FULFILL

Operative definition and indicators for energy sufficiency

Fundamental decarbonisation
through sufficiency by lifestyle changes

FULFILL

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Fundamental decarbonisation through sufficiency by lifestyle changes

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Authors:	Lorenzo Pagliano, Gianluca Brunetti, Matteo Clementi, Silvia Erba, Alessandro Rogora (Politecnico di Milano)
Contributors:	Vivek Gilani, Avinay Kumar Yadav, Kirti Makhija, Deepika Manoharan, Vipul Patil (cBalance) Riccardo Mastini (consultant)
Internal reviewers:	Janis Brizga (Zala briviba), Raphael Moser (Wuppertal Institut)

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Project Partners

No	Participant name	Short Name	Country code	Partners' logos
1	**Fraunhofer Institute for Systems and Innovation Research ISI**	FH ISI	DE	
2	**Wuppertal Institut für Klima, Umwelt, Energie GGMBH**	WI	DE	
3	**Accademia Europea di Bolzano**	EURAC	IT	
4	**Notre Europe - Institut Jacques Delors**	JDI	FR	
5	**Association négaWatt**	NW	FR	
6	**Politecnico di Milano**	POLIMI	IT	
7	**International Network for Sustainable Energy-Europe**	INFORSE	DK	
8	**Zala Briviba Biedriba SA**	ZB	LV	

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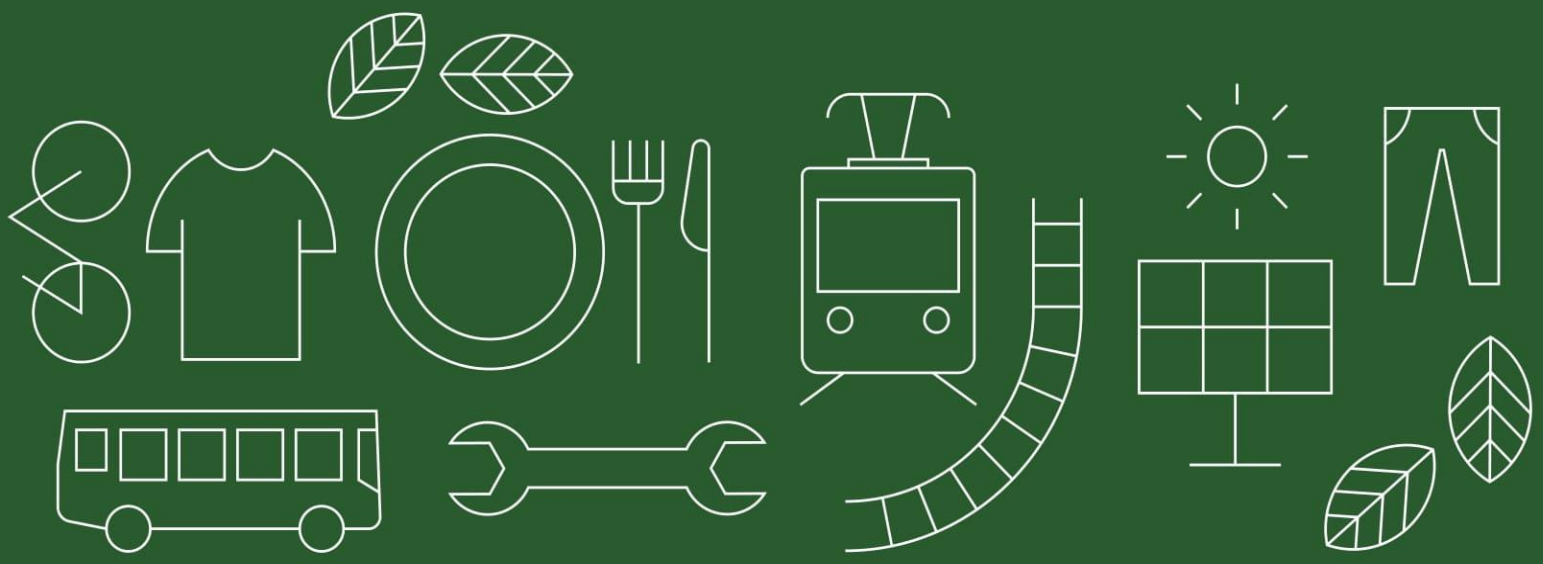

Content

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List of Abbreviations

EU	European Union
EEA	European Environment Agency
WHO	World Health Organization
NDC	Nationally Determined Contributions
SSH	Social Sciences and Humanities
ASI	Avoid, Shift, Improve framework
SER	Sufficiency, Efficiency, Renewable framework
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
UNEP	United Nations Environment Programme
EREI	Energy Return on Energy Invested
PMV	Predicted Mean Vote (an indicator in comfort assessment)
CBA	Consumption-based accounting of CO_2 emissions
PBA	Production-based accounting of CO_2 emissions
SUVs	Sport Utility Vehicles
GDP	Gross Domestic Product
PEDs	Positive Energy Districts
ITF	International Transport Forum

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Abstract / Summary

Based on the literature review presented in the report D2.1 on the concept of sufficiency, and on consultations with sufficiency experts from the Expert Panel in the Advisory Board, this task aims at establishing an operative definition of sufficiency and a list of quantitative and qualitative indicators applicable in FULFILL to study lifestyle changes in relation to decarbonisation strategies.

This is achieved by building on:

(i) the literature review on ***sufficiency habits***, ***infrastructures*** and ***social frameworks*** carried out in T2.1

(ii) referring of the energy efficiency literature as an established field

(iii) cultural principles from outside Europe, and

(iv) scenarios which analyse the potential of sufficiency policies for reducing final energy use and emissions.

The indicators were derived from the literature for the four main sectors identified as most relevant during the literature review: buildings, mobility, food and product.
In addition, this report proposes a reclassification of the indicators based on

- the different leverages of sufficiency i.e service-based (how consumers use equipment), dimensional (size and types of products proposed to consumers), and organizational (collective planning, infrastructure, legal framework)
- and in terms of relevance for the work in the subsequent project work packages.

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Overview about the FULFILL project

Project Summary

The project FULFILL takes up the concept of sufficiency to study the contribution of lifestyle changes and citizen engagement in decarbonising Europe and fulfilling the goals of the Paris Agreement. FULFILL understands the sufficiency principle as "**creating the social, infrastructural, and regulatory conditions for changing individual and collective lifestyles in a way that reduces energy demand and greenhouse gas emissions to an extent that they are within planetary boundaries, and simultaneously contributes to societal well-being**". The choice of the sufficiency principle is justified by the increasing discussion around it, underlining it as a potentially powerful opportunity to actually achieve progress in climate change mitigation. Furthermore, it enables us to go beyond strategies that focus on single behaviours or certain domains and instead to look into lifestyles in the socio-technical transition as a whole. The critical and systemic application of the sufficiency principle to lifestyle changes and the assessment of its potential contributions to decarbonisation as well as its further intended or unintended consequences are therefore at the heart of this project. The sufficiency principle and sufficient lifestyles lie at the heart of FULFILL, and thus constitute the guiding principle of all work packages and deliverables.

Project Aim and Objectives

To achieve this overarching project aim, FULFILL has the following objectives:

- Characterise the concept of lifestyle change based on the current literature and extend this characterisation by combining it with the sufficiency concept.
- Develop a measurable and quantifiable definition of sufficiency to make it applicable as a concept to study lifestyle changes in relation to decarbonisation strategies.
- Generate a multidisciplinary systemic research approach that integrates micro-, meso-, and macro-level perspectives on lifestyle changes building on latest achievements from research into social science and humanities (SSH), i.e. psychological, sociological, economic, and political sciences, for the empirical work as well as Prospective Studies, i.e. techno-economic energy and climate research.
- Study lifestyle change mechanisms empirically through SSH research methods on the micro- (individual, household) and the meso-level (community, municipal):
    - achieve an in-depth analysis of existing and potential sufficiency lifestyles, their intended and unintended consequences (incl. rebound and spillover effects), enablers and barriers (incl. incentives and existing structures) as well as impacts (incl. on health and gender) on the micro level across diverse cultural, political, and economic conditions in Europe and in comparison to India as a country with a wide range of economic conditions and lifestyles, a history which encompasses simple-living movements, and a large potential growth of emissions.
    - assess the dynamics of lifestyle change mechanisms towards sufficiency on the meso-level by looking into current activities of municipalities, selected intentional communities and initiatives as well as analysing their level of success and persisting limitations in contributing to decarbonisation.

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- Integrate the findings from the micro and meso-level into a macro, i.e. national and European, level assessment of the systemic implications of sufficiency lifestyles and explore potential pathways for the further diffusion of promising sufficiency lifestyles.
- Implement a qualitative and quantitative assessment of the systemic impact of sufficiency lifestyles which, in addition to a contribution to decarbonisation and economic impacts, includes the analysis of further intended and unintended consequences (incl. rebound and spillover effects), enablers and barriers (incl. incentives and existing structures) as well as impacts (incl. on health and gender).
- Combine the research findings with citizen science activities to develop sound and valid policy recommendations contributing to the development of promising pathways towards lifestyle.
- Generate findings that are relevant to the preparation of countries' and the EU's next national determined contributions (NDCs) and NDC updates to be submitted in 2025 and validate and disseminate these findings to the relevant stakeholders and institutions for exploitation.
- Consider the relevance and potential impacts of sufficiency lifestyles beyond the EU.

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1. Sufficiency potential and some cultural roots of the concept

In Deliverable 2.1 "Literature review for analysis of lifestyle changes" we present the results of a literature review aimed at exploring the theoretical and conceptual foundations of climate-oriented lifestyle changes. More specifically, it outlines the current state of knowledge on the role of the sufficiency principle in lifestyle changes as well as a screening of the literature on potential effect of sufficiency-oriented policies.

The review, comparing various conceptual frameworks and nomenclature proposed in literature, finds that there is a large consensus on the view that a sufficiency-oriented lifestyle is based on changes of the habits of people, companies and institutions which can happen at the needed scale only in the presence of adequate enabling conditions, both at the physical and the regulatory level.

We propose to make explicit those findings also in the nomenclature used to describe sufficiency-oriented lifestyle changes by adopting the definitions:

- ***Sufficiency habits*** = Sufficiency measures taken by individuals due to permanent lifestyle changes
- ***Sufficiency infrastructures*** = Physical and non-physical infrastructures enabling ***Sufficiency habits***
- ***Sufficiency societal framework*** = institutions, legislation, norms enabling ***Sufficiency habits***.

The report D2.1 analysed relevant literature on the potential reduction of final energy use and emissions as a result of the adoption of policies which support the uptake of ***sufficiency habits***. We found a large number of studies published in peer revied journals or as reports by Institutions (such as International Energy Agency, UNEP,…) or research bodies, which converge on the large reduction potential offered by sufficiency policies, on their positive side benefits, and on the rapidity by which those policies can produce measurable results.

For example (Millward-Hopkins et al., 2020), based on Rao and Min's (Rao & Baer, 2012) living standards framework, conclude via energy modelling that through the widespread application of strong 'demand-side-reduction' or sufficiency measures and energy efficiency measures, the global energy consumption in 2050 could be reduced to the levels of 1960s, despite a population three times larger.

(Millward-Hopkins et al., 2020) also compare the final energy use of the scenario they developed to scenarios of other authors. E.g. they state "An early bottom-up estimate was made by (Goldemberg et al., 1985). They compiled an inventory of activities across residential (cooking, food storage, etc.), commercial (floor space), transportation (private, public and freight), manufacturing (steel, cement, etc.) and agricultural (food) sectors. Together these were suggested to provide 'basic needs and much more', for only 30 GJ/cap/yr of final energy consumption annually.

Most recently, (Rao et al., 2019) estimated that 12–24 GJ/cap of final energy consumption annually would be required to provide decent material living standards in India, Brazil and South Africa. They used a similar inventory to (Goldemberg et al., 1985), but included modern communication and information technologies, education, healthcare and water provision (among other things) and, in addition, made robust estimates of indirect energy use."

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We can hence note that the discussion and analysis about how to define basic needs and how to reduce the amount of energy to satisfy those needs has been conducted since the '80s by researchers both from the North and from the South.

This should not be surprising even if southern countries have relatively low average per capita use of energy and material resources, since lifestyle attitudes towards low energy and material consumption have roots in many cultures in the Global South, premised upon the logic of flourishing with enough in a context of equality among members of a community. Among the main Southern discourses that extol principles coherent with sufficiency there are *sumak kawsay* in South America, *ubuntu* in Africa, and *swaraj* in India.

Sumak kawsay is a word in *Quechua (*an indigenous language family spoken primarily by the peoples living in the Andes) and it has been translated as 'good living', although experts agree that a more precise translation would be 'the plentiful life' (Alvarez, 2015). In the original Quechua phrase, s*umak* refers to the ideal and beautiful fulfillment of the planet, and *kawsay* means 'life': hence, a life with dignity, plenitude, balance, and harmony. Since the 1990s, *sumak kawsay* has grown into a political project that aims to achieve collective wellbeing, social responsibility in how people relate to nature, and an alternative to traditional development projects. *Sumak kawsay* proposes the collective realization of a harmonious and balanced life based on ethical values, in place of a development model that views human beings as an economic resource. Under the pressure of indigenous movements, Ecuador incorporated the concept into its national constitution in 2008 as also Bolivia did in 2009. (Gudynas, 2011) outlines eight core ideas for the concept: 1) create space for sharing critiques of development, 2) uplift ethical outlooks grounded in values, 3) center decolonization, 4) foster intercultural dialogue, 5) deny the nature–society binary, 6) reject manipulative and instrumental rationalities, 7) reject linear understanding of progress and 8) express feelings and affections.

Ubuntu is a southern African concept, which means 'humanness'. Humanness implies both a condition of being and a state of becoming. It concerns the unfolding of the human being in relation to other human beings and the more-than-human world of non-human nature. Moreover, *ubuntu* suggests that a human being is not an atomized individual of the Western tradition but is embedded in social and biophysical relations. Like all African cultural values *ubuntu* circulated through orality and tradition, with its meaning interwoven in the cultural practices and lived experiences of African peoples (Le Roux, 2000). Such cultural values became eroded or effaced by colonization. However, in post-colonial Africa, *ubuntu* has been re-invoked as a part of a decolonizing project. For example, some Afro-descendent groups in South America are invoking it to gain a more nuanced understanding of what a good life really means (Le Grange, 2012). *Ubuntu* is the current theme for the Global Agenda for Social Work and Social Development and represents the highest level of global messaging within social work profession for the years 2020–2030 (Mayaka & Truell, 2021). Furthermore, *ubuntu* can guide research objectives, ethics, and methodology: such a research approach provides researchers with an African oriented tool that decolonises research agenda and methodology. The objectives of *ubuntu* research are to empower families, communities, and society at large. In doing *ubuntu* research, the position of the researcher is important because it helps create research relationships (Seehawer, 2018).

Swaraj can mean generally 'self-governance' and it lays stress on governance, not by a hierarchical government, but by individuals and community building. The focus is on political decentralization (Kapur, 2000). Gandhi's concept of *swaraj* advocated India's discarding British political, economic, bureaucratic, legal, military, and educational institutions. The *swadeshi* movement was a self-sufficiency movement that was part of the Indian independence movement and it aimed at curbing foreign goods by relying on domestic production. Gandhi described it as the soul of *swaraj* (Parel, 1997). Although Gandhi's aim of totally implementing the concepts of *swaraj* in India was not achieved, the voluntary work organisations which he founded for this purpose

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did serve as precursors and role models for people's movements, voluntary organisations, and some of the non-governmental organisations that were subsequently launched in various parts of India. Gandhi's idea of *swaraj* has to do with an individual's or a community's autonomy to create their choices, rather than passively accepting the menu from which they must 'choose' (Shrivastava, 2019). Applied to our market-driven, media-prompted world, it would first require us to take ecological and cultural responsibility for our desires and explore their origins in passions stoked by advertising. Desire, which is at the philosophical heart of the notion of freedom in modern consumer democracies, has to be critically scrutinized under *swaraj*, especially given the context of an ecologically imperiled world. One implication of this is that Gandhi's idea of *swaraj* is inevitably bound up with *swadeshi*, which brings in the necessity of economic localization. The idea of *swaraj* continues to inspire social, political, and ecological movements in India. The resistance against displacement by development undertaken by several movements are initiatives attempting to creatively adapt the notion of *swaraj* in today's context (Shrivastava, 2019).

This report (D2.2.) proposes a list of quantitative and qualitative indicators applicable in FULFILL to study lifestyle changes in relation to decarbonisation strategies, borrowed from various scenarios, perspectives, and cultural attitudes.

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2. Overview on efficiency indicators

We present here a short review on *efficiency* indicators as a starting point for the discussion of *sufficiency* concepts and indicators, since "efficiency in the end-use of energy" is a long-established concept, but metrics for its evaluation continue to evolve, in parallel to the rising ambition of energy and climate policy. This is useful to allow for a clarification of the distinction between efficiency and sufficiency, with the goal of reducing as much as possible the areas of overlapping.

Efficiency is generally defined as the **ratio of useful output of a certain physical quantity to the input of the same quantity (or a homogeneous one) in a certain process**.

For example, one might consider the mechanical efficiency of a gas turbine, defined as the ratio of useful energy output (in the form of mechanical energy) to the input (in the form of thermal energy provided by burning gas), or the electrical efficiency of the system composed of the gas turbine plus the electricity alternator (which converts mechanical energy into electric energy). From this example, it is apparent that **the explicit identification of the boundaries of the system is an integral part of the definition**. An ambiguous identification of the system takes away precision from the indicator "efficiency" up to the point of making it useless.

An example of the crucial importance of an explicit and clear definition of the physical system considered, identified by its boundaries, can be found in the assessment of building performance. According to ISO 52000-1 (EN ISO 52000-1:2017 Energy performance of buildings - Overarching EPB assessment - Part 1: General framework and procedures, 2017), there should be three indicators to assess and design an efficient building (also called a high performance building) or a nearly Zero Energy Building (nZEB) and they should be considered in the following order:

(1) *energy needs for heating and cooling*, to reflect the performance of the building fabric, quantifying and promoting the reduction of energy losses through the envelope and ventilation;

(2) *total primary energy*, to reflect the performance of the technical building systems in addition to the performance of the building fabric;

(3) *non-renewable primary energy* for quantifying and promoting the reduction of the non-renewable fraction within *total primary energy* use.

Within the Affordable Zero Energy Buildings (AZEB) and the Africa-Europe Bioclimatic Buildings for XXI century (ABC21) project, the end-use Efficiency Research Group has developed a series of simplified graphical illustrations (Figure 2) and a video to show, in a clear and concise way, the above concepts and nomenclature (*Project: AZEB - Affordable Zero Energy Buildings. ID: 754174. Available at: https://azeb.eu/. (Accessed on 6 October 2022)*, 2017).

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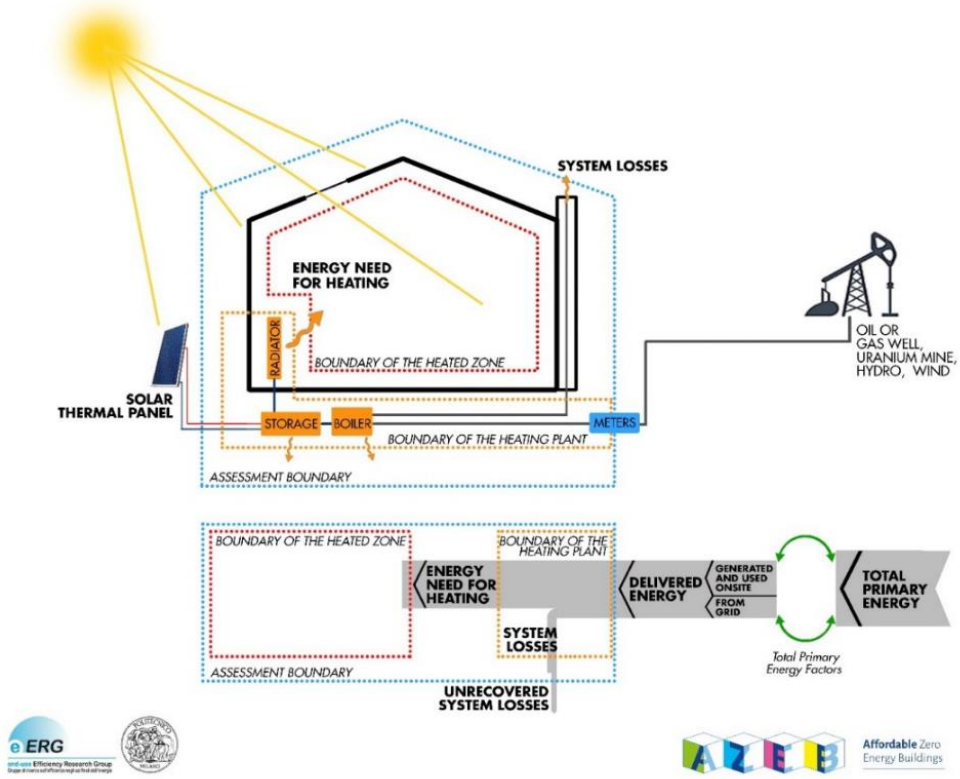

Figure 1 Graphical representation of energy levels; case where the energy service considered is space heating, delivered by a boiler and on-site solar thermal panels (Erba & Pagliano, 2021)

The indicators of *energy needs* and *total primary energy* correspond to the energy efficiency first (EE1st) principle, which is one of the key principles of the Energy Union, intended to ensure secure, sustainable, competitive and affordable energy supply in the EU. The parameter *non-renewable primary energy* corresponds to the objective of "increasing the share of renewables".

It should be noted that reducing *energy need*s will not reduce the necessity of (and the market for) renewables and building controls (for effective operation of dynamic components of the envelope, es. e.g. windows and ventilation openings and active systems). On the contrary, it constitutes an indispensable prerequisite for these to be deployed with effective and acceptable results from the social and environmental point of view, including the EU objective of zero "land take", and therefore for their rapid penetration.

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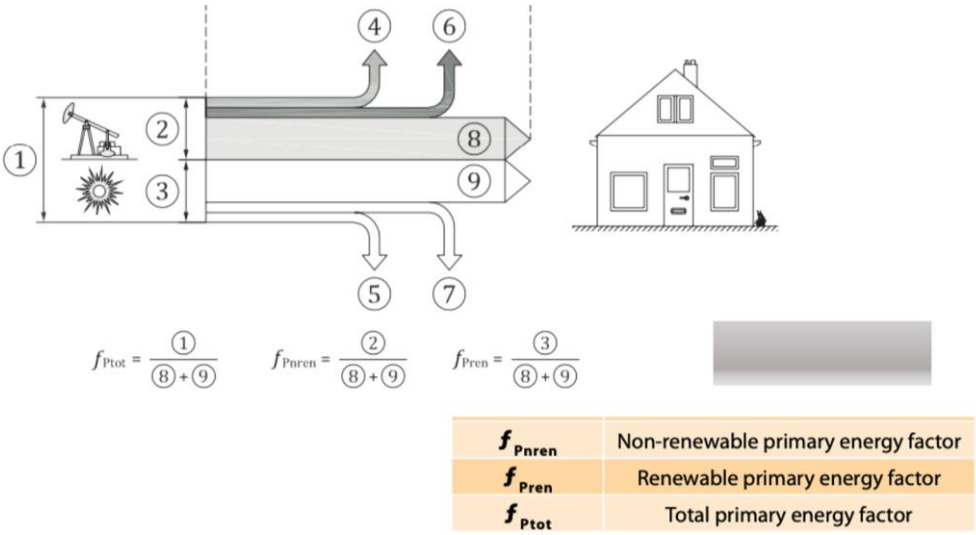

Figure 2 Energy nomenclature in buildings. Source: (EN ISO 52000-1:2017 Energy performance of buildings - Overarching EPB assessment - Part 1: General framework and procedures, 2017)

We want to note here that, even if often described as "efficiency" indicators, energy needs, primary energy, not being defined as ratio output/input are in fact rather to be more precisely considered as "performance" indicators. Even more importantly, their value can be lowered by both technical efficiency measures (e.g. adding external insulation to the building envelope) and ***sufficiency habits*** (e.g. adapting clothing levels and correspondingly lowering the heating setpoint temperature and raising the cooling setpoint temperature)

After the above examples of a few indicators of energy performance of buildings, and their possible use to quantify the results of efficiency measures and/or ***sufficiency habits*** we proceed to the analysis of indicators proposed in literature to assess "sufficiency" in a series of domains.

For example (Lewis Akenji, Magnus Bengtsson, Viivi Toivio, et al., 2021) come to the following conclusion, based on their detailed analysis : "The environmental impacts of lifestyles mainly come from four domains: **food, personal transport, housing, and consumer goods**. Among these, as this report shows, eating meat, using fossil fuel cars, flying, and large and high energy-consuming houses are especially problematic. Prioritising design, production, and consumption patterns in these domains will address about three-quarters of environmental impacts."

In the following, we review sufficiency indicators proposed in literature in the above domains. The EnSu research group (The Role of Energy Sufficiency in Energy Transition and Society)[1] has produced a synthesis of useful sufficiency indicators in the context of buildings, food, spatial access (including mobility), goods and services, that among other sources, have been used to identify a series of indicators as well as analyses which use those indicators.

[1] https://energysufficiency.de/en/startseite-english/

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3. Sufficiency Indicators in four domains

Based on the work presented in the report D2.1, (literature review on the concept of sufficiency), and consulting sufficiency experts from the Expert Panel in the Advisory Board, while performing the literature review, we have found specific references which deal with indicators.

Those specific references, rather than being duplicated, in both documents, are specifically summarized and analysed in this chapter.

3.1. Buildings

Many of the indicators suggested by a spectrum of researchers for sufficiency practices and policies in the context of buildings (commercial and residential), whose work is synthesized below, share the objective of shifting the focus away from the concept of "use per unit of space" (e.g. energy used per m² of built space provided by a building) to instead emphasizing the role of energy or resources used "per person" served by the benefits/services offered by the building. This can be seen as a paradigmatic shift in the perspective of this field of energy conservation with the recognition that in richest parts of the world and social classes the growing use of space per person is acting as a fundamental 'fuel' that gives impetus to a rising total energy and resource consumption by societies.

The analysis for shaping sustainable lifestyles presented in (UNEP et al., 2016) introduces two approaches to assess and design sustainable lifestyle policies and actions. The **Refuse, Effuse and Diffuse** (**REDuse)** framework[2] supports bottom-up approaches, encourages programmes and actions that directly empower individuals and households in their daily lives (and, indirectly, communities), enabling them to understand, create and/or choose the more sustainable lifestyle options. The **Attitude-Facilitator-Infrastructure (AFI)** framework is a top-down approach to support government policy, business models, institutional arrangements, and actions that set the conditions necessary for sustainable lifestyles to thrive.

From suggested sufficiency practices presented in 'examples of REDuse actions by consumers' in high-impact consumption domains emerging from housing related lifestyle choices, the following indicators can be conceived:

- Refuse: per-capita living space (to assess the tendency towards living in larger homes)
- Refuse: per-capita or percentage population exhibiting ownership of large TV sets and fridges (to estimate tendency to own high energy consuming appliances beyond rational needs)
- Effuse: percentage built-up-area of insulated building stock or per-capita insulated living space (m² of insulated space)
- Effuse: annual per-capita end-use of electrical and thermal energy, and water consumption
- Effuse: percentage built-up-area of 'passive housing' in building stock
- Diffuse: percentage buildings with, or per-capita access to gardening tools library

[2] The term *refuse* deals with interventions that disengage from habits which perpetuate negative impacts on the environment or society (e.g., reduction of food waste or buying overpackaged products). *Effuse* relates to interventions that encourage habits with minimal and/or positive environmental and social impacts (e.g., using a bicycle instead of a private car or composting of organic waste). *Diffuse* addresses interventions that transcend individual behaviors and activate multiplier effects through engaging communities in collective sustainable habits (e.g., sharing or collaborative consumption – such as community gardens or farms and carpooling).

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Similarly, using the Attitude-Facilitators-Infrastructure (AFI) Framework[3], the following policy level indicators can be derived as an aid in examining initiatives, practices and policies deployed at meso- and macro-scale to enable sustainable lifestyle objectives

- Facilitators: Establishment of progressive taxation (tax on property, tax on income and luxury goods) by municipalities or government bodies,
- Facilitators: Establishment of progressive/telescopic tariff/billing (price of the unit of energy or water growing with the quantity of units used) by Regulators/Policymakers (Pagliano et al., 1999)
- Facilitators: Establishment of decoupling of profits from sales for energy and water utilities by Regulators/Policymakers (Pagliano et al., 2001)
- Infrastructure: per-capita or percentage city-area reserved for public green spaces and recreational centres,
- Facilitators: Establishment and/or percentage adoption (percentage building stock or built-up-area) of efficiency building and home renovation standards,
- Infrastructure: percentage buildings with, or per-capita access to, shared laundromats
- Infrastructure: percentage of buildings with protected spaces dedicated to bikes, e-bikes, wheelchairs, as foreseen by the Energy Performance of Buildings Directive (DIRECTIVE (EU) 2018/844 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency (Text with EEA relevance), 2018, p. 844), recital 28[4] and article 8.

Work done by (Bierwirth & Thomas, 2019) makes use of household-level choices or policy-enabled practices that can help assess the degree of sufficiency of living practices. In terms of sufficiency practices and enabling conditions related to space, design and construction, equipment, and use of buildings, they suggest the following two measures of sufficiency-based choices that can be exercised by residents:

- reducing numbers, sizes, or energy-using features of equipment, appliances - possibly quantifiable through connected load (kW)/m² of built-up-area,
- choosing a lower room temperature - possibly quantifiable through a) connected load kWh of electrical or thermal energy/m²/year of built-up-area, b) average **operative temperature** (measured through real-time sensors)".

In terms of indicators (and hence 'targets', space design methodologies, planning objectives etc. informed by these ideas of sufficient living) that can be used by assessors, planners or policy makers in estimating and/or shifting the trajectory of the building economy towards energy sufficiency of buildings, (Bierwirth & Thomas, 2019) make the following suggestions, along with their measurement units:

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[3] The *Attitudes-Facilitators-Infrastructure* (AFI) framework describes quintessential elements of sustainable lifestyles policy package at a systems level: pro-sustainability stakeholder attitudes, facilitators or access to sustainable options, and the supporting infrastructure. ATTITUDES: refers to a set of positive values that lead to a predisposition to act sustainably and are shaped by knowledge and value orientation, FACILITATORS: create or provide access to an enabling environment for sustainable lifestyles; they are a set of mechanisms, such as regulation, legal platforms, administrative process, market facilities, or institutional arrangements that provide incentives or constraints for sustainable options, INFRASTRUCTURE: are essentially provisioning systems and include the products and services being consumed, the social environment and physical infrastructure that foster sustainable behaviours.

[4] "…Member States should consider the need for holistic and coherent urban planning as well as the promotion of alternative, safe and sustainable modes of transport and their supporting infrastructure, for example through dedicated parking infrastructure for electric bicycles and for the vehicles of people of reduced mobility."

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- floor area per person (m²/capita)
- rooms per person (rooms/capita)
- time a building/dwelling is used (h/day or days/month)
- flexible size and organisation of rooms (yes/no)
- multiple usable rooms / areas (yes/no)
- flexibility of construction can be adapted easily to changing needs (yes/no)
- Heating/cooling system adequate for size and performance of building (kWh final energy use / hours during which the system works at full-load)
- building can be comfortable without heating or cooling equipment (yes/no)
- indoor temperature levels
- windows closed while heating or cooling
- shock ventilation with short-term wide window-opening instead of long-term tilting (yes/no)
- room by room, daytime / night-time temperature control (yes/no)
- energy use for heating per person (kWh/capita)
- share of dwellings equipped with sanitary facilities (indoor bath, shower, flushing toilet) (percentage)
- municipal living space agencies, offering a combination of advice about living space, practical support for moving, and the provision of financial support (yes/no)
- financial incentives for alternative forms of housing and the dwelling space needed for them (yes/no)

Besides the above, (Bierwirth & Thomas, 2019) suggest the following prescriptive norms (and thus indicators for assessment related to the degree of their accomplishment) that can be integrated into sufficiency-based housing policies at city or state level:

- enabling infrastructure that requires occupants to confirm the on-times and settings of heating or cooling for each room every day
- requiring heat recovery ventilation in building codes
- requiring the linking of heating/cooling thermostats to sensors for window opening
- labelling and Ecodesign requirements should also oblige manufacturers to install an automatic switch-off after a time to be determined for appropriate types of equipment, such as air-conditioners
- grants or tax deductions, may be justified for the purchase of products supporting or enabling the energy-sufficient use of buildings, such as heat recovery ventilation, controls like occupancy controls for the heating or cooling of rooms, linking of heating/cooling thermostats to sensors for window opening

(Lewis Akenji, Magnus Bengtsson, Viivi Toivio, et al., 2021) also suggest the use of per-capita floor area as an indicator of the 'intrinsic' sufficiency of the housing patterns of a region, and a property tax regime linked to this parameter, but they go beyond these metrics when they suggest the establishment and accessibility of sufficiency-facilitation or enablement services available to citizens who are keen to participate in this social-ecological transition, or facilities for reuse of building components.

The following are the sufficiency criteria either explicitly mentioned by (Bierwirth & Thomas, 2019) or derived from their narratives:

- Per-capita floor area
- Ratio of multi-family buildings over single-family homes (derived from narrative)
- Per capita access to sufficiency consultancy services to citizens (derived from narrative)

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- Establishment of progressive taxation based on a cap in the per-capita floor area
- Housing energy demand in the use phase (kWh of final energy use/cap)
- Energy needs for heating or cooling (kWh/m²/year)
- Enhance building utilization over long time periods (percentage building stock with long lifespans) - (derived from narrative)
- Access to facilities for reuse of building components (derived from narrative)

The report "The future of urban consumption in a 1.5°C world" (C40 Cities Climate Leadership Group et al., 2019) focuses on aspects of the building life-cycle well beyond the 'use-phase' of the building (influenced by the practices and behaviours of the occupants as much as it is by the enabling factors integrated intrinsically into the building design). Thus, the construction-phase related climate impacts and resource consumption aspects of the building, as well as emphasising the role of durability in reducing the ecological impacts of planned or perceived obsolescence, are discussed through the following criteria:

- Reduction in steel and cement use (use of steel and cement per m² in building stock)
- Reduction in virgin metal and petrochemical-based materials (use of virgin metal and petrochemical in building stock per m²)
- Average age of household appliances.

In their work on "A low energy demand scenario for meeting the 1.5 °C target and sustainable development goals without negative emission technologies", Grubler et. al. also reinforce the recurrent theme of 'per-capita' consumption of space and devices etc. through the following criteria:

- m² of floor space/capita
- number of devices or appliances per capita
- kWh used/device

In addition to the sufficiency indicators related to buildings/housing derived from an expansive literature review above, the authors of this review would like to suggest the following to be considered by researchers seeking to intensify and amplify their research in this realm:

- per-capita or percentage population exhibiting ownership of large home jacuzzis, saunas, rain-shower heads (to estimate tendency to own high water consuming extravagant appliances beyond rational needs)
- percentage homes fitted with low-flow / water-use restricting devices
- percentage of days (according to municipal directives) with restriction on water use for car wash and lawn watering
- number of building energy management businesses per capita

3.2. Food

Our largely industrial food system exerts a significant ecological impact, especially when the growing/farming, processing, and finally distribution and consumption is organised around a model of globalisation and stark physical and social-cultural 'separation' of the producers and consumers. Both groups are becoming increasingly polarised and often present contradictory 'interests' and act based on economic practices and patterns that are largely oblivious of planetary limits. Our review of literature related to sufficiency of food systems (spanning the whole life cycle of food systems from production to consumption) reveals a few recurrent concepts

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that allude to pathways of food sufficiency, that supports health and wellbeing of all actors in the food system - growers and eaters.

These are:

- Local food production and consumption
- Reduced dependence on animal (especially ruminants) derived protein
- Regenerative forms of food production that maintain soil health and fertility while concomitantly reducing dependence on industrial inputs such as fertilizers and pesticides
- Reduced waste across the food system

Food is a subject deeply enmeshed with local socio-cultural contexts: place, history, identity etc. It is vital to remember that oversimplification of the issue of food sufficiency through monocultural ideas would be profoundly counter-productive to the objectives of social equity. Additionally, it would further perpetuate 'globalised' and 'reductive' hegemonic perspectives that have produced the current adverse effects of the industrial food system in the first place. The centrality of this idea of respecting and fostering plurality of responses to achieve the goals of a sustainable food systems that safeguards the health of societies and the earth cannot be overemphasized, especially in the case of the contented issue of animal meat in diets. Implications of this issue would be vastly different for urban 'industrial eaters' whose realities are greatly severed from connection to the land or water, as compared to its implications for indigenous communities or communities that are primarily agrarian or involved in small-scale fishing or deriving their diets directly from forests, rivers, oceans etc.

The works of (Faber et al., 2012; Lewis Akenji, Magnus Bengtsson, Viivi Toivio, et al., 2021; Repenning et al., 2015) all underscore the role of moderation of animal products in sufficiency-oriented diets through the following criteria:

- consumed animal products/capita
- kg of exported meat
- reduction of meat consumption

The Energy and Climate Action Plan developed by (Republic of Lithuania, 2020), p. 78,80, proposes the following indicators:

- kg of mineral fertilizer
- livestock units per hectare

Similarly, the Energy and Climate Action Plan developed by (Republic of Slovenia, 2020), p. 70, proposes share of regional products as a criterion while the Spanish Plan presented by (Government of Spain, 2020), p. 178, highlights the role of food waste by suggesting the criterion of food waste in kg/capita.

Food sufficiency changes elaborated upon in (UNEP et al., 2016) proposes similar criterion related to food waste as presented earlier, but adds a new dimension of integration and solidarity between urban eaters and rural growers through underscoring the importance of actions by consumers in high-impact consumption domains and suggests for instance "investment in food cooperatives" as a possible measure of examining systemic efforts to foster food sufficiency. Besides these, the following food sufficiency indicators are proposed:

- composting food to reduce wastage and making efficient use of the carbon cycle and sing the compost to encourage own cultivation of foods
- reduction of resource intensive foods (High GHG producing foods)
- reduction of consumption of packaged foods.

Through their work on "Energy sufficiency in private households enabled by adequate appliances (Brischke, L.-A., F. Lehmann, L. Leuser, S. Thomas, and C. Baedeker., 2015) present three

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approaches: reduction, substitution and adjustment. Under substitution it is suggested that preferring fresh foods over frozen foods could effectively bring down energy requirements at homes. Therefore, the percentage of fresh foods in the overall food purchased by a family or in a food system could be a useful food sufficiency indicator. Furthermore, (Brischke, L.-A., F. Lehmann, L. Leuser, S. Thomas, and C. Baedeker., 2015) suggest the tracking of food-related carbon footprint ($tCO_2e/cap/yr$) and its breakdown between consumption components (e.g. carbon intensive drinks such as coffee and beer) as a 'meta-indicator' of food system sufficiency.

Strong parallels exist between indicators suggested by (Lorenzen, 2012) and those that were highlighted by the works presented in (UNEP et al., 2016). (Lorenzen, 2012) underscores the importance of food composting and its cascading influence on promoting self-cultivation of food as a way of adjusting the existing food system that is highly industrialised. It is further suggested that growing one's own food brings down the rate of consumption of an individual and also reduces energy use in various ways including packaging, freezing, transporting etc. A possible indicator that emerges from this discourse is the 'percentage of population (within a certain age group that possesses the physical agency for self-cultivation) with access to, and also the percentage that actually practice cultivation of a portion of their food intake'.

The overarching and recurrent emphasis on curbing food waste, and meat/dairy consumption as primary focal points for achieving food-sufficiency find mention in the work of (Newell et al., 2021) who affirm that food waste, meat and dairy consumption are key hotspots for carbon footprint reduction and that a plant based diet and reduced food waste bear the potential to diminish energy consumption significantly. This is further corroborated by the work presented in (C40 Cities Climate Leadership Group et al., 2019) wherein it is stated that "reduction in meat and dairy intake would contribute to 43% (meat) and 17% (dairy) reduction in emissions respectively".

Finally, the low energy demand scenario modelling for meeting the 1.5 °C target and sustainable development goals presented by (Grubler et al., 2018) contains some seminal ideas related to aligning food systems to the goals of equity and climate mitigation. While indicators are not directly proposed in this work, the following possible food system performance indicators can be inferred from the narratives:

- per capita daily caloric food intake (kcal/capita/day)
- percentage per capita daily caloric food intake (kcal/capita/day) from local food production systems (within 100 miles)
- percentage per capita daily caloric food intake (kcal/capita/day) from small scale (granular) food production systems
- percentage per capita daily caloric food intake (kcal/capita/day) from non-meat food production systems.

3.3. Spatial access to work and services

"Accessibility paradigm" versus "mobility paradigm"

A number of researchers are analysing the accessibility to services in cities and territories. ***Rather than focusing on transport and physical movement, they focus on what are the causes of the need for transport***. In an idealised situation where work places and main services would be at relatively short distances from residence, the need for transport would be very limited. An accessibility approach recognizes the importance of public transport and non-motorised modes of travel (walking and cycling), as well as the role of - and need for coordination with - land-use policy decisions (e.g. in creating location-efficient urban development models). It can also highlight the role of mobility substitutes (e.g. smart-working and home delivery services).

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According to the report (*Improving Transport Planning And Investment Though The Use of Accessibility Indicators*, 2019) by the International Transport Forum (ITF) [5] "[t]he term ***accessibility*** has become more present in the political discourse; however, it has been regularly misinterpreted or poorly defined. Accessibility is often used without a definition or as a synonym for ***mobility***. This reinforces policies that bias towards car-oriented planning by favouring physical movement, while ignoring the role of land-use policies in improving access. Careful and consistent use of the term accessibility is important if there is to be a shift in policy making". See Figure 3.

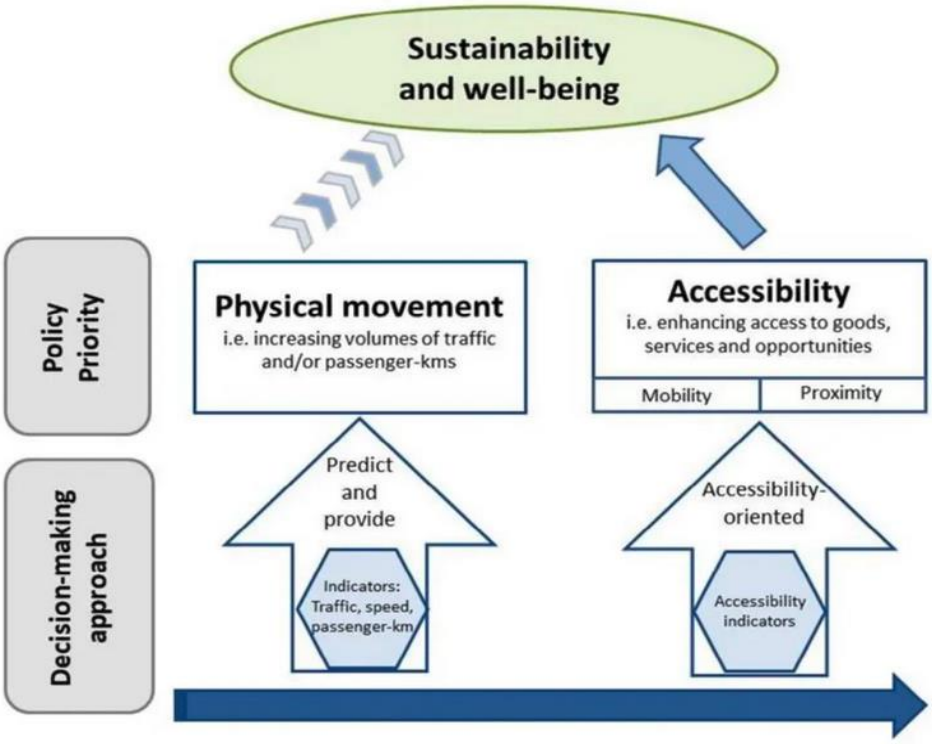

Figure 3 Framing the notion of accessibility versus mobility and the respective indicators. Source: (Improving Transport Planning and Investment through the use of Accessibility Indicators, 2019)

In the report ***absolute accessibility*** is defined as the combination of ***proximity*** and ***transport performance*** (Figure 4) and is declined according to various destinations (schools, restaurants, …), modes of mobility (walking, cycling, bus, …) and times of displacement.

[5] ITF is an intergovernmental organisation with 59 member countries. It acts as a think tank for transport policy and organises the Annual Summit of transport ministers

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Table 3. Indicator parameters

Indicator parameters	Possible values	
Modes	Car, public transport, cycling	Walking
Threshold and associated distance	15 min (4 km), 30 min (8 km), 45 min (12 km)	15 min (1 km), 30 min (2 km), 45 min (3 km)
Destinations	People, schools, hospitals, food shops, restaurants, recreation, green spaces	

Figure 3. Breaking down absolute accessibility

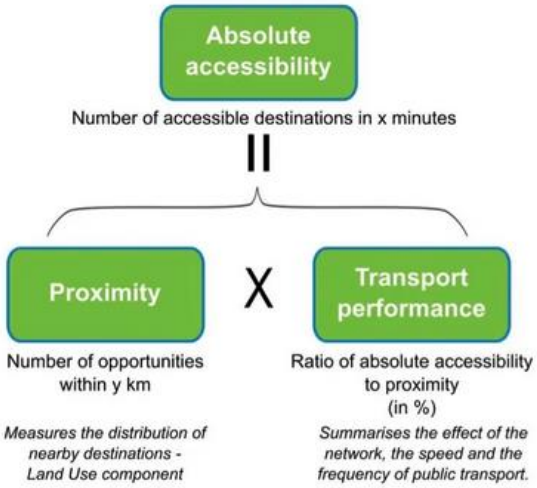

Figure 11. Absolute accessibility scores in 30 min by car in Hamburg, Germany

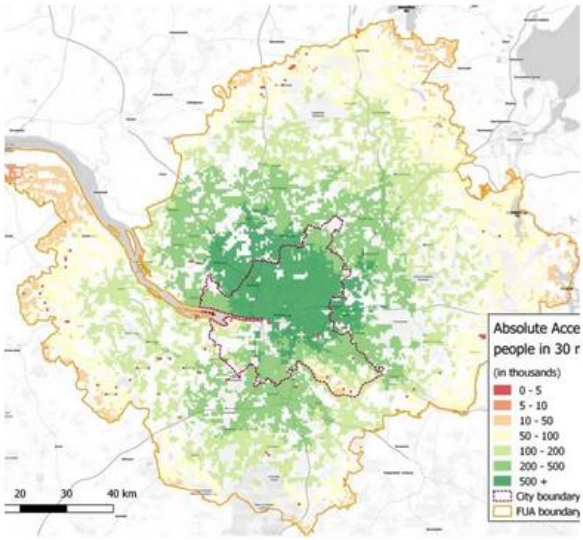

Figure 4 Absolute accessibility defined as the combination of proximity and transport performance. Source: (Improving Transport Planning and Investment through the use of Accessibility Indicators, 2019)

Some authors highlight the importance of equity issues in the definition and use of accessibility indexes. For example (van der Veen et al., 2020) state: "Equity considerations in transportation planning literature have received increasingly more attention in the previous decades. While there have been theoretical suggestions to base transportation planning methods on the philosophical principle of "sufficientarianism" (whereby everyone is entitled to a minimum level of a good or service), the proposed approaches have not yet been developed enough to be usable for policy decision-making. In this paper we aim to bridge this gap by operationalizing in a case study an indicator of equity based on the theoretical work of Martens (2017) which argues for sufficientarianism. The presented formalised methodology can identify and quantify equity issues in transportation, is flexible to different contexts, and is a transparent way to assess equity in transportation."

(Moreno et al., 2021), offer a review of various approaches to "chrono-urbanism" such as the 15-Minute Walkable Neighbourhoods, the 15 minutes and 20 minutes city and their implementation and evolution under the pressure of the COVID pandemic.

(Badii et al., 2021) propose an operational definition of accessibility at various functions (Housing, Govern, Safety, Culture and Cult Services, Environment, Slow Mobility, Fast Mobility, Sport, Economy/sustainability, Food, Health, Education, Services, Entertainment), define indexes for each and their computability, including the availability of data sources for each. They define a grid of points for the computation. The basic element of the grid is a circle with ray of 500 meter in each grid point, thus taking a diagonal close to 1000 meter. This means that they may be partially overlapped. They describe the whole computing process, which has been implemented on the Snap4City platform, and produces a 15MinCityIndex by combining and normalising the subindexes. "The combination of the above-described subindexes may produce a global 15MinCityIndex to express with a single value, the suitability of each single grid area to the concept of 15-Minute City as proposed in this paper. According to the above formulation, all the subindexes

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should provide values in the range of 1-5 in Likert scale, and thus also the 15MinCityIndex should be in Likert scale to be represented as a heatmap as the other subindexes."

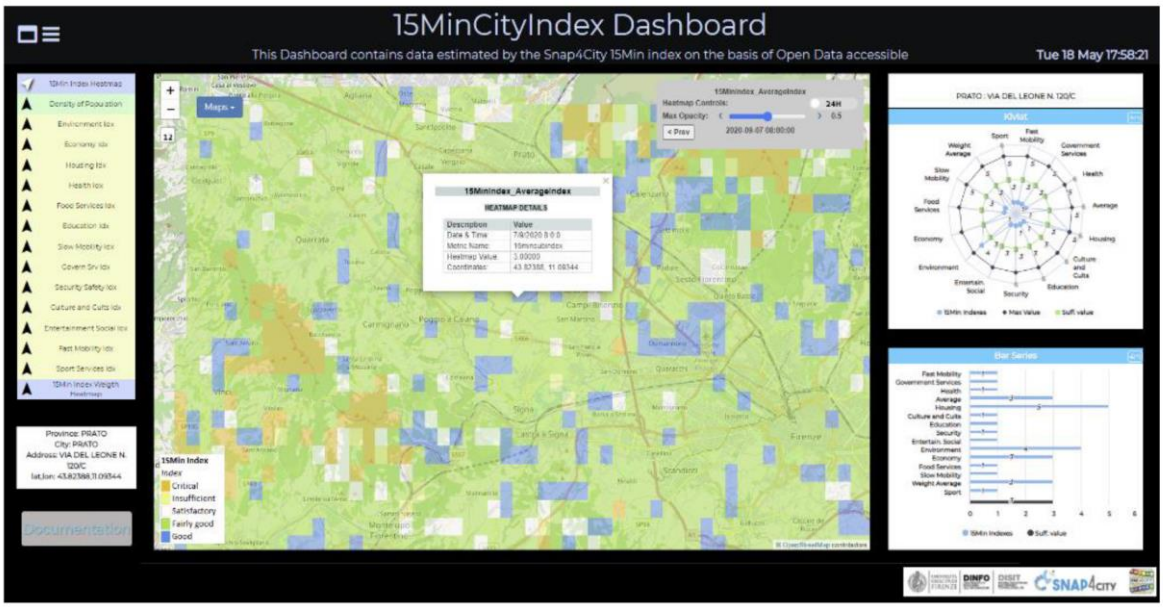

Figure 5 The 15MinCityIndex applied to the Florence area. Source (Badii et al., 2021)

They conclude, "we can state that the proposed 15MinCityIndex performs in a satisfactory manner in the city areas while in the rural areas, in most of the cases they are not computable and thus the global index fails in providing a correct assessment."

Other authors such as (Valdés Cano, 2022) put emphasis on qualitative rather than (only) quantitative evaluation of urban design and suggest avoiding being distracted by the technical sophistication of a tool and concentrate on the desired indicators.

"The success of a particular public space should not only be measured quantitatively (i.e., by the number of people who use the space after an urban intervention) but rather qualitatively (i.e., on the benefits and usefulness of the space to local communities).

Tip: How can your administration think about indicators?

• Put happiness at the centre of public space design and define clear objectives for the public space in question before identifying indicators.

• Rely on the desired indicators, not on the technical sophistication of a tool. Sometimes a simple spreadsheet can be useful to gather and analyse data.

• Choose indicators based on the needs of a specific project. It is always important to use a common set of indicators across all departments. Nevertheless, not all projects have the same set of objectives. Choose indicators that can better help your administration understand and respond to the needs of the communities that use the space."

The aforementioned report (*Improving Transport Planning and Investment through the use of Accessibility Indicators*, 2019), p. 14, also attempts a classification of indicators as follows:

Table 1 Overview of accessibility indicators. Source: (Improving Transport Planning and Investment through the use of Accessibility Indicators, 2019)

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Indicator type	Description	Examples
Infrastructure-based	Indicators that quantify the observed or simulated performance of the transport system. These indicators can also potentially reflect interpersonal differences (e.g. access to public transport varying by social group).	Congestion levels, travel times, average travel speeds, travel costs, proximity to public transport.
Location-based	Indicators that measure the number of opportunities that can be reached from a fixed location using a specific mode within a specified time. They can also potentially reflect individual characteristics if the data used are differentiated accordingly (e.g. by number of jobs available to people in a certain age range or income group).	The number of jobs or other opportunities that can be reached within 30 minutes from a given place by car or public transport.
Person-based	Indicators that analyse accessibility at the detailed individual level based on time-space geography (i.e. on a micro level).	Indicators showing travel times varying according to ownership of a vehicle at different times of day; access to specific types of jobs depending on level of education.
Utility-based	Indicators that measure welfare benefits people derive from access to spatially distributed opportunities.	Logsum indicator – consumer surplus ("willingness to pay") under a range of transport planning scenarios.

Other research in this realm of spatial access related to sufficiency such as (Martin et al., 2020), p. 70, and (Federal Ministry, Republic of Austria, 2019), p. 116, have relatively simple quantifiable indicators as their focal point such as:

- Number of business trips
- Number of trips (other purpose)

While it isn't explicitly stated, the above can perhaps be estimated on an annual per capita basis to arrive at an evaluable mobility sufficiency indicator.

(Matthias et al., 2020) and the National Energy and Climate Action Plan presented by the (Republic of France, 2020), pp. 57, 66, suggest a focus on per capita car ownership rate and tracking of the modal split of trips taken (presumably per capita on an annual basis) as being critical for assessing the sufficiency attributes of a transport system.

Policy or framework-level sufficiency indicators, that seek to assertively address the need to reduce demand for car use and flying, form the crux of the concept resented by (Newell et al., 2021) as is evident from the indicators presented below:

- Congestion charges
- Vehicle fuel-efficiency improvement
- Affordable electric public transport

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- Frequent flyer taxes/air travel adaptation levy
- Support for bicycle lanes and pedestrianisation

(Grubler et al., 2018), in their work on "A low energy demand scenario for meeting the 1.5 °C target and sustainable development goals without negative emission technologies" do not directly refer to spatial access sufficiency related indicators. However, the following can be inferred as valuable potential indicators emergent from an examination of the narratives constructed by them:

- percentage eligible population with driving licences
- uptake of shared mobility usership
- passenger-km/capita/year
- average vehicle occupancy
- per capita users or access to telepresence facilities o enable work-from-home

A similar exercise of inferring potential indicators was performed for the works of (Mueller.N et al, 2018) and (Banerjee. T, 2022). The primary emphasis of both these research efforts was the subject of non-motorised spatial access systems, and amongst them the most pivotal system investigated was cycling. The following relevant sufficiency indicators have emerged from these efforts:

- km of cycling lanes/100 000 persons
- proximity of train/metro/subway stations and cycle stations
- bicycles per 1000 persons
- bicycles per km² and corresponding trips/year
- bicycle network density.

3.4. Goods & Services

The reviewed literature related to sufficiency through moderate use of goods and services reveals a recurrent theme of examining the quantity of appliances, gadgets and their relative 'sizes' owned by members of society, as well as the time spent using high-energy devices and equipment to satisfy living needs. Much research also illuminates the need to systemically support and track the adoption of 'sharing' based collective (rather than private) ownership of large pieces of high energy consuming equipment at building/neighbourhood level etc. as effective and impactful sufficiency indicators. It also alludes to indicators of reduction of time spent using electrical devices at an individual level and reducing/avoiding highly energy consuming leisure.

From the work done by (Wiedenhofer et al., 2018), related to 'Household time use, carbon footprints, and urban form' the following indicators can be derived:

- dependency on services and products: amount of products and services consumed on average by households in cities.
- adoption rates of technological alternatives vs. Do-It-Yourself practices
- moderation of buying/spending potential (through moderation of income)

(Brischke, L.-A., F. Lehmann, L. Leuser, S. Thomas, and C. Baedeker., 2015) have investigated a broad spectrum of possibilities in their work. Issues examined by them have spanned community-scale sharing systems and macro-level re-organizing of product design 'codes' and practices. The following have emerged as some of the most pivotal suggested sufficiency indicators from their work:

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- product customization or adjustment: adjustment of the technical service and product as per the needs (for e.g. appliance size, switching off an appliance when not used, adjusting refrigerator or room temperatures to actual needs)
- community services and sharing of products (for e.g. community washing machines and other utilities, and shared cars in the community).

The report (C40 Cities Climate Leadership Group et al., 2019) explores the potential for sufficiency through re-localization of goods and services provisioning (stemming from the fact that 85% of the emissions associated with goods and services consumed in C40 cities are generated outside the city), and greatly enhancing product lifespan to reduce material and resource consumption 'throughput' without compromising on the total 'quantity' of goods available in society, stemming from the fact that keeping electronic goods and household appliances for longer and optimising their lifespan can yield as much as 33% reduction in embodied carbon of those goods by 2050. Consequently, the following indicators can be proposed based on this report:

- share of local goods and services and exported goods and services
- lifecycle of products and reusing/recycling potential

Finally, (Brischke, L.-A., F. Lehmann, L. Leuser, S. Thomas, and C. Baedeker., 2015) provide an exhaustive array of systemic 'framework' level transformations that would be indispensable to achieve sufficiency of goods and services consumed by society. These lead to the following inferences related to potential indicators for evaluating sufficient 'performance' or levels of practice within society:

- number of appliances and machines in households
- standardisation in product design
- share of complex 'smart' appliances with multiple features which actually increase total energy consumption for providing the same service as simpler equipment[6]
- time spans for innovation cycles and line of products[7]
- establishment and implementation of legislation and associated rules/regulations related to producer's responsibility of reuse/repair/recycling of products, goods and services.

4. Classification of indicators by drivers / levels across sectors

Following the classification suggested by [Marignac, Y. et al. *Scaling-up energy sufficiency on a European level through a bottom-up modelling approach: lessons and perspectives.* European Council for an Energy Efficient Economy, 2021], it is possible to reformat the list of indicators under a different categorization.

The indicators can be classified following different level of conceptualization and action:

[6] more and more complex appliances require typically more instead of less attention and effort for energy saving usage by consumers. Examples include: a growing number of product features are in operating mode and often cannot be deactivated, even though they are not needed; the fridge or freezer part of fridge-freezers often cannot be deactivated separately; a range of consumer electronics devices have no hard-off switch

[7] the increasingly shorter innovation cycles and respective marketing strategies lead to the "need" (more appropriately, the desire or wish) to own the newest device or appliance. The result of this development is an increased number of still functioning devices owned by households. These are not discarded but used additionally or in parallel with new devices.

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- service-based (how consumers use equipment),
- dimensional (size and types of products proposed to consumers),
- organizational (collective planning, infrastructure, legal framework)

This categorization will help in better characterize when a sufficiency indicator relates closely to individual behaviors or rather t is a matter of policy -making, or when it depends more on structural aspects. Each indicator might be related to one or more of the above levels.

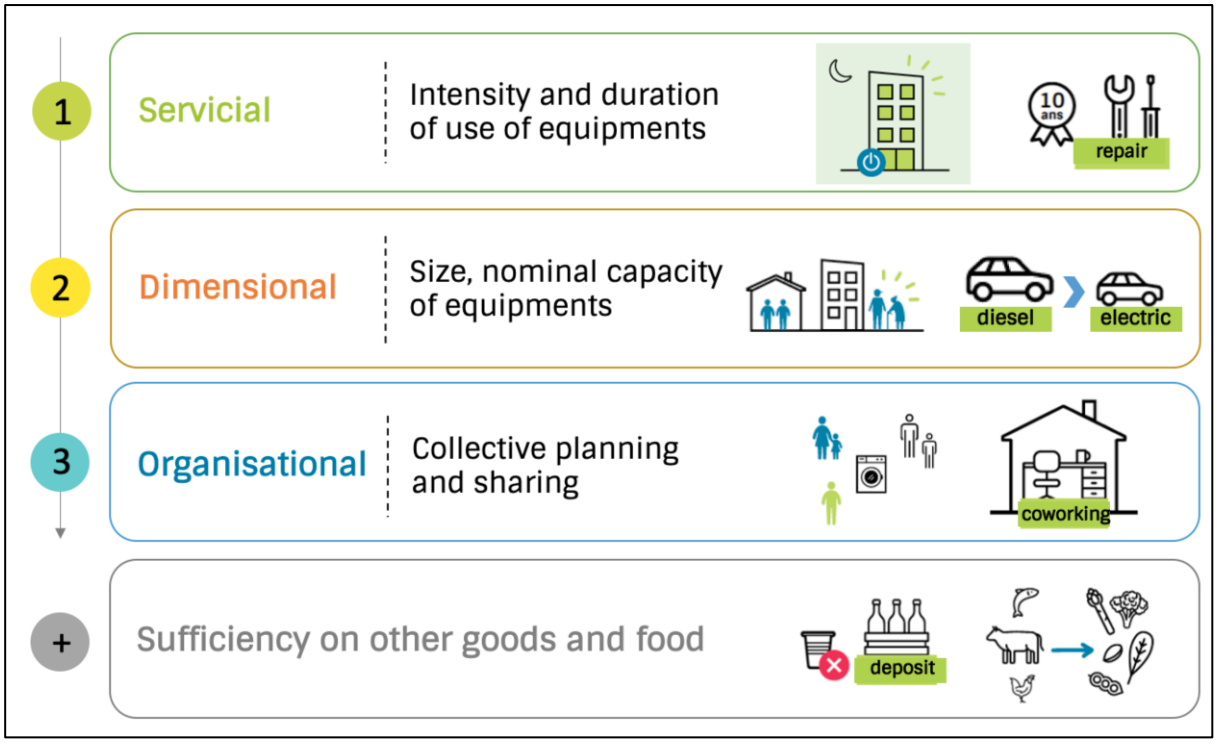

Figure 6: Categorization of sufficiency levers proposed in the CACTUS project, from https://cactus-energy-sufficiency.eu/wp-content/uploads/2021/01/201222_CACTUS-Kick-off_Workshop-Presentation.pdf

This categorization could provide also valuable input for the analysis carried out in the other Work Packages of the project. More in detail:

- WP3 will address the micro level, providing an analysis of lifestyle change mechanisms and sufficiency lifestyle;
- WP4 will identify enablers and barriers for sufficiency lifestyles on the meso- level (intentional communities' success and local political framework, infrastructures);
- WP5 focuses on the identification and analysis of structural drivers in the diffusion of lifestyle changes towards deep social transformation at the macro level.

Part of the indicators are common for more levers (or more Work Packages): as highlighted in the D2.1 analysis of literature, most authors come to the conclusion that it is necessary to provide adequate enablers such as ***sufficiency infrastructures*** and/or ***sufficiency social frameworks*** (at the meso and macro level) in order to allow for permanent life-style changes (***sufficiency habits***) at the micro level.

E.g. the indicator on the energy use for heating per person (kWh/capita) can depend both from the intensity of use and the size/dimension/power of the appliance for providing heat, typically dimensioned based on the peak need. At the same time this indicator can involve the WP3 subject (individual behaviour, like defining the set-point for heating that influences the energy consumption) and the local/national policy framework, typically limiting by law maximum energy needs for heating.

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An existing example of list of indicators, is the MONET[8] (Monitoring Nachhaltiger Entwicklung – monitoring of the sustainable development) system, created in Switzerland by the Federal Statistical Office (FSO), the Federal Office for the Environment (FOEN), the Swiss Federal Office for Spatial Development (ARE) and the Swiss Agency for Development and Cooperation (SDC).

The indicator system provides information about the current situation and helps in defining the targets – where possible - and understanding the trends in all aspects of sustainable development (social, economic and environmental), also linked to the SDGs, and allowing in many cases inter-countries comparisons.

The list of indicators presented by the MONET system is not directly designed for providing data on the aspects linked to sustainability policies or sufficiency only, but it addresses other issues such as impacts and responsibilities of the national policies abroad, the gender equality and the social cohesion.

[8] HTTPS://WWW.BFS.ADMIN.CH/BFS/EN/HOME/STATISTICS/SUSTAINABLE-DEVELOPMENT/MONET-2030/METHODOLOGICAL-ASPECTS.HTML

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Sector	Indicator	Levers			Useful for		
		Dimensional	Servicial	Organisational	WP3	WP4	WP5
Buildings	Connected load (kW)/m² of built-up-area				x	x	x
	Consumption in kWh of electrical or thermal energy/m²/year of built-up-area					x	x
	Average operative temperature in rooms (measured, in °C)				x		x
	Floor area per person (m²/capita)					x	
	Rooms per person (rooms/capita)					x	x
	Time a building/dwelling is used (h/day or days/month)				x	x	x
	Flexible size and organisation of rooms (yes/no)					x	x
	Multiple usable rooms / areas (yes/no)					x	x
	Flexibility of construction can be adapted easily to changing needs (yes/no)					x	x
	Heating/cooling system adequate for size and performance of building (kWh final energy use / hours during which the system works at full-load)					x	
	Building can be comfortable without heating or cooling equipment (yes/no)					x	x
	Indoor temperature levels definition (setpoint, in °C)				x	x	
	Windows closed while heating or cooling (yes/no)				x	x	x
	Shock ventilation with short-term wide window-opening instead of long-term tilting (yes/no)				x	x	x
	Room by room, daytime / night-time temperature control (yes/no)				x	x	
	Energy use for heating per person (kWh/capita)				x	x	
	Share of dwellings equipped with sanitary facilities (indoor bath, shower, flushing toilet) (percentage)					x	
	Municipal living space agencies, offering a combination of advice about living space, practical support for moving, and the provision of financial support (yes/no)						x
	Financial incentives for alternative forms of housing and the dwelling space needed for them (yes/no)						x
	Per-capita floor area				x	x	x
	Ratio of multi-family buildings over single-family homes (derived from narrative)						x
	Per capita access to sufficiency consultancy services to citizens (derived from narrative)						x
	Establishment of progressive taxation based on a cap in the per-capita floor area						x
	Housing energy demand in the use phase (kWh of final energy use/cap)				x	x	
	Energy needs for heating or cooling (kWh/m²/year)					x	x
	Enhance building utilization over long time periods (percentage building stock with long lifespans)					x	x
	Access to facilities for reuse of building components (derived from narrative)					x	x
	Reduction in steel and cement use (use of steel and cement per m² of built surface in building stock)					x	x
	Reduction in virgin metal and petrochemical-based materials (use of virgin metal and petrochemical in building stock per m² of built surface)					x	x
	Average age of household appliances (years)					x	
	Number of devices or appliances per capita					x	
	energy used per device (kWh/year or kWh/cycle)				x	x	
	Per-capita or percentage population exhibiting ownership of large home jacuzzis, saunas, rain-shower heads (to estimate tendency to own high water consuming extravagant appliances beyond rational needs)				x	x	x
	Percentage homes fitted with low-flow / water-use restricting devices					x	x
	Percentage of days (according to municipal directives) with restriction on water use for car wash and lawn watering						x
	Number of building energy management businesses per capita						x

Table 2 : classification of indicators in the buildings sector, by drivers / levels and relevance for the project work packages

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Sector	Indicator	Levers			Useful for		
		Dimensional	Servicial	Organisational	WP3	WP4	WP5
Food	Consumed animal products/capita (kg/cap.)				x		
	Kg of exported meat (kg)						x
	Reduction of meat consumption (in percentage)				x		x
	Kg of mineral fertilizer for food (kg of fertilizer / kg of food)					x	x
	Livestock units per hectare (units/ha)					x	x
	Composting food to reduce wastage and making efficient use of the carbon cycle and sink the compost to encourage own cultivation of foods (kg of compost per capita)				x		x
	Reduction of resource intensive foods (High GHG producing foods) (kg of resources / kg of food)				x	x	x
	Reduction of consumption of packaged foods (%)				x		x
	Per capita daily caloric food intake (kcal/capita/day)				x		
	Percentage per capita daily caloric food intake (% of kcal/capita/day) from local food production systems (within 100 miles)				x	x	x
	percentage per capita daily caloric food intake (kcal/capita/day) from small scale (granular) food production systems				x	x	x
	Percentage per capita daily caloric food intake (% of kcal/capita/day) from non-meat food production systems.				x	x	x
Spatial access to work and services	Km of cycling lanes (km/100 000 persons)					x	x
	Proximity of train/metro/subway stations and cycle stations (metres)					x	x
	number of bycycles (number per 1000 persons)				x	x	
	Bicycles per km² and corresponding trips/year (number per km² and number of trips per year per km²)				x	x	x
	Bicycle network density (km per km²)					x	x
	Percentage eligible population with driving licences (% of adult population)				x		
	Uptake of shared mobility usership (number of travels per capita)				x		
	Passenger-km/capita/year				x		
	Average vehicle occupancy (persons)				x	x	x
	Per capita users or access to telepresence facilities o enable work-from-home (% of number of persons)					x	x
	Congestion charges (yes/no)					x	x
	Vehicle fuel-efficiency improvement (% of fuels saved)					x	x
	Affordable electric public transport (in time travels in %)					x	x
	Frequent flyer taxes/air travel adaptation levy (yes/no)						x
	Support for bicycle lanes and pedestrianisation (yes/no)					x	x
	Number of business trips (number per capita)				x	x	
	Number of trips (other purpose) (number per capita)				x		
Goods and services	Number of appliances and machines in households (number per household)				x	x	
	Standardisation in product designs (yes/no)					x	x
	Share of complex 'smart' appliances with multiple features which actually increase total energy consumption for providing the same service as simpler equipment (%)					x	x
	Yime spans for innovation cycles and line of products (months or years)					x	x
	Establishment and implementation of legislation and associated rules/regulations related to producer's responsibility of reuse/repair/recycling of products, goods and services (yes/no)						x
	Share of local goods and services and exported goods and services (%)					x	x
	Lifecycle of products and reusing/recycling potential (years and % of reusable parts)					x	x
	Product customization or adjustment: adjustment of the technical service and product as per the needs (for e.g. appliance size, switching off an appliance when not used, adjusting refrigerator or room temperatures to actual needs) (yes/no)					x	x
	Community services and sharing of products (for e.g. community washing machines and other utilities, and shared cars in the community) (yes/no)					x	x
	Dependency on services and products: amount of products and services consumed on average by households in cities (number of services)				x	x	x
	Adoption rates of technological alternatives vs. Do-It-Yourself practices (% of users and number of practices)				x	x	
	Moderation of buying/spending potential (through moderation of income) (yes/no and %)					x	x

Table 3 : classification of indicators in the food, transport and goods and service sectors, by drivers / levels and relevance for the project work packages

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5. Conclusions

Based on the literature review presented in D2.1 we found a general agreement that major environmental impacts of lifestyles (and major possibilities for a change to *sufficiency habits*) mainly come from four domains: **food, personal transport, housing, and consumer goods**.

This report (D2.2.) proposes a list of quantitative and qualitative indicators applicable in FULFILL to study lifestyle changes in those domains, based on published academic and grey literature, identified during the literature analysis (T2.1) and singled out in this report which is focused on indicators.

Some authors warn that the choice of the type of indicators can strongly influence (possibly not explicitly but implicitly) the direction of the analysis, the conclusions and finally the policy decisions.

For example, the use of indicators of "mobility" reinforces policies that bias towards car-oriented planning by favoring physical movement of people, while ignoring the role of land-use and other policies in providing and improving access in manners that are environmentally benign and socially equitable.

A transition from indicators of "mobility" to indicators of "accessibility" can avoid that implicit bias and open up more possibilities for sufficiency-oriented analysis and policy making.

The additional classification of the indicators, based on drivers and levers across sectors - service-based (how consumers use equipment), dimensional (size and types of products proposed to consumers) and organizational (collective planning, infrastructure, legal framework) provides an input to the work in the subsequent work packages and can be one of the basis for defining and assessing sufficiency policies at the different levels.

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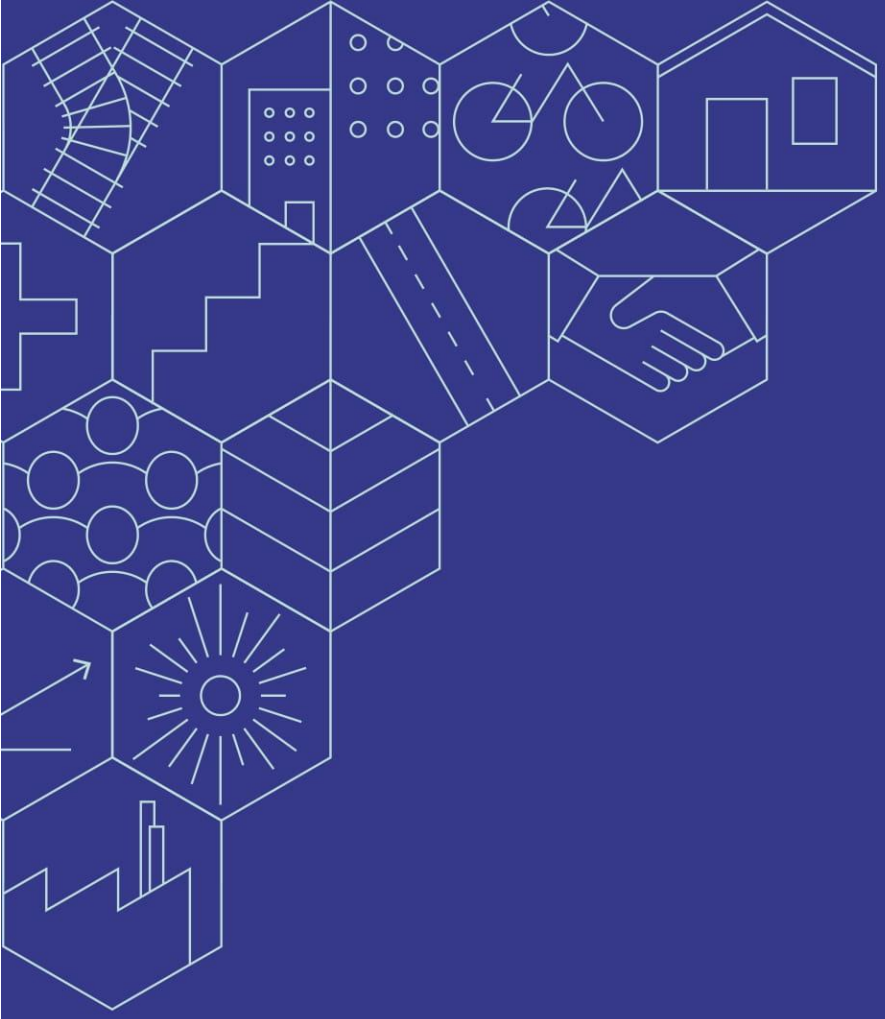

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