ratio addresses of goods or services (IZT, 2018) and, for the building sector, means e. g. the use of thermal insulation and optimal operation of heating, ventilation and air conditioning systems. The German political and legal framework has already provided incentives for this for several decades by stipulating certain minimum thermal insulation standards for new builds and refurbishments or by providing financial support. Consistency raises the question of how a qualitative transformation of resource and energy use can take place (IZT, 2018). Consistency in the building sector requires the use of renewable energies and renewable or circular

raw materials. The consistency strategy in the building sector is also already being promoted in political and legal terms. On the one hand, for example, through the subsidization of solar thermal and photovoltaic systems. On the other hand, (some) new heating systems installed today must be operated with at least 65 % renewable energy in accordance with the Building Energy Act, which is fulfilled by heat pumps and heating networks, for example. Sufficiency attempts to answer the question of how much consumption planetary boundaries and global justice allow us. It stands for an absolute and not just a relative reduction of environmental impacts and complements the two technical approaches with a focus on human needs and social or societal innovations. For buildings sufficiency can be defined as a planning approach that aims to satisfy users' needs for attractive and affordable housing while taking local and global ecological limits into account (Over et al., 2021). It can be stated that building sufficiency currently is inadequately addressed by political measures (Zell-Ziegler et al., 2021).

Besides the building sector's environmental impact adequate and affordable housing is a fundamental need for individuals. There is an urgent need for action here as in Germany, especially in cities, there is a shortage of affordable housing. So far there is no universally accepted definition for the affordability of housing but in this paper we make use of a widely-used concept in Germany. Affordability is defined through a maximum rent burden of 30-40 % from the net income – for a single-person household, this amount is approximately 670 Euro (FES, 2019). In 2022 3.1 million households had a rent burden of 40 % or more. 1.5 million households even spent 50 % of their income on the net cold rent and non-consumption-related operating costs (Destatis, 2023b). Political attempts to solve the problem have so far focused on promoting new construction or social housing, housing benefit payments and reducing price increases through rent indexes (in German "Mietspiegel"), rent controls (in German "Mietpreisbremse") or limiting the allocation of modernization costs.

While efficiency and consistency measures are defined in detail and have already been studied in detail from both an ecological and economic perspective, this is not yet the case for sufficiency measures in the building sector. This paper therefore attempts to answer the questions of how sufficiency can be precisely defined for the building sector, what measures can be implemented and how these can be assessed from an ecological and socio-economic perspective. The paper focuses on summarizing a study commissioned by the German Federal Institute for Research on Building, Urban Affairs and Spatial Development, conducted by ifeu – Institut für Energie- und Umweltforschung Heidelberg gGmbH, Wuppertal Institut and BTU Cottbus-Senftenberg (Zimmermann et al., 2023). In addition to those findings, this article develops these findings through the use of a literature review further with special reference to the affordability of housing.

Definition of building sufficiency measures

Building sufficiency addresses all sufficiency aspects in connection with the life cycle of buildings and can be further divided into the following two sub-categories (Zimmermann et al., 2023):

- Constructional sufficiency: This includes sufficiency aspects in connection with the planning and construction of buildings, dwellings and rooms. Greenhouse gas reductions are mainly realized in the industrial sector (according to the sector definition of the German Climate Law) and in the construction industry, i.e. in the construction process. It contains a focus on maintaining, renovating and expanding existing buildings, reducing per capita living space (space sufficiency) and low fit-out standards.
- Energy sufficiency: This stands for sufficiency aspects in connection with the (energy and resource-relevant) operation or use of buildings. Greenhouse gas reductions are assigned to the building and energy sector. It includes technical building equipment and the provision of household and electrical appliances (sufficient equipment) as well as usage behaviour (sufficient use).

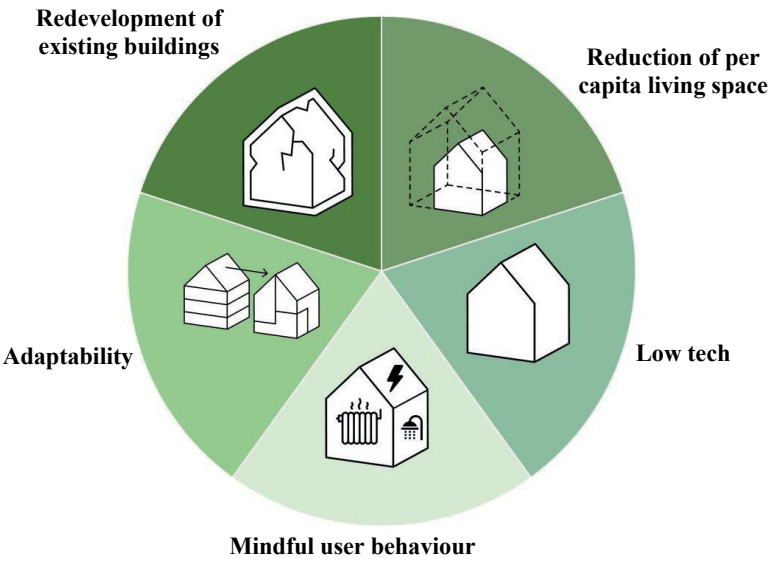


Figure 1. Five building sufficiency measures (Zimmermann et al., 2023).

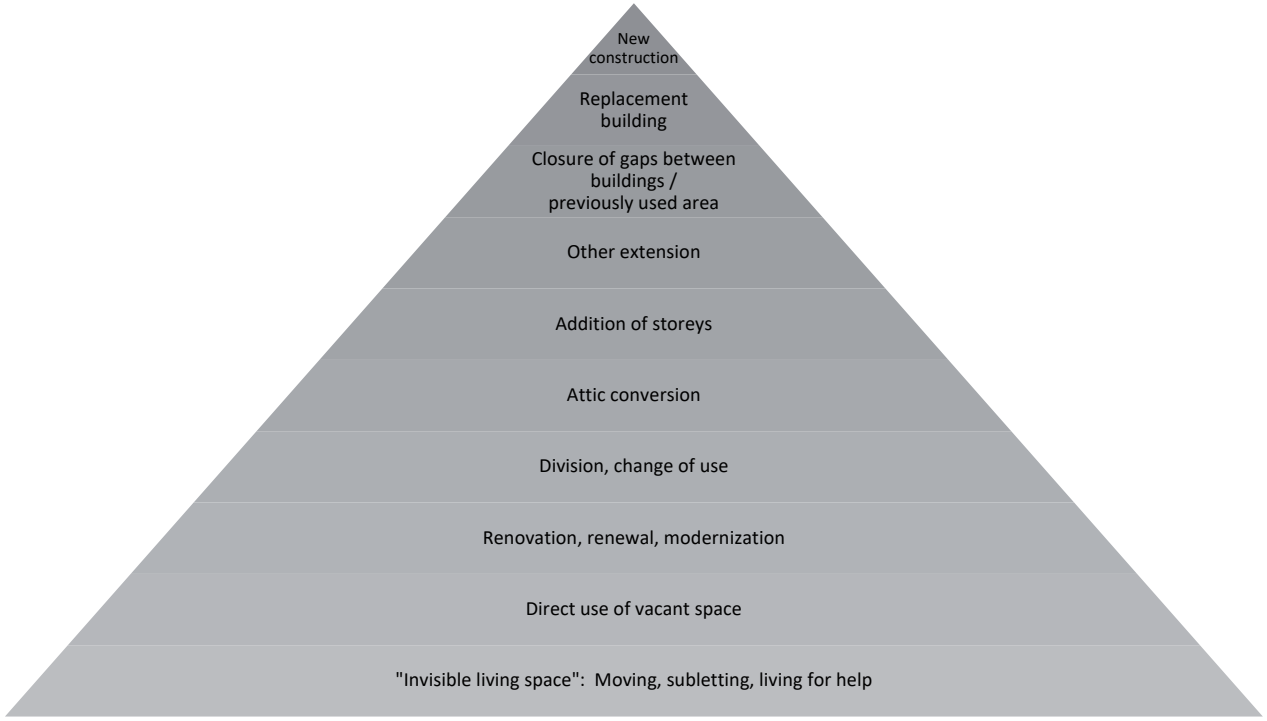


Figure 2. Building sufficiency prioritization pyramid (Zimmermann et al., 2023 extended).

Building on these two basic classifications, building sufficiency can be concretized with the five measures described below. The first two measures are described in more detail with also discussing the ecological and socioeconomic implications.

REDEVELOPMENT OF EXISTING BUILDINGS

Sufficiency aims for a needs-oriented approach to what is already available, in particular existing buildings, established structures and previously unused areas. Accordingly, construction tasks can be prioritized according to production efforts (virgin materials, energy, money).

Based on several considerations the following sufficiency prioritization pyramid can be derived. It builds on the suggestions of the German Association of Cities on prioritizing the use of existing buildings over new construction (Deutscher Städtetag, 2021). It sorts various construction measures schematically in terms of their ecological and economic impact and is thus based on the concept of the waste hierarchy, according to which waste avoidance is more important than recycling and the latter is preferable to landfilling. Non-construction measures for the creation or use of living space are also listed at the bottom. So-called invisible living space can be used or created by moving into more suitable apartments, subletting unneeded rooms or living for help (Fuhrhop, 2023).

It is sorted from bottom to top from the least demanding or least complicated and therefore most sufficient measures to the least sufficient. If demand planning shows a need for new or different space, it should therefore first be checked whether this can be covered by subletting or living for help measures in apartments that are currently too large (see the following chapter on living space) or simple renovation or conversion measures. If this cannot be achieved for justified reasons, it is possible to extend the living space, e.g. by adding storeys. Only if these measures are also not feasible fully new constructions would be possible from a sufficiency perspective.

Ecological benefits

The prioritization of the use of existing buildings over new buildings is also due to the lower ecological impact, at least during production, which is proven by the following figures.

GHG emissions

For typical new residential buildings in Germany, the embodied carbon – the emissions caused by the production, maintenance and disposal of the materials needed to construct the building – amount for 10–16 kg CO_2 equivalents/m^{2*}a. In contrast, typical existing renovations only emit 3–8 kg CO_2 equiv./m^{2*}a (Mahler et al., 2019). Even when looking at the entire life cycle of a building and with kg CO_2 equiv. per person as reference value, renovated existing buildings always have lower GHG emissions than new buildings – when insulation standards of the renovated existing building and the new construction are comparable (Zimmermann et al., 2023). By converting currently and future vacant office space – as a result of the trend towards more home office – into living space, up to 9.2 million tons of CO_2 can be saved per year by 2040 (Walberg & Gniechwitz, 2020).

Material consumption

Massive savings can be achieved, particularly in terms of material requirements. On average, adding storeys to residential buildings only requires 10 % of the materials of a new building (Zimmermann et al., 2023).

Land use

Further, the potential for land use reduction becomes particularly clear and obvious. Generally, no additional space is used or sealed through renovations, divisions or additions, neither for

the building nor for infrastructure (Zimmermann et al., 2023). Therefore, compliance with circular economy of land use can only be achieved by focusing strongly on existing development.

Economical and societal implications

The question of the affordability of housing (in new and existing buildings) for large sections of the population depends on the total costs for the construction of buildings (construction, financing and land costs). All of these sub-costs have risen sharply in recent years due to various factors (Destatis, 2024). Because of these developments it is nowadays very difficult to not feasible to create affordable housing for lower income groups in new construction without subsidies. While being more expensive per square meter in the construction phase (Figure 3) new buildings bring further problems with them. They are also exempt from orientation towards local comparative rent and rent control measures. At the same time, their high rents are factored into the calculation of the rent index and hence drive-up rents for existing apartments (Ahlert et al., 2018). Although the modernisation or use of existing buildings is particularly associated with high regulatory hurdles and therefore costs (Architects for Future Deutschland e.V., 2020), it proves to be economically viable from an investment cost perspective. The influence of modernization measures on rents is complex, partly due to political stipulations such as the level and structure of the modernization levy and will not be discussed in any further detail here.

Potentials

As a more sufficient alternative to new construction, potentials for implementing the housing requirements in existing buildings were researched and calculated. It should be noted that these quantifications are maximum values in terms of construction technology and design (technical potential) without taking into account financial, procedural (availability of skilled workers) and socio-cultural (acceptance) restrictions.

For the case of Germany, it can be seen in Figure 4 that in total up to 83 % of the national governmental housing target (400.000 new dwellings per year) can be realized through measures in, on and on top of existing buildings (Zimmermann et al., 2023).

It should be noted that forecasts of housing demand are heavily dependent on population trends and internal migration. For a given initial state of the building stock, this results in different possible degrees of coverage of housing requirements through measures on existing buildings.

REDUCTION OF PER CAPITA LIVING AREA

As sufficiency aims for an absolute reduction of environmental impacts, the goal is to reverse the trend of constantly increasing living space per person and reduce it to a fair and needs-based level.

Unfair and uneven distribution

The average living space in European countries (2020) fluctuates between 24 m^2 in Romania to 62 m^2 in Cyprus with an average of 41 m^2 (CLEVER, 2023). The value in Germany is 48 m^2 and has increased from 35 m^2 in 1991 (Statista, 2023).

Despite that increase in per capita living space, no such rise in residential satisfaction can be observed; on the contrary, it has been constant for decades (Liebig et al., 2022). Very high living spaces per capita, such as that which occurs for older couples or individuals in single-family homes ("empty nester"), even leads to problems. 20 % of homeowners over the age of 54 say they are overwhelmed by caring for their house and garden. However, due to a lack of alternative suitable housing and economic concerns, it is often most convenient to continue living in the house (Sunderer et al., 2018).

In addition to the increase over time, a detailed look shows that there are regional and, above all, social and economic differences in distribution (Figure 5). In the case of Germany, higher values can be seen in rural areas compared to cities. But socioeconomic factors as age, income level or household size are better predictors for high living space consumption per capita (IW Köln, 2021). Another statistic that illustrates the uneven distribution of living space is that while 11 % of the population live in overcrowded flats, 33,6 % live in under-occupied dwellings (eurostat, 2023). It can be deduced from this that in Germany there is no general lack of housing but an uneven and unfair distribution, leading to shortages and therefore high prices in some "popular" regions. A just redistribution of living space can counteract further growth, and therefore be a key adjustment factor.

In the quantitative discussion about the per capita living space, other factors such as the availability of green spaces close

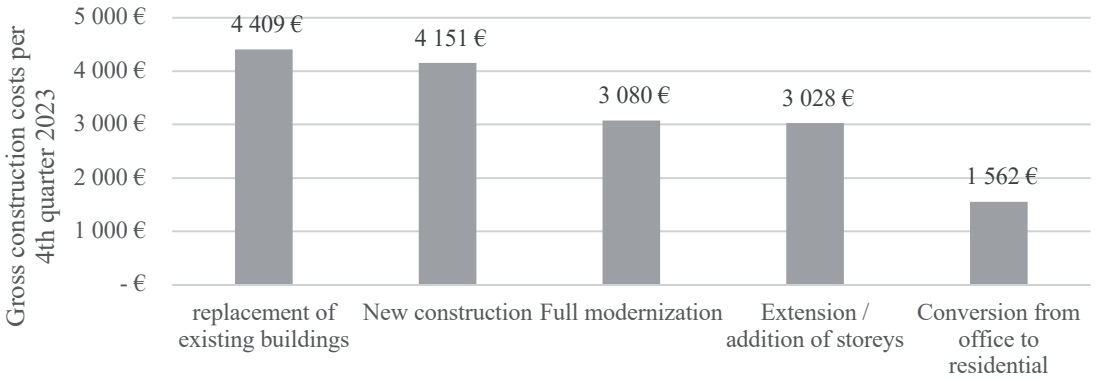


Figure 3. Cost comparison of different construction types for the German case (BKI, n.d.; Walberg et al., 2022).

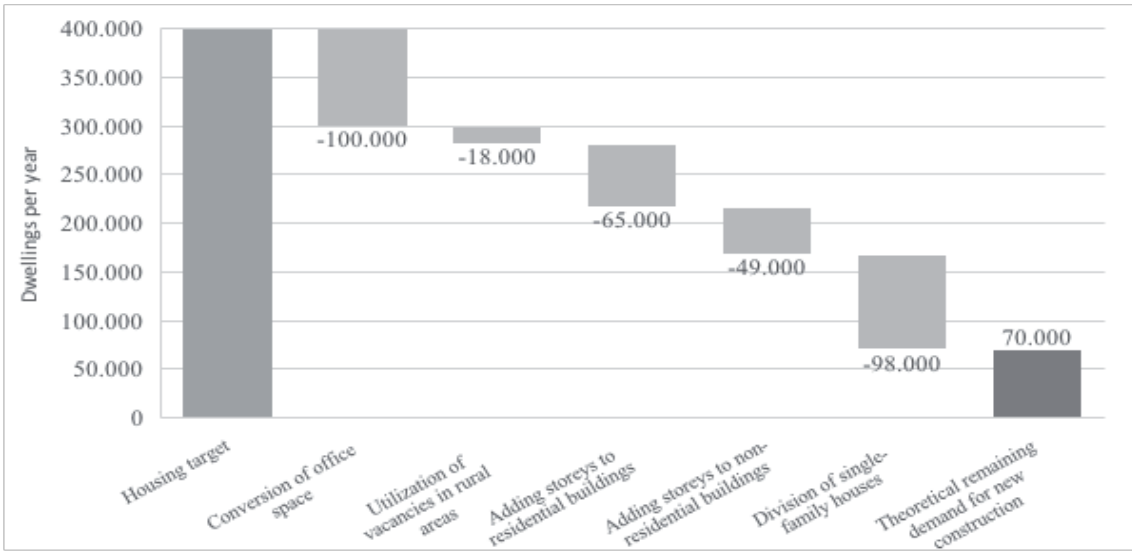


Figure 4. Waterfall diagram housing potential in existing buildings (Zimmermann et al., 2023).

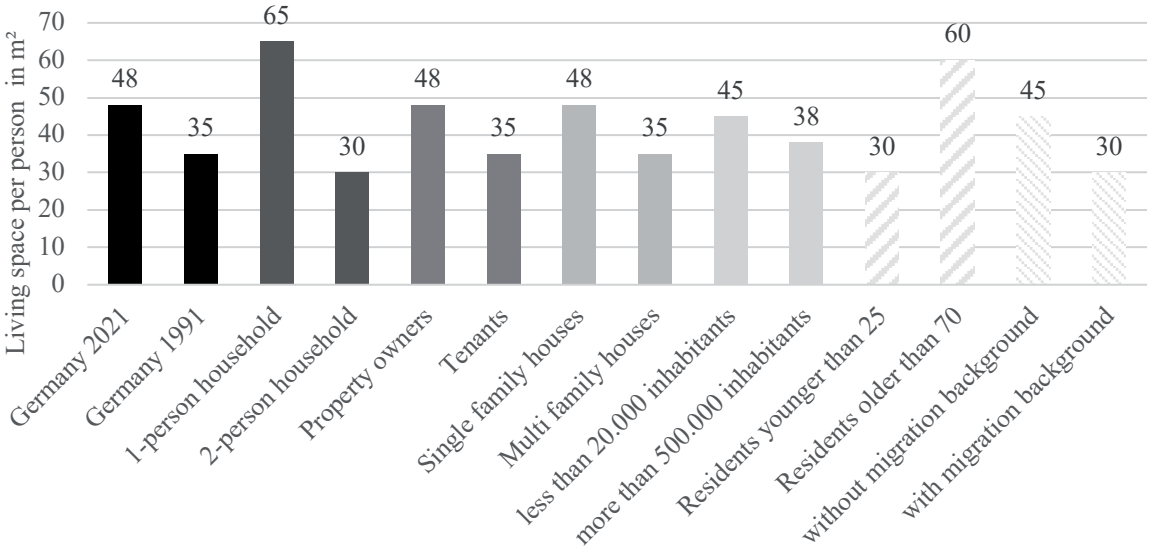


Figure 5. Living space per capita in relation to different parameters (IW Köln, 2021; Statista, 2023).

to home or publicly accessible areas, like libraries, should always be taken into account when interpreting the figures.

Socio-ecological consumption corridor

One option to illustrate sustainable development is the Doughnut Economy – named after its shape and developed by Kate Raworth. It combines the concept of planetary boundaries (outer ring) with the idea of social boundaries (inner ring). The area between the ecological ceiling and the social foundation defines the safe and just space for humanity (Raworth, 2022). An idea that can be derived from the Doughnut Economy concept is the idea of consumption corridors (Fuchs et al., 2021). This approach will be transferred in the following to the parameter living space per capita by literature research and a statistical data evaluation to determine the value range to which the living space should develop.

Ecological ceiling and benefits

For the derivation of a theoretical maximum value, we carried out a meta-analysis. Four European and global climate neutrality scenarios were examined, all of which explicitly take sufficiency measures into account (CAN Europe et al., 2020; CLEVER, 2023; ECF & Climact, 2018; Kuhnhenn et al., 2020). The values range from 31–37 m² with an average of 35 m² which is therefore suggested as the average target value for the ecological boundary. Many countries in the global north are above this limit. Therefore, there is a responsibility to act, both from an ecological necessity and from a justice perspective. This is because many countries in the Global South fall far short of this value.

The ecological savings potential is illustrated using individual examples from the literature. Regarding to personal GHG emissions it makes a crucial difference how many people live

in a house. In an average existing German single-family home with 2, 3 or 4 occupants, the per capita living space is 65, 43 or 32 m² per capita respectively. Assuming a refurbishment standard that results in an energy requirement that is 45 % below the legal requirements, this leads to per capita emissions of 2264, 1509 or 1134 kg respectively. Other ecological benefits can be quantified based on the comparison of the new construction of single and multi-family houses with different per capita living spaces according to Figure 5. The material requirement per dwelling equals 420 tons in single-family houses, while it is only 280 tons in multi-family houses. Significant savings potential can also be quantified in terms of land use. In Germany the land and infrastructure area for single-family houses is around 700 m² per dwelling, while for multi-family houses it is only around 90 m² (Liebig et al., 2022).

Social foundation

The design of living spaces is influenced by various factors (e.g. cultural norms, climate zone, land availability, legal provisions). Therefore, defining a widely applicable minimum value is difficult. One possible approach would be to use limit values from social housing. However, this is first and foremost a political determination from a primarily economic perspective. But the minimum value should instead primarily reflect minimum socio-cultural needs. For this reason, the "decent living standard" developed by Rao and Min (2018) was used to determine the lower limit. In this study, various conditions that are needed for fulfilling basic human wellbeing have been defined from a broad literature review. Minimum household requirements are therefore "30 m² and 10 m² per additional person, above three members". For an average two-person household this means 15 m² per capita as a minimum value.

Potentials

If the current living space were reduced by around one square meter per person, an area of 80 million m² would be freed up. With an average of 80 m² per apartment, one million apartments could be created without new construction (werkum, 2022).

What is more effective than this top-down approach is to identify population groups with large living spaces and to quantify the potential savings there. Pensioners make up 22 % of the total German population and have a median per capita living space of 60 m². 13 % of this group have a living space per person over 100 m² (IW Köln, 2021). If only around a quarter of this group is willing to halven their living space (Sunderer et al., 2018) – and thus ends up roughly at the German average – around 32 million m² of living space would be freed up, which at 80 m² per dwelling would theoretically meet the overall housing construction target of the German government of 400,000 apartments per year (Zimmermann et al., 2023).

ADAPTABILITY

According to the above definition, the concept of sufficiency focuses on human needs including the needs of future generations, whose needs and preferences in relation to housing cannot be predicted precisely. In order to reduce or avoid resource and emission intensive conversion or demolition and new construction buildings need to be planned future proof for changing conditions and needs. Adaptability and flexibility - the third measure of building sufficiency – mean that other types of use are possible in an appropriate and optimal form compared to the initial use and these can be implemented with minimal intervention in the building fabric (Stroetmann et al., 2022). This means for example that office buildings can be easily converted into apartments. Another example would be so called joker rooms, which can be assigned to one of the adjoining apartments as required by means of simple structural changes.

LOW TECH

Building sufficiency aims for low tech or simplicity on material and construction level as well as building technology level in order to achieve absolute environmental impact reduction. Low tech aims for minimized technology and design concepts that rely on passive measures, self-regulating effects and the avoidance of redundancies, and makes minor sacrifices in comfort in favour of low-maintenance, uncomplicated operation (Zimmermann, 2018). On the one hand, this can be achieved through simple superstructures (e. g. monolithic exterior walls) or low finishing standards (e.g. visible construction and installations, omitting superfluous decorative layers) (Nagler, 2022). On the other hand, the aim is a minimalized technical concept that relies on passive measures, self-regulating effects, local energy use and avoidance of redundancies and accepts minor losses in comfort in favour of low-maintenance and uncomplicated operation. One example would be to do without an energy-intensive air conditioning system and instead accept a few hours or days with higher, possibly somewhat uncomfortable temperatures (Zimmermann, 2018).

MINDFUL USER BEHAVIOUR

The last building sufficiency measure focuses on the use phase of the building. It addresses the actual (not theoretically calculated) usage of resources and energy that users have in influence on. The fields of action include heating, (hot) water use, ventilation and electrical consumers, e.g. household appliances or lighting (Brischke et al., 2016). The aim is to reduce consumption through needs-based behaviour. This can mean, for example, the following recommendations (Zimmermann et al., 2023):

- Adequate room temperatures for occupied living spaces within an individual comfort tolerance (heating period: 19 to 21 °C, summer air conditioning: 25 to 27 °C)
- Adequate room temperatures depending on the type of use (e.g. bedroom different from bathroom)
- Adequate room temperatures depending on the times of use: Reducing or switching off heating and air conditioning in rooms that are rarely used or during longer periods of absence
- Correct ventilation behaviour depending on the type of building, heating and ventilation

Policy recommendations

Supporting sufficiency approaches in the building sector requires political and legal backing and not just individuals or planner initiative. We would therefore like to conclude this article with suggestions on how sufficiency could be integrated into

Table 1. Policy instrument overview (Zimmermann et al., 2023 adopted).

Communicating sufficiency: raising awareness, providing information, setting an example	
National Building Sufficiency Strategy	While there are national strategies on sustainability, climate protection, and efficiency, sufficiency should also be addressed adequately for example by a designated strategy process or a specification (focus on use of existing buildings) of the national housing target like this is done for the renewable energy goals
Public relations & nationwide campaign	Sufficiency should be declared as the third pillar in nationwide communication and public relations work on the energy transition and climate protection especially critical questioning of previous narratives with regard to single-family houses. The framing should not be aimed at "renunciation" but should be positive and focus on benefits: contribution to increasing the quality of housing and life as well as social and intergenerational justice.
Sufficiency in Federal buildings	The public sector should act as a role model and take greater account of sufficiency in its own building stock and the sustainability certification system for public buildings (BNB) or create flagship projects worthy of emulation.
Promotion of sufficiency in consulting, integration in planning and implementation of measures	
Integration of sufficiency into municipal planning processes	To ensure that local authorities have sufficient information, e.g. on the use of existing buildings and the demographic distribution of living space, GIS-based and publicly accessible registers should be created, possibly with financial support from the federal government, which show vacancies and vertical and horizontal re-densification options. Concept allocation procedures (in German "Konzeptvergabe") or heritable building rights (in German "Erbbaurecht") are decisive instruments for specifying sufficiency criteria.
Integration of sufficiency-oriented content in advisory services	Advisory services already play a role in climate protection and the heating transition and are necessary for obtaining subsidies, for example. Sufficiency aspects should therefore also be integrated into existing energy advice services, for example, and special housing advice services or agencies should be developed and promoted.
Sufficiency-weighted funding landscape	In line with the principle of thriftiness and more climate impact as well as affordable living space per subsidized euro, the existing funding schemes (BEG) must be adapted, in particular by: Gradual discontinuation of subsidies for new construction, promotion of (conversion) construction in existing buildings, dependence on per capita living space, adaptability as a funding criterion.
Impulses for integration into legal frameworks and nationwide standards	
Adjustments to building, planning, and renting law	Some of the sustainability goals that have been set need to be anchored in a more binding manner. At the same time, there is a need to simplify the requirements for converting existing buildings and the multitude of regulations and standards in general. The implementation of a right to exchange apartments, analogous to Austria, should be examined.
Further development of the Building Energy Act	In addition to the use phase embodied carbon emissions should be addressed (separately) to get a full life cycle perspective and to enable a fair comparison between new and existing buildings. Further measures could be the (informative) introduction of per capita-related parameters, progressive requirements depending on the building type, the strengthening of low-tech concepts and the consideration of further planetary boundaries.

the political and legal framework. The proposal is based on a broad literature review, building on existing instruments where possible and supplementing them with sensible new measures. In this context, the question of re-municipalization or expropriation is currently receiving special attention in Germany due to a civil society initiative and a referendum in Berlin. It is argued that socialization of housing or municipality-owned housing supply can create permanently affordable and climate-friendly living space.

Conclusions

This article defines the sustainability strategy of sufficiency for the building sector by presenting five specific measures. The two major measures of building sufficiency are the strengthening of the (re-)use of existing buildings in comparison to new construction and the long-term reduction of per capita living space. Both measures have the potential to reduce environmental impacts and costs significantly. Building sufficiency thus opens up the possibility of not perceiving downsizing as a sacrifice or economic necessity, but rather as a contribution to ecological transformation and social and intergenerational justice. This requires not only voluntary bottom-up initiatives, but above all political will to shape things so that sufficiency is not the exception but the rule.

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